Migration, Livelihood, and Energy Transition
of Rural Farming Households

by

Seung-Yong Han*

Center for Population Dynamics
Arizona State University

* Direct correspondence to SeungYong Han, PhD candidate, Center for Population Dynamics, Arizona State University; shan32@asu.edu

Migration, Livelihood, and Energy Transition of Rural Farming Households

Abstract

This study examines the effects of migration and household capitals on energy transition in the setting of Chitwan, Nepal, which is undergoing rapid socioeconomic and environmental changes in recent years. By using the Chitwan Valley Family Study data collected since 1996, event history analysis explores the bi-directional transition between traditional and modern energy sources. The results shows that migration is positively associated with the transition from traditional energy sources to modern ones, especially to gas and kerosene, but not to electricity. Human, physical, and social capitals also affect the transition. For the opposite direction of the transition, while other results are consistent, possessing land increases the likelihood of the transition. Interactive relationships between migration and household capitals are examined as well. In sum, the results suggest that rural households in developing countries constantly juggle their resources for the choice of the main energy sources to adapt to their surrounding conditions.

Migration, Livelihood, and Energy Transition of Rural Farming Households

Introduction

The 2014 report by the United Nations on water and energy sends us a few important messages that increasing energy demand, especially from countries under rapid socioeconomic development, in the coming years will be at serious risk without proper management and regulations at the national and global level (WWAP 2014). According to the report, this growing demand also means significant environmental impacts on water specifically in those countries since most power generation is water-intensive. In sum, the report shows the growing concern over the long-term environmental impacts of social transitions accompanied by urbanization in the setting of developing countries with poverty.

Among various social transitions, the focus of this study is energy transition; how migration and household capitals affect rural households to alter the main energy source. Energy transition is the transition from the use of traditional energy sources, such as fuel wood, to modern ones, such as electricity. In general, energy transition has environmental impacts since the demand for energy will exponentially increase with socioeconomic development that is coupled with the increasing numbers of population and households (Knight and Rosa 2012). This is an important question in that a substantial rise in energy demand is closely linked with sustainable development at the national and global level in the near future (Sadorsky 2014). At the micro level, exploring energy transition is also important in that it is related to individual health, empowerment of women and children (Filippini, and Pachauri 2007; Spalding-Fecher 2005; Jiang and O’Neill 2004). Thus, to be prepared for the surge of energy demand and to directly and indirectly improve the current socioeconomic conditions of rural households in developing countries in the coming years, understanding energy transitions at the household level would be the first step towards sustainable development.

The setting of this study is Chitwan, Nepal, which is a region located in the Terai ecological zone. The Terai zone is one of the three ecological zones of Nepal, which are mountain, hill, and Terai, and has humid tropical and sub-tropical climate in low altitudes. Due to this friendly climate and high agricultural productivity as pull factors, the Terai has been the primary destination for domestic migrants of the mountain and hill zones since the early 1950s (Central Bureau of Statistics 2003). As the population size increased in Chitwan, in addition to the national economic plan which dates from 1956 focusing on the development of infrastructure across Nepal, the region has been under rapid urbanization process with the city Narayangarh as the central part of it. As an evidence for urbanization, the average minutes to the closest services and facilities, such as cinema, health post, bus stop, school, police station, employer, and market by walk were at least more than 150 minutes in 1953, and the time to most of them reduced significantly down to less than 30 minutes in 1995 (Yabiku 2002). This indicates that infrastructure, especially the transportation system in Chitwan, has been substantially improved, and as a result, more and more people in Chitwan have migrated internally and internationally for better opportunities in the last couple of decades (Central Bureau of Statistics 2003; Sill and Kirkby 1991).

Despite a high volume of migration in developing countries, like Nepal, the effects on the changes in the livelihood of rural households have not been fully studied. Indeed, not enough attention has been given to the multidirectional relationships between migration, environment, and development (Hugo 2008). The purpose of this study is to complement this gap between the relationships; it is to assess the effects of migration and capitals at the household level on energy transition in the context of the socioeconomically changing agricultural region, Chitwan, Nepal, over ten years between 1996 and 2006.

Theoretical considerations

The framework of livelihood approach is relevant to explain energy transitions associated with sustainability issues. The livelihood approach is a perspective with the focus on how a household utilizes household assets in terms of five capitals: human, natural, physical, financial, and social (Ellis 2000). This perspective is useful to categorize a variety of household assets in five ideal types of capitals, and each capital is expected to have distinct effects on energy transition. Within this framework, therefore, we can better understand how a rural household utilizes what they have, and in turn, what it suggests for their future livelihood and environment. Throughout the text, the term “household assets” will be referred to as “household capitals” to emphasize that household assets consist of a variety of capitals at the household level.

Migration, in addition to household capitals, is expected to have significant direct and interactive effects on energy transition as well. Domestic and international migration has been a large part of livelihood of most households in Chitwan in the last few decades. Migration could have direct effects on the transition. Levitt (1998, 2001) argues that migration brings not only financial remittance, but also social remittances, such as experience, new ideas and thoughts. This implies that, besides money, what migrants have seen and experienced in migration destinations might have changed the way they looked at the world and could affect the ways of living. At the same time, migration could have moderating effects on the transition through household capitals. Successful migration would play an important role in upgrading household capitals, such as financial capital, through remittances (Connell and Conway 2000). Migration could also work in different directions based on how much a household possesses of a certain capital. For example, if there are few household members in young ages, who usually participate in fuel wood collection on a daily basis in rural areas, the household might use the remittances from migration to switch their main source of energy to decrease the burden of the fuel wood collection. On the other hand, the household might use those remittances for other activities, such as for intensifying farming activities, when there are enough household members in young age to collect fuel wood. In sum, the effect of migration on energy transition depends on many household characteristics.

Previous studies have shown that one of the main causes of energy transition is the level of income (Pachauri and Jiang 2008; Jiang and O'Neill 2004). Thus, in the setting of high volume of migration, like Chitwan, there is a high chance that financial remittance from migration would accelerate energy transition. However, the study of Masera, Saatkamp, and Kammen (2000) in the setting of Jaracuaro, Mexico, points out that rural households might keep using traditional energy sources even though they are capable of purchasing modern ones. The main reason is that traditional energy sources are considered to be better and more appropriate than modern ones for cooking traditional meals and for traditional parties. This fact implies that energy transition is not only a matter of financial status of a household, but also a matter of how people perceive and accept a new technology. In other words, cultural barriers or lack of familiarity to modern techniques could delay the transition. And migration experience could be a catalyst for the transition since there is a high chance that migrants are more likely to be exposed to modern energy sources and the idea of using them than non-migrants during migration. Therefore, I hypothesize that migration experience of a household would accelerate the transition.

However, more questions on the transition process are left to be answered regarding whether or not 1) a household would completely abandon traditional energy sources and only accept modern ones; 2) a household would use both energy sources with different purposes at the same time. The first question is related to fuel switching, and the second question is linked with fuel stacking (Heltberg 2004). Fuel switching is a complete transition from one to another energy source while fuel stacking is adding additional energy sources to traditional ones. The view focusing on complete transition is summarized as the "energy ladder model" (Smith 1987;

Hosier and Dowd 1987). This model has been criticized mainly for ignoring the fact that rural households in developing countries are using multiple energy sources combining traditional and modern ones together (Joon, Chandra, and Bhattacharya 2009; Hiemstra-van der Horst and Hovorka 2008). This new perspective is summarized as the “multiple fuel model” (Masera, Saatkamp, and Kammen 2000). The reason for using multiple energy sources might be cultural as described before, but another reason could be found at the neighborhood level: accessibility to modern energy sources and quality of the supply (Pachauri and Jiang 2008). In most rural areas in developing countries, including Chitwan, Nepal, the accessibility to modern energy sources, such as electricity, might be still limited. But the supply of it is very unstable even if it is widely available; for instance, the sudden power blackout is quite common in Chitwan. Due to this reason, an electrified household might keep using traditional energy sources to prepare for frequent disconnections.

It is important to recognize that these two perspectives might not be two completely different arguments. Based on the previous research, it seems that using multiple energy sources is one of the coping strategies as a buffer to prepare for the instability of the supply of modern energy sources in a given region. Therefore, as the infrastructure of the region improves, in a positive case of this scenario, the supply will be stabilized and most households would eventually change their main energy sources from traditional energy sources to modern ones. Further, experience during migration would accelerate this trend. This implies that the level of energy transition could be a reasonable indicator to assess which stage a given society is in. These considerations lead us to a hypothesis that household capitals and migration would increase the likelihood of energy transition.

Data and Methods

The data, the Chitwan Valley Family Study (CVFS), has been collected in Chitwan, Nepal, over fifteen years since 1996 as a multifaceted project composed of several datasets (Axinn et al, 2011). Over time, several datasets with different topics have been collected based on the sampled neighborhoods, and four of them will be used for this study; 1) Household Registry, 2) Household Agriculture and Consumption Survey, 3) Individual Questionnaire and Individual Life History Calendar, and 4) Neighborhood History Calendar. All the datasets are merged into one dataset for the analysis. And the unit of analysis is at the household level. Since the main dataset that has the information about energy transition and household capitals was collected in three time points, 1996, 2001 and 2006, the sample includes only those households who took the survey at all three time points. New households who moved into the study site after 2001 or who got separated from pre-existing households as a result of household fission in the survey in 1996 or 2001 are excluded as well. The main reason is that migration data are not complete or are missing for most new households since the Household Registry data did only follow those individuals in initial households in 1996 even if they moved out of the survey area. The data did follow those individuals in new households, but once they moved out of the survey area, they were not tracked.

To test the effect of migration and household capitals on energy transition, the analysis method is binary logistic regression model using discrete-time event history approach controlling for the variation at the neighborhood level. It is the most appropriate technique when 1) the dependent outcome is the dichotomous transition and not all observations experienced the event, and 2) when observations were measured in several clusters so that households from the same neighborhood tend to resemble each other. These techniques have been used successfully in similar analysis (Yabiku, 2004; Axinn and Yabiku, 2001), and it will be of great use in my analysis as well. These estimation techniques correctly compute the standard errors inherent in clustered data and thus help to avoid incorrect hypothesis tests, which result in wrong conclusions. In the analyses, I will incorporate a random effect for the neighborhood-level variance, because households are grouped by neighborhoods. Thus each model of the analyses is a two-level multilevel model. The SAS command PROC GLIMMIX with RANDOM statement allowing an intercept for each neighborhood is used. In case, a model with Pseudo Likelihood Residual method as an estimation technique fails to converge, Laplace's method is used instead (Kiernan, Tao and Gibbs 2012).

There are two main dependent variables measuring bi-directional energy transition. The survey question asks which heating sources a household uses for cooking. Traditional energy sources include fuel wood, sawdust, biogas, and others. Modern energy sources include kerosene, gas, and electricity. The first variable is measuring the transition from traditional energy sources to modern energy sources. The second variable is measuring the opposite direction of the transition: from modern energy sources to traditional energy sources. For example, if a household did use fuel wood in 1996 and changed the energy source to electricity or adapted any modern energy sources in combination with traditional ones in 2001, this is considered as the transition from traditional energy sources to modern ones. If a given household did use fuel wood in 1996 and 2001 without using any modern energy sources, and they adapted or completely moved to electricity in 2006, this is also considered as the transition. Thus, in the event history analysis, the events are the transition from traditional energy sources to modern ones and the transition in the opposite direction; these two transitions are examined in two separate models. The duration of the event is one or two since the Household Agricultural Consumption Survey was only conducted in three time points: 1996, 2001, and 2006. Households become at risk of the transition in 1996, and they are removed from the risk after the event occurs. Households that continued using either traditional or modern energy sources only in all three time points (1996, 2001, and 2006) are censored. The time unit of the analysis is the household-time. An additional consideration is the parameterization of time, which is measured with the time variable that indicates duration. The hazard has been parameterized with a continuous time variable having a value of one or two. Although event history analyses are typically used when there are many periods of risk (many years, many months), my analyses examine the transition across only two periods of risk. While this means there will be many ties in the data (many households experiencing the event at the same time), this is not a violation of discrete-time event history, which is amenable to tied events. While a finer time resolution in the measurement of transitions, would allow for more accuracy, my approach is still valid for examining household variation in the transition from one energy source to another, given that the household has not experienced the transition before.

Independent variables are migration and five household capitals: how they are measured is explained in detail below. Predictors are time-varying: when the transition period at risk is between 1996 and 2001, the first time period, is examined, migration between 1996 and 2001 and independent variables from 1996 survey are used to test the effects of each on energy transition. When the transition between 2001 and 2006, the second time period, is examined, migration between 2001 and 2006 and independent variables from 2001 survey are used to test the effects of each on energy transition.

Migration

The accumulated duration of monthly migration is used to test the effects of migration on energy transition. Household Registry data is used to measure migration. By the rules of the data collection of CVFS, an individual was considered as “away” from a given household if he or she did not stay, eat, and sleep in the household for more than fifteen days each month. Away information in Household Registry data is monthly and at the individual level and it does not have any information about the destination and the purpose of each away. Thus, it might contain some unsuccessful domestic or international migration (early return) as well as casual travel to other cities or countries. To circumvent those unwanted possibilities, being away from a household for more than 3 consecutive months is only counted as migration. Age is restricted to be over fifteen years old to mostly consider voluntary labor migration.

Human capital

Human capital is measured with household size and education, and these variables are from the Household Registry and Individual Questionnaire data. Household size is divided into three age groups: the number of young children under age 15, the number of adults in working age between 15 and 65, and the number of the elderly over 65. Since household size was measured in each month since February, 1997 in the dataset, using the household size at a certain point only might not reflect the real household size of a household. For example, if there are currently 3 migrants in working age in a given household and we measure the size today, we will significantly underestimate the number. To avoid this case, I calculated the average household size for each age category during the first and second time periods and used them as household size variables. Education includes the education level of the youngest household member over 15 years old, and the education level of the oldest household member in years.

Natural capital

Natural capital is measured with land possession and environmental perceptions of water quality, and these variables are from the Household Agriculture and Consumption Survey. Land possession includes the possession of bari (upland) and khet land (irrigated low land). For both, it is coded 1 if a household owns bari or khet land, otherwise, it is 0. Environment perceptions is measured with the question about a respondent's perception of water quality (much dirtier, little dirtier, same, little better, or much better) each year compared to the prior three years. The value is 0 if a household answered that the water quality was the same compared to three years ago. And the value is negative if a household answered that the water quality was little dirtier (-1) or much dirtier (-2) compared to three years ago. The value is positive, on the other hand, if a household answered that the water quality was little better (+1) or much better (+2) compared to three years ago. The range of the value is between -2 and +2.

Physical capital

Physical capital is measured with agricultural equipment, consumer items, and housing quality, and these variables are from the Household Agriculture and Consumption Survey. Agricultural equipment measures how many pieces of agricultural equipment, such as tractor, cart, irrigation pump set, gobar gas plant, or others (thresher, chaff cutter, sprayer, or any), a household owns. The range of the value is between 0 and 5. Consumer items measures how many consumer items, such as radio, television, bicycle, motorbike, a household owns. The range of the value is between 0 and 5.

An index for housing quality is also created. This index consists of the number of stories and the material of wall, roof, and floor. One story of a house adds one point to the index, so the range is from 1 to 5. For materials used to build a wall, concrete adds 6 point, brick 5, stone 4, wood 3, mud 2 and cane with mud 1. For materials used to build the roof and floor, concrete adds 4 point, brick 3, wood 2, and mud 1. The range of the index is, therefore, from 4 to 19.

Financial capital

Financial capital is measured with livestock and poultry, and these variables are from the Household Agriculture and Consumption Survey. Livestock is the total number of livestock, such as cows, bullocks, buffaloes, sheep, goats, and pigs, weighted by the value of each livestock based on the study by Regmi (1999). For example, cows are considered to be more valuable than pigs in the context of Asian countries in general, so the number of cows is multiplied by .69 while the number of pigs is multiplied by .30, and the sum of those two numbers are used for livestock. In detail, the number of cows is multiplied by.69, bullocks by.96, male buffalos by .95, female buffalos by .71, sheep or goats by .25, and pigs by .30. Poultry includes chickens, ducks, and pigeons, and the total number of all poultry is used. For poultry variable, weights are not used.

Social capital

Social capital is measured with the proportion of households using any modern energy sources in the same neighborhood. For example, if 5 households out of 10 households in the sample in the same neighborhood used any modern energy sources in 1996, 50% (5 out of 10) is used as a social capital variable for the transition between 1996 and 2001. Any neighborhoods that have only one household are excluded from the sample. The major drawback of social capital measurement is that the proportions are computed only based on the sample, not the actual entire household in the neighborhood. As a result, the number of households used for the computation for each neighborhood might be as small as three households for some neighborhoods.

Preliminary Analysis Results

First, we look at the number of households that used each energy source in three survey years summarized in <Table 1>. It shows that most households used fuel wood as their primary energy source for cooking in all three years despite the fact that modern energy sources, such as electricity, became widely available in most neighborhoods in Chitwan since 1996. At the neighborhood level, the data collected by Chitwan Valley Family Study (CVFS) shows that electricity was available in about a half of 171 neighborhoods in 1996 and the number increased to about ninety eight percent of all the neighborhoods in 2001 and 2003. As a matter of fact, the number of households that used electricity as one of their primary energy source substantially increased between 2001 and 2006, but the number was still not as large as the one for fuel wood. In 1996, there were only 13 households using electricity, but the number became 206 households in 2006. Among the modern energy sources, gas became popular over time and even more popular than electricity in 2006 while kerosene significantly lost the popularity between 1996 and 2006; only 28 households used kerosene in 2006 while 371 households used it in 1996. Among the traditional energy sources, besides fuel wood, the trend of biogas is noticeable. In 1996, there were only 59 households using it, but the number increased to 223 in 2006.

These numbers, however, do not show how many households actually moved from the use of one energy source to another. To explore more about the actual transition in detail, we first look at the number of households for each transition. Adapting the perspective of energy stack, I consider multiple energy sources, which is the mixture of traditional and modern energy sources, as one of the categories of the transition. As a result, there are three bi-directional energy transitions we can observe; between only traditional energy sources and only modern energy sources, between only traditional energy sources and multiple energy sources, and between only modern energy sources and multiple ones. <Figure 1> shows the patterns of these transitions in Chitwan, Nepal, between 1996 and 2001, and <Figure 2> shows the patterns between 2001 and 2006. Throughout the text, the term “traditional and modern energy sources” will be referred to as “multiple energy sources” to simplify the term.

During both time periods, many households in Chitwan stayed in using only traditional energy sources for everyday use, mostly fuel wood as indicated in <Table 1>. And not many households transitioned from traditional energy sources to modern ones in spite of the availability of electricity in Chitwan as discussed before. This might indicate that availability does not fully account for the use of modern energy sources. In addition, a substantial number of households moved from only traditional energy sources to multiple energy sources during both time periods: 94 households in the first period and 116 households in the second period. And a small number of households moved from multiple energy sources to only modern sources: 36 household in the first time period and 31 households in the second time period. These two patterns of energy transition implies that there might be a hierarchy in the use of energy sources as only traditional ones in the lowest place, multiple ones above that, and only modern ones on top of the hierarchy. If this is the case, then it might mean that the perspective of the energy stack and ladder are all valid but just need to be combined together.

However, considering the hierarchy, there are a noticeable number of households that move back to the previous stage in both time periods: from multiple ones to only traditional ones, from modern ones to only traditional or multiple ones. This pattern is clear especially between multiple energy sources and only traditional ones. There were 141 households who moved from multiple energy sources to only traditional ones between 1996 and 2001, and 180 households between 2001 and 2006, while 94 and 116 households moved to the opposite direction in each time period, respectively. Going back to traditional energy sources indicate that the energy stack and ladder perspectives might not be enough to explain energy transition in developing countries; the livelihood perspective should be introduced here to understand the transition better. It is still true that availability of and accessibility to modern energy sources as well as income level matter as previous research shows, but it would be better understood in the framework of livelihood perspective in that the livelihoods of rural households are dependent on the ever-changing surrounding environmental and socioeconomic conditions and household capitals reflect how they responded to societal changes. Therefore, I argue that energy sources a household uses are not fixed or only move upwards in the hierarchy as implied by the perspective of energy stack and ladder. What energy sources a household uses everyday constantly interacts with their livelihoods, changing household composition and circumstances, and surrounding conditions, like any other social transition. In other words, rural households juggle their resources, which can be replaced with household capitals in the perspective of livelihood approach, to adjust to their surrounding conditions, and the choice of primary energy sources is dependent upon it. Therefore, it is also important to examine the opposite direction of the transition: from modern energy sources to traditional energy sources.

Based on these considerations, I analyze two directions of energy transition in the next step of the analysis: 1) the transition from traditional energy sources to modern energy sources; 2) the transition from modern energy sources to traditional energy sources. Specifically, the first transition is the transition from only traditional energy sources to only modern energy sources or multiple energy sources. And the second transition is the transition from only modern energy sources to only traditional energy sources or multiple energy sources.

The results of event history analysis to assess the effects of migration and household capitals on the transition from traditional energy sources to modern ones are summarized in <Table 2>. Model 1 only includes a variable measuring accumulated duration of migration in the last five years before the event, and Model 2 includes all the household capitals in addition to migration. The results are presented as odds ratios, so a coefficient greater than one represents a positive effect that accelerates the rate of the transition, while a coefficient less than one represents a negative effect that delays the transition.

In both models, one additional month in the duration of migration increases the likelihood of the transition from only traditional energy sources to modern or multiple energy sources by 1 percent. For example, for a household that has a migrant who was away for ten months prior to the period of risk, the likelihood of the household to use modern energy sources increases by 10% compared to other households without migration experience.

Not only migration, but also household capitals affect the transition as expected. Among five household capitals, human, physical, social capitals affect the transition. The results in model 2 show that the number of household members under age 65 is negatively associated with the decrease in the likelihood of the transition. This is probably due to the fact that one of the main traditional energy sources, fuel wood, is usually collected by young household members in most rural areas of developing countries. Chitwan is not an exception. One additional household member in young age, under 15, decreases the likelihood of the transition by 18% (1.00 - .82 = .18), and one additional household member in working age, between 15 and 65, decreases the likelihood by 13%. On the other hand, education is positively associated with the increase in the likelihood of the transition as expected; regardless of generation, one extra year in education increases the likelihood of the transition by 4%. It is very likely that education increases the chance of using consumer items as well as the familiarity to or necessity of them, and it naturally increases the chance of the transition.

Using more consumer items and better housing quality are positively associated with the increase in the likelihood of the transition from traditional energy sources to modern energy sources. One additional consumer items, such as radio and television, increases the likelihood of the transition by 64%, and one unit increase in housing quality increases the likelihood by 10%.

Last, what energy sources other households use affect the decision making of a household on the switch of main energy source as well. One percent increase in the proportion of the households using modern energy sources increases the likelihood of the transition by 254%.

The results of the interactions between migration and household capitals on the transition from traditional energy sources to modern energy sources are summarized in <Figure 3> and <Figure 4> (tables will be provided on request). Among five capitals, physical and financial capitals show significant results. First, the interaction results between migration and consumer items tells us that having many consumer items substantially increases the likelihood of the transition regardless of migration experience, which was confirmed in <Table 2>. This pattern is the same even when the duration of migration is high, 36 months in <Figure 3> for example, but the effect of consumer items reduces though it is still high. Second, the interaction results between migration and livestock indicates that having many valuable livestock is associated with high chance of the transition without migration experience as presented in <Figure 4>. However, as the duration of migration increases, having less valuable livestock becomes a good indicator of changing the main energy source to modern ones. In fact, when the duration of migration is high, longer than 24 months, having 17 livestock is negatively associated with the transition. In sum, the results imply that rural households tend to liquidate their financial capital to purchase modern energy sources when there is no migration. When they accumulated some money from migration and possess few valuable livestock, rural households tend to use the money to buy modern energy sources. In this situation, having many valuable livestock could be an indicator of a household substantially investing in agriculture, so they tend to stay in traditional energy sources and invest the money from migration instead for other activities.

As a next stage of the analysis, I analyze the transition from traditional energy sources to each modern energy source: electricity, gas, and kerosene (tables will be provided on request). The main reason of doing this analysis can be found in <Table 1>. As discussed, the pattern of the popularity of each energy source over time is very different from each other. More households use electricity as their energy source over time, but not as many as expected. Kerosene was very popular in 1996, but the number of households using it decreased dramatically over time. On the other hand, the number of households using gas increased greatly. The results show that migration has a positive effect on the transition to gas and kerosene, but not electricity. Considering that gas and kerosene are purchasable at a market relatively easy, the positive relationships between migration and the use of those two modern energy sources seem relevant. The result of electricity suggests that it is a matter of more than money. In fact, even though the availability of and accessibility to electricity in Chitwan has reached over 95 percent since 1996, but the supply of electricity has never been stable. Since the electricity has been generated at hydropower plants, which supplies power to Chitwan, the supply has been affected significantly by severe droughts. In addition to droughts, some forest conservationists also argue that the dry of the river is due to the forest depletion in recent years (Setopati, 2014). Besides migration, other results seem to stay the same in general. And interactions results are consistent with previous interaction results or just marginally significant, so they are not reported.

<Table 3> summarizes the results of event history analysis on the transition from modern energy sources to traditional energy sources: the opposite direction. Essentially, the results are consistent with the results of the transition from traditional energy sources to modern energy sources except a few factors. First, migration does not significantly affect the transition. Second, the number of household members does not affect the likelihood of the transition. Third, possessing bari (upland) land, which is considered to be less productive than khet (low irrigated

land), increases the likelihood of the transition back to traditional energy sources though it is marginally significant. In sum, this result and the result of the interaction between migration and livestock in <Figure 4> suggests that households already invested a lot of resources in agriculture tend to stay in the use of traditional energy sources. I speculate that they can acquire traditional energy resources, such as fuel wood, biomass or hay, relatively easier than those households without significant possession of agricultural assets, so they tend to invest their resources on other activities besides energy sources. The result of the interaction between migration and education of the youngest household member is presented in <Figure 5>. Overall, having a highly educated household member in young age is negatively associated with the likelihood of the transition. Education reduces the chance of the transition from modern energy sources to traditional energy sources. However, the gap between no education and high education, 4 years of education in <Figure 5> for example, reduces as the duration of migration increases. If we compare the result with no migration and the one with 3 years of migration, the difference in the likelihoods between no education and 4 years of education is not as much as when the duration of migration is zero. The reason being might be found in that new ideas, thoughts, experiences from migration might be able to replace the function of education. For example, households learned about how useful and effective modern energy sources are from migration experience as if they could have learned it at school. As a result, the effect of education reduces as the duration of migration increases.

Discussion and Future Study

The purpose of this study is to assess the effects of migration and household capitals on energy transition in the context of Chitwan, Nepal, which is undergoing rapid socioeconomic changes in recent decades. The results of event history analysis on the transition from traditional energy sources, such as fuel wood, biogas, and saw dust, to modern energy sources, such as electricity, gas, and kerosene show that 1) migration supports rural households to change their main source of energy to modern ones; 2) household structure, especially the number of household members in young age, is negatively associated with the transition; 3) highly educated household member tend to push a household to use modern energy sources; 4) having consumer items, such as radio and television, increases the likelihood of the transition; 5) what other household in the same neighborhood do can affect the energy choice of a given household. Interestingly, the results on the opposite direction of the transition suggest that those households possessing agricultural assets, such as land tend to stay in the use of traditional energy sources, and some interactions results support this. In sum, energy transition can be better understood in the framework of the livelihood perspective, which reflects how hard rural households in developing countries juggle their resources to adapt to their ever-changing socioeconomic and environmental conditions.

To explore migration further, I will test two types of migration, domestic and international migration, by merging another dataset having yearly information about migration. Considering that international migration tends to bring bigger financial remittances, I expect that international migration would be positively associated with energy transition more than domestic migration. Not only financial remittances, but also social remittances from international migration could be meaningfully larger in that living in developed sectors of other countries would affect an individual significantly through new ideas, information, and culture as the duration of exposure to all of them increases. Due to these considerable impacts of international migration, it might show more interesting effects interacted with household capitals as well. Further research is required.

References

Axinn, W. G., A. Thornton, J. S. Barber, S. A. Murphy, D. Ghimire, T. Fricke, S. Matthews, D. Dangol, L. Pearce, A. Biddlecom, S. Shrehtha, and D. Massey. 2011. *Chitwan Valley [Nepal] Family Study: Changing Social Contexts and Family Formation.* ICPSR04538-v7. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]. Retrieved October 27th, 2012 (http://dx.doi.org/10.3886/ICPSR04538.v7)

Central Bureau of Statistics. 2003. *Population Monograph of Nepal*. Kathmandu, Nepal.

Connell, J. and D. Conway. 2000. "Migration and Remittances in Island Microstates: A comparative Perspective on the South Pacific and the Caribbean." *International Journal of Urban and Regional Research* 24(1): 52-78.

Ellis, F. 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford University Press.

Farsi, M., M. Filippini, and S. Pachauri. 2007. "Fuel Choices in Urban Indian Households." *Environment and Development Economics* 12: 757-774.

Heltberg, R. 2004. "Fuel Switching: Evidence from Eight Developing Countries." *Energy Economics* 26: 869-887.

Hosier, R. H., and J. Dowd. 1987. "Household Fuel Choice in Zimbabwe." *Resources and Energy* 9: 347-361.

Hugo, G. 2008. "Migration, Development, and Environment." International Organization for Migration Research Series. Retrieved September 20, 2012 (http://www.iom.int/jahia/webdav/site/myjahiasite/shared/shared/mainsite/published_docs/serial_publications/MRS35_updated.pdf).

Jiang, L. and B. C. O'Neil. 2004. "The Energy Transition in Rural China." *International Journal of Global Energy Issues* 21(1/2): 2-26.

Joon, V., A. Chandra, and M. Bhattacharya. 2009. "Household Energy Consumption Pattern and Socio-Cultural Dimensions Associated with It: A Case Study of Rural Haryana, India." *Biomass and Bioenergy* 33: 1509-1512.

Kiernan, K., J. Tao, and P. Gibbs. 2012. *Tips and Strategies for Mixed Modeling with SAS/STAT® Procedures*. SAS Institute, Cary, North Carolina, USA.

Knight, K. W. and E. A. Rosa. 2012. "Household Dynamics and Fuelwood Consumption in Developing Countries: a Cross-National Analysis." *Population and Environment* 33: 365-378.

Levitt, P. 1998. "Migration Driven Local-Level Forms of Cultural Diffusion." *International Migration Review* 32(4): 926-948.

Levitt, P. 2001. *The Transnational Villagers*. Berkeley: University of California Press.

Masera, O. R., B. D. Saatkamp, and D. M. Kammen. 2000. "From Linear fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model." *World Development* 28(12): 2083-2103.

Pachauri, S. and L. Jiang. 2008. "The Household Energy Transition in India and China." *Energy Policy* 36: 4022-4035.

Sadorsky, P. 2014. "The Effect of Urbanization and Industrialization on Energy use in Emerging Economies: Implications for Sustainable Development." *American Journal of Economics and Sociology* 73(2): 392-409.

Setopati, 2014. "Hydropower Plant not Generating Electricity." setopati.net, March 15. Retrieved September 20, 2014 (http://setopati.net/society/1005/).

Sill, M. and J. Kirkby. 1991. *The Atlas of Nepal in the Modern World*. London: Earthscan Publications Ltd.

Smith, K. 1987. *Biofules, Air Pollution and Health*. New York: Plenum Press.

Spalding-Fecher, R. 2005. "Health Benefits of Electrification in Developing Countries: A Quantitative Assessment in South Africa." *Energy for Sustainable Development* IX(1): 53-62.

WWAP (United Nations world Water Assessment Programme). 2014. The United Nations World Water Development Report 2014: Water and Energy. Paris, UNESCO.

Yabiku, S. 2002. "Social Organization and Marriage Timing in Nepal." Ph.D. dissertation, Department of Sociology, the University of Michigan, Ann Arbor, MI.

<Table 1> Number of Households Using Traditional and Modern Energy Sources in Chitwan, Nepal

	1996	2001	2006
Traditional energy source			
wood	1,226	1,203	1,182
biogas	59	130	223
sawdust	46	106	163
other	25	8	16
Modern energy source			
electricity	13	32	206
gas	48	188	419
kerosene	371	307	28

Note: out of total 1354 households; numbers do not sum up to the total since some households use more than one energy source; energy sources are used for everyday cooking.

<Table 2> Energy Transition from Traditional Energy Sources to Modern Energy Sources, Event History Model Results

	Model 1			Model 2		
	Odds		t value	Odds		t value
Migration						
Duration (month)	1.01	**	4.13	1.01	**	3.20
HH capitals						
Human capital						
Number of young				0.82	**	-3.92
Number of working				0.87	*	-2.16
Number of old				0.82		-1.61
Edu of the youngest				1.04	*	2.10
Edu of the oldest				1.04	*	1.98
Natural capital						
Own bari				1.07		0.45
Own khet				1.29		1.51
Water quality				0.95		-0.49
Physical capital						
Consumer items				1.64	**	5.57
Agro equipment				0.96		-0.43
Housing quality				1.10	**	3.63
Financial capital						
Livestock				0.97		-0.66
Poultry				1.00		-1.19
Social capital						
% HH using modern energy sources				3.54	**	3.48
Time	1.47	**	2.91	0.99		-0.05
Intercept	0.14	**	-14.19	0.04	**	-9.67
Intercept at the neighborhood level	0.74		0.18	0.32		0.13
Generalized Chi-square / DF		0.81			0.88	
N		1,728			1,728	

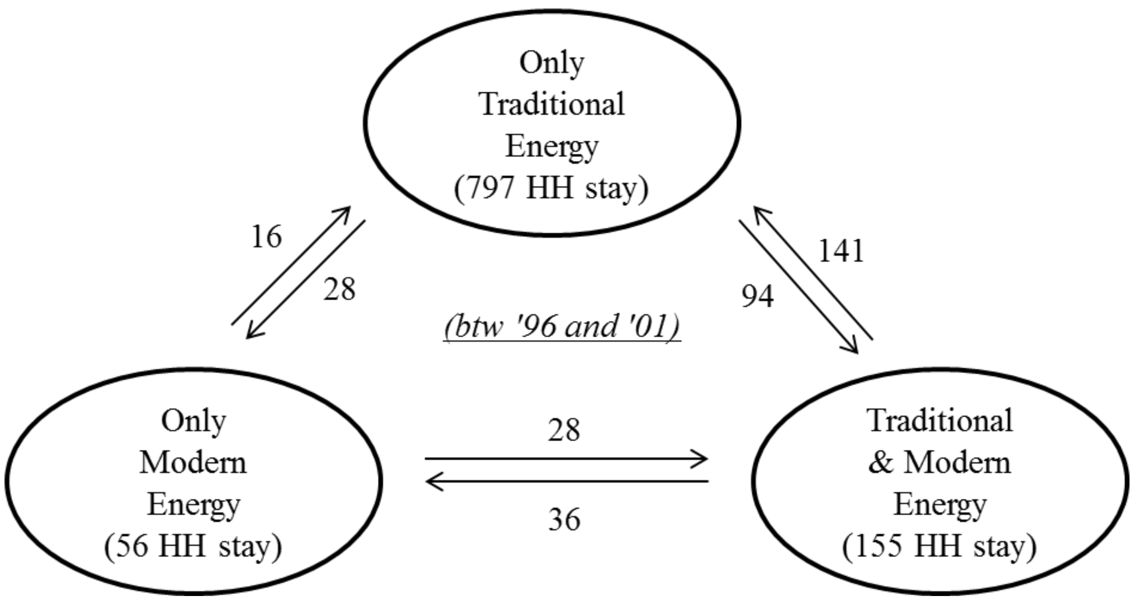
Note: † $p < .10$; * $p < .05$; ** $p < .01$, two tailed.

<Table 3> Energy Transition from Modern Energy Sources to Traditional Energy Sources, Event History Model Results

	Model 1			Model 2		
	Odds		t value	Odds		t value
Migration						
Duration (month)	1.00		-0.23	1.00		-0.35
HH capitals						
Human capital						
Number of young				0.97		-0.46
Number of working				0.95		-0.60
Number of old				0.97		-0.14
Edu of the youngest				0.95	*	-2.02
Edu of the oldest				0.94	**	-2.69
Natural capital						
Own bari				1.51	+	1.94
Own khet				1.12		0.51
Water quality				0.90		-0.72
Physical capital						
Consumer items				0.56	**	-4.95
Agro equipment				1.36		1.35
Housing				0.99		-0.20
Financial capital						
Livestock				1.12		1.44
Poultry				1.00		-0.60
Social capital						
% HH using modern energy sources				0.21	**	-4.33
Time	0.73	+	-1.69	1.18		0.68
Intercept	0.48	**	-4.44	3.36	*	2.45
Intercept at the neighborhood level	0.53		0.21	0.05		0.13
Generalized χ^2 / DF		0.88			0.96	
N		657			657	

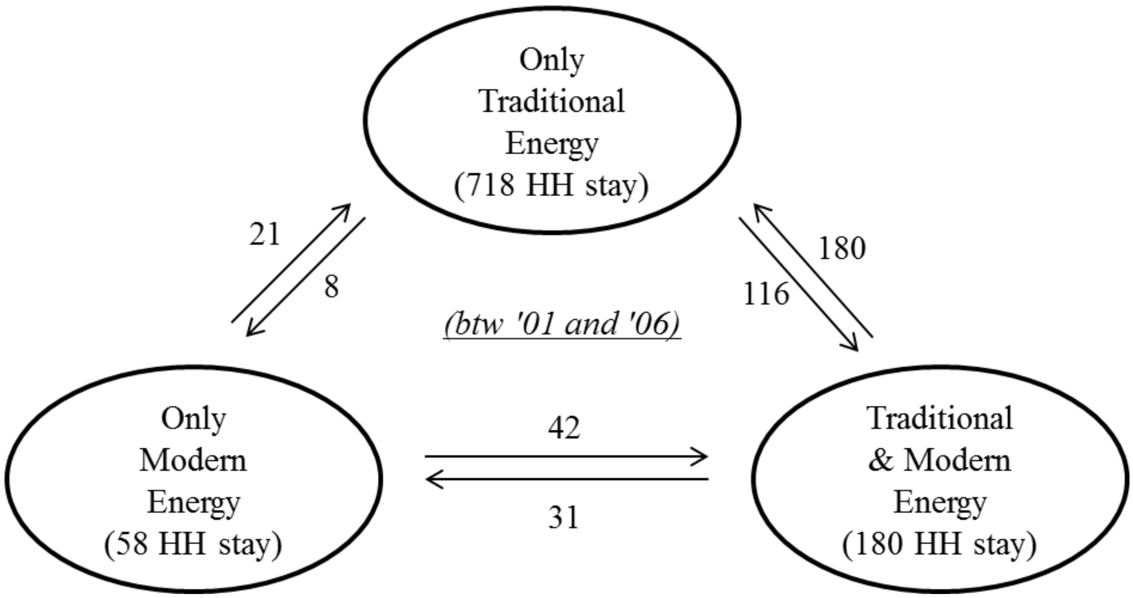
Note: † *p* < .10; * *p* <.05; ** *p* <.01, two tailed.

<Figure 1> Energy Transition between 1996 and 2001, Number of Households



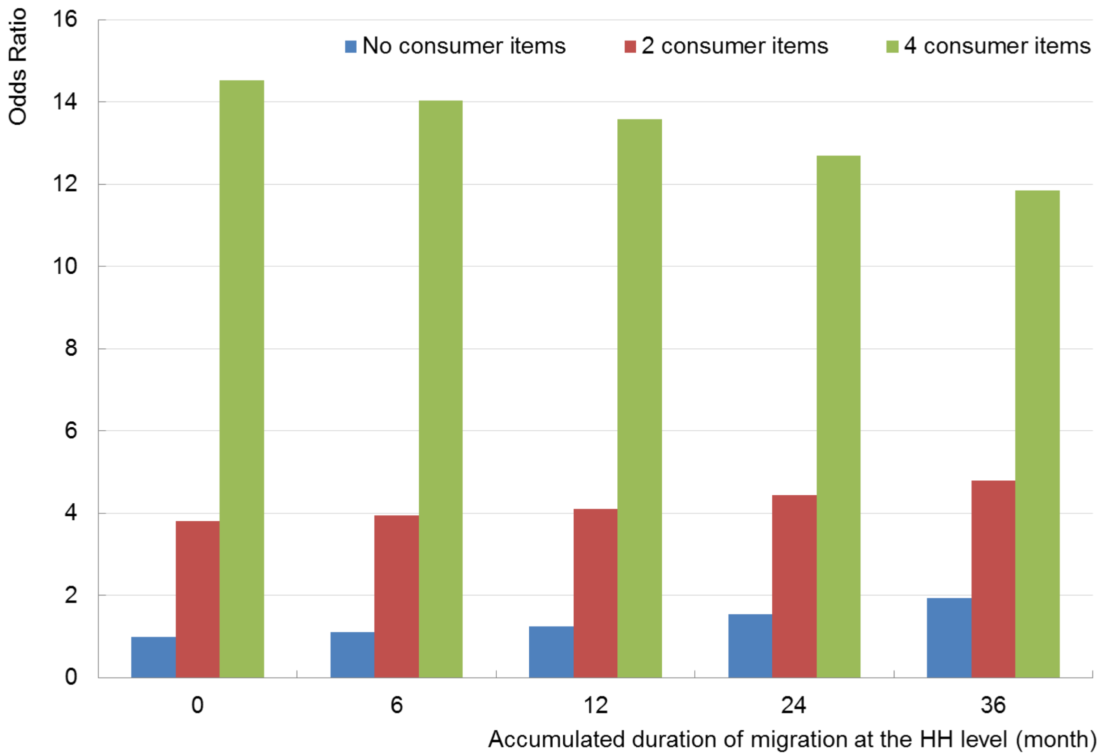
Note: out of total 1354 households.

<Figure 2> Energy Transition between 2001 and 2006, Number of Households



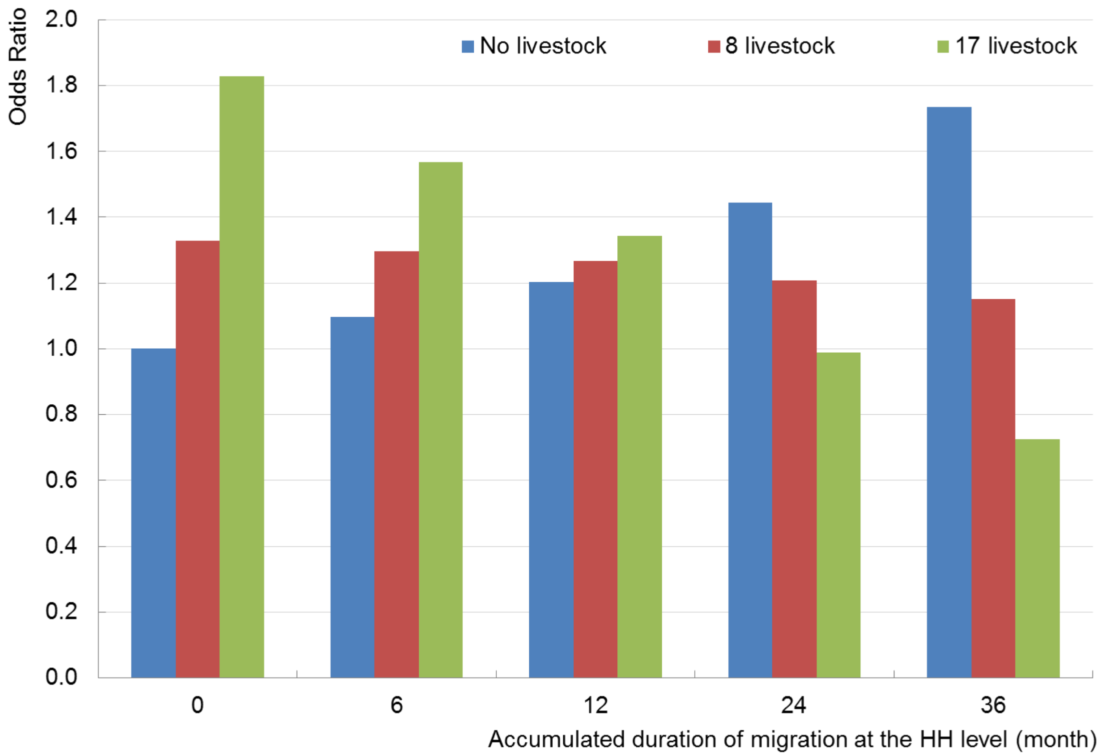
Note: out of total 1354 households.

<Figure 3> Interaction between Migration and Consumer Items on Energy Transition from Traditional Energy Sources to Modern Energy Sources



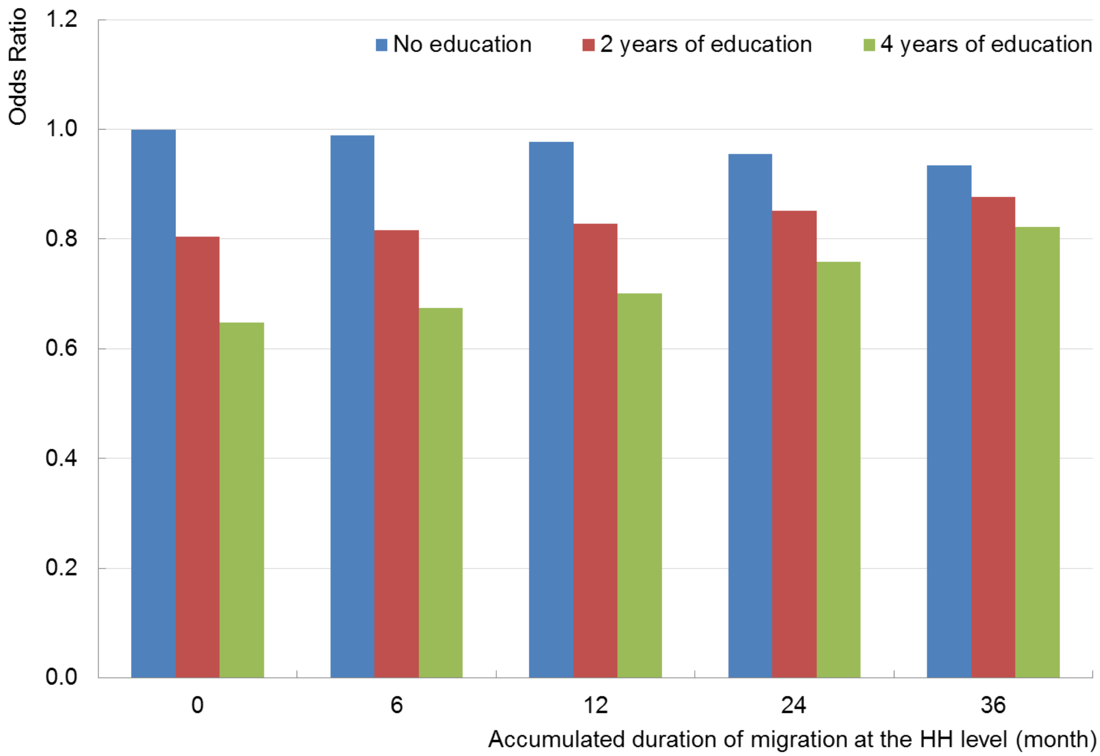
Note: *p*-value for the interaction coefficient is .02

<Figure 4> Interaction between Migration and Livestock on Energy Transition from Traditional Energy Sources to Modern Energy Sources



Note: *p*-value for the interaction coefficient is .04

<Figure 5> Interaction between Migration and Education of the Youngest Household Member on Energy Transition from Modern Energy Sources to Traditional Energy Sources



Note: *p*-value for the interaction coefficient is .02