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Household Energy Consumption: Community Context and the Fuelwood Transition*

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Abstract

We examine the influence of community context on change over time in households' use of non-wood fuels. Our theoretical framework builds on sociological concepts in order to study energy consumption at the micro-level. The framework emphasizes the importance of nonfamily organizations and services in the local community as determinants of the transition from use of fuelwood to use of alternative fuels. We use multilevel longitudinal data on household fuel choice and community context from rural Nepal to provide empirical tests of our theoretical model. Results reveal that increased exposure to nonfamily organizations in the local community increases the use of alternative fuels. The findings illustrate key features of human impacts on the local environment and motivate greater incorporation of social organization into research on environmental change.

Keywords

Human Ecology; Asia; Community Context; Environment and Natural Resources; Forestry; Consumption/Consumers

Degradation of the natural environment has become the subject of increasingly intense research over recent decades. This is just as true in the social sciences as in the natural, biological and physical sciences. The social sciences have been particularly concerned with the consequences of social organization and social actions for levels of environmental degradation. Human consumption of natural resources is generally identified as the key link between human behavior and degradation of the natural environment (Stern et al. 1997). Though social research has primarily focused on the total volume of human consumption, classical sociology points toward the importance of transitions in the nature of consumption as a fundamental change in the way people relate to their environment (Foster 1999). In this study we investigate a key transition in the total environmental footprint of human

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consumption (York, Rosa and Dietz 2003), the transition away from biomass fuel toward more highly processed alternative energy sources.

To do this we build on a new theoretical trend in the field to formulate a framework for the study of energy use transitions that focuses on the type of energy consumed rather than the amount of energy consumed. This framework has broader application than energy use per se, because it identifies key mechanisms through which macro-level social changes reorganize individual and household consumption practices in general. The framework takes an explicitly multilevel and longitudinal approach to understanding this fundamental energy use transition. It identifies the specific dimensions of contextual change – the spread of new nonfamily organizations and services – most likely to reorganize daily life in rural agrarian populations to shape energy use and transitions in energy use. The framework goes on to identify specific mechanisms linking different dimensions of contextual change to change and variation in individual and household consumption behaviors. Thus this framework provides an important general tool for understanding the relationship between macro-level social change and micro-level behaviors.

Multilevel longitudinal data from the foothills of the Nepalese Himalayas enable us to document the influence of new nonfamily organizations and services in the local community context on household fuel substitution. Nepal is widely known as one of the world's most diverse ecological settings, but also as a setting on the brink of serious environmental degradation (Adhikari, Di Falco and Lovett 2004; Bajracharya 1983; Blaikie and Brookfield 1987; Eckholm 1976; Gautam, Shivakoti and Webb 2004; Ives and Nesslerli 1989; Jodha 1995). The fragile Himalayan environment is suffering rapid deforestation and soil erosion, which threaten the region's biodiversity of flora and fauna. As in other poor countries, energy consumption in rural Nepal is heavily dependent on traditional biomass based energy. Traditional sources of energy constituted 86% of the total energy consumption in 2001 (with fuelwood constituting 76%, agricultural residues constituting 4%, and animal wastes constituting 6%). Residential households are the largest energy consumers, responsible for 89% of the total energy and 99% of the total fuelwood consumption. However, commercial and renewable energy have recently increased their share of the total energy consumption with annual growth rates of 15.4% and 21%, indicating an important shift in household energy consumption patterns (MEST 2003; Rijal 1998). Rural Nepal is an ideal setting to examine community context and fuel substitution because local communities have changed rapidly over the lifetimes of its current residents. Thus measures from this setting provide an opportunity to test key hypotheses derived from our theoretical framework. The results give us valuable new insights into forces driving the energy transition.

Fuelwood Consumption

Firewood gathered from forested commons is an important source of domestic energy in rural areas of many poor countries (Cecelski, Dunkerley and Ramsay 1979; Heltberg, Arndt and Sekhar 2000). It has been estimated that more than 2.4 billion people rely directly on traditional biomass fuels for their cooking and heating, and in poor countries biomass use represents over half of residential energy consumption (International Energy Agency 2005). The consumption of fuelwood has a complex interrelationship with deforestation (Heltberg et al. 2000; Rudel 2005). According to recent data, the global rate of deforestation continues to be alarmingly high – about 13 million hectares per year (Food and Agriculture Organization of the United Nations 2005). In recent decades deforestation has come to be perceived as a global problem, because of the perception that the earth's resources are reaching the limits for supporting the world's population and economic systems (Schmink 1994). Deforestation, mainly caused by land clearance for agricultural purposes, depletes

natural forest stocks creating fuelwood scarcity. Fuelwood scarcity can trigger many different feasible responses from households who rely on it. For example households can economize their use of fuelwood by eating fewer cooked meals or eating foods that take less time or fuelwood to cook, they can continue to increase time and efforts to find fuelwood, or they can increasingly purchase fuelwood rather than collect it. Thus although fuelwood demand is unlikely to be the primary cause of world deforestation, continued fuelwood consumption can help to perpetuate the vicious cycle of deforestation in particular localized areas (Arnold, Kohlin and Persson 2006; Kohlin and Parks 2001; Pimentel et al. 1986).

In addition to the scarcity of fuelwood as a crisis per se, deforestation has numerous other harmful consequences such as loss of biodiversity and soil erosion (de Sherbinin, et al. 2007; DeFries, et al. 2010; Heltberg et al. 2000; Palloni 1994; Rudel 2005; Rudel et al. 2009). Also, because women are the main gatherers of fuelwood, the depletion of forests forces women to spend more time looking for wood and search farther from their homes, lengthening their working day (Agarwal 1994). Finally, deforestation exacerbates conditions that could produce global warming, such as the release of carbon dioxide into the atmosphere (Heltberg et al. 2000; Palloni 1994). Therefore the transition from fuelwood to alternative sources of energy is a key transition in how humans affect the environment. Substitution of fuelwood with alternative fuels can reduce pressure on natural forests, because alternative sources of rural domestic energy (such as crop residues, animal dung, wood from trees on the farm, biogas, kerosene, sun and wind power) do not cause forest degradation (Heltberg et al. 2000).

Theoretical Framework

To build a framework guiding our study of the relationship between community-level social change and micro-level energy use choices, we begin by outlining current models of energy transition and micro-level fuel choices. We then integrate these models into recent sociological research on the links between macro-level contextual change and micro-level behaviors.

Household Energy Transition

The “energy ladder” is a commonly used concept in models of domestic fuel choices in poor countries (Alam, Sathaye and Barnes 1998; Campbell et al. 2003; Davis 1998; Hosier and Dowd 1987; Leach 1992). The principal notion underlying this concept is that households face a range of energy supply choices, which can be ordered from least to most technologically sophisticated. Most empirical studies on the determinants of fuel transitions have linked factors such as income, access to electricity, and forest scarcity to fuel substitution (Alam et al. 1998; Campbell et al. 2003; Davis 1998; Heltberg et al. 2000; Madubansi and Shackleton 2007; Ouedraogo 2006).

Although studies of changing household fuel choices are sparse, evidence of the energy transition is mounting. Household energy surveys have found income to be a major determinant of the energy transition (Alam et al. 1998; Campbell et al. 2003; Davis 1998; Ouedraogo 2006). For example, Campbell et al (2003) found that in the four largest cities in Zimbabwe higher income households were less likely to use wood as their primary cooking fuel, switching to kerosene and electricity. Ouedraogo (2006) found that households’ firewood utilization rate decreased with increasing household income in the capital city of Burkina Faso. Access to electricity has been found to be another important determinant of the energy transition (Campbell et al. 2003; Davis 1998; Ouedraogo 2006). However, Madubansi and Shackleton (2007) found that the introduction of electricity into a rural region of South Africa had little impact on fuelwood consumption. Other factors associated with reduced consumption of fuelwood and use of alternative fuels are forest scarcity and

increased fuelwood collection time (Heltberg et al. 2000) and household size (Alam et al. 1998; Ouedraogo 2006). In fact numbers of people, numbers of households, and complex changes over time in the numbers of people per household have each been linked to change and variation in fuelwood consumption (Carr 2003; Carr, et al. 2005; Liu et al. 2003).

More nuanced formulations of energy transition theory suggest that the scenario of households switching from exclusive use of one type of fuel to exclusive use of another is overly simplistic. More accurately, steps on the energy ladder include households using various combinations of fuels. Although the use of biomass fuels may gradually decline from exclusive use by many households towards less use by fewer households, the use of biomass fuels may not be entirely abandoned as households climb the energy ladder (Campbell et al. 2003; Hosier and Dowd 1987). For example, in his analysis of multiple fuel use patterns in South Africa, Davis (1998) found that changes in fuel choice were not a smooth transition from biomass to commercial fuels, but a continual switching between different combinations. He found that while high-income electrified households were more likely to rely on only electricity, low-income households were more likely to rely on four or more fuels even if they were electrified. Therefore, we develop hypotheses regarding the inclusion of non-wood fuels in households' fuel selection, and not the complete substitution of non-wood for wood.

Macro-Level Social Organization and Household Energy Transition

Most economic and sociological studies of energy consumption emphasize factors affecting the total volume of consumption, such as income and household size, as key determinants of the transition from wood-energy to alternative fuels. However, in his innovative theoretical work on environmental sociology, Foster (1999) expands the focus from factors that influence the total volume of consumption to incorporate factors that change the *nature* of consumption as important determinants of environmental quality. Drawing on classical social theory, he identifies the social organization of daily life as potentially critical determinants of the nature of consumption. Our theoretical framework links variations in social organization to fuel choices.

We use the modes of social organization approach (Thornton and Fricke 1987; Thornton and Lin 1994) to aid our understanding of social change and household energy consumption. Building on frameworks which focus exclusively on the mode of production (Coleman 1990; Durkheim 1984; Marx [1863-65] 1981, [1867] 1976; Thornton and Lin 1994), the modes of social organization approach gives consumption, residence, recreation, protection, socialization, and procreation all the same analytic status as production (Axinn and Yabiku 2001; Coleman 1990). Below we summarize the link between social organization and human consumption (for a detailed description of social organization and consumption see Axinn, Barber and Biddlecom 2010).

Historically, most social activities of daily living were organized within the family (Ogburn and Nimkoff [1955] 1976; Thornton and Fricke 1987). Changes in the social context alter the extent to which these activities are organized within family and kinship units (Thornton and Fricke 1987; Thornton and Lin 1994). As new nonfamily organizations and services spread at the macro-level, the social activities of daily life are reorganized at the micro-level so that they increasingly take place outside of the home and family (Axinn and Yabiku 2001; Coleman 1990). One example of this is the shift from making clothes in the home to buying clothes in stores. Another example is the shift from cooking in the home to eating in restaurants. There are many other examples (Coleman 1990; Ogburn and Tibbits 1934). These changes in daily life promote changes in patterns of consumption such that individuals are more likely to consume things which they themselves did not produce. Marx describes this change as a *metabolic rift* – the creation of a gap between natural resources

and the people consuming those resources, causing humans to interact ever more indirectly with the natural resources they consume (Foster 1999; Marx [1867] 1976). Axinn, Barber and Biddlecom (2010) describe this change as a shift from direct to indirect consumption of environmental resources.

Changes in the extent to which social activities are organized within the family can have broad and dramatic consequences (Coleman 1990; Durkheim 1984; Marx [1863-65] 1981, [1867] 1976; Thornton and Lin 1994). Previous research has demonstrated important consequences of change in the modes of social organization for common land use (Axinn, Barber and Biddlecom 2010; Axinn and Ghimire 2011). We hypothesize that access to nonfamily organizations and services will change patterns of fuel use as well.

Applying the Modes of Social Organization Framework

Application of the modes of social organization framework requires knowledge of the starting state of family versus nonfamily social organization and the outcome of interest (Thornton and Fricke 1987; Thornton and Lin 1994). The context-specific consequences of social change depend on these initial conditions. This characteristic of the framework is advantageous compared to existing frameworks predicting fuel use transitions. For example, most fuel transition theories imply that any economic or organizational changes away from subsistence agriculture will produce substitution of higher technology fuels for firewood (Amacher, Hyde and Kanel 1996; Bluffstone 1995; Leach 1992). This unilineal outcome, however, is not necessarily a universal consequence of changes in modes of social organization. For example, in a setting that does not use fuelwood at the starting state, the reorganization of social activities outside the family may actually *increase* fuelwood use, not reduce fuelwood use. Therefore, before predicting the consequences of specific social changes using the modes of social organization framework, we briefly describe the setting and the starting state of energy use.

Setting

The setting for this study is the Western Chitwan Valley located in South-Central Nepal. Because poverty and topographical barriers have delayed the spread of new nonfamily organizations and institutions in Nepal (Blaikie, Cameron and Seddon 1982), the vast majority of social activities were organized within the family up until the recent past (Fricke 1986). Chitwan Valley remained an isolated setting until the late 1970s, when a series of road construction projects transformed one corner of the Valley into the transportation hub of the country. This change produced a rapid proliferation of government services, businesses, and wage labor jobs in Narayanghat that spread throughout Chitwan (Pokharel and Shivakoti 1986). These changes also continued to stimulate the government's investments in agriculture in the region, including heavy investments in irrigation, mechanization, improved seeds, pesticides, fertilizer, and new methods of production and marketing (Shivakoti and Pokharel 1989).

Together these forces dramatically altered the social and economic organization of Chitwan within the lifetimes of its residents. As of the late 1950s, there were virtually no employment opportunities, market places, schools, health posts, or transportation services. Bus service through the valley has given residents access to the wage labor opportunities and commerce of Narayanghat. Commercial enterprises, such as grain mills and new retail outlets, have scattered throughout Chitwan. A wide range of government services, from schools, to health posts, to police posts, have also sprung up. These changes constitute a significant transformation of the local context for the hundreds of small farming communities in Western Chitwan Valley. It is exactly these changes in access to nonfamily organizations

that we expect to transform the nature of energy consumption, away from wood for fuel and toward the use of alternative fuels.

Despite this massive transformation of the local context, most of the valley is still rural and remains predominantly an agriculture-based society. 83% of the households in the study reported that they were growing crops. Rapid population growth and lack of supply of alternative energy sources in Chitwan has caused extensive use of biomass energy sources like fuelwood and agricultural residue. Fuelwood is currently being consumed at rates higher than are sustainable, causing forest encroachment and local environmental degradation (Metz 1990; Pandit and Thapa 2003, 2004; Rijal 1999; Sharma 1991; Varughese 2000). An estimate of supply and demand for Chitwan suggests a net shortage of 326,683 tons of fuelwood for the year 2007 alone (Rijal 1999). Although Nepal has a large economic potential for hydropower generation (42,000 MW), because of the poor economy only about 0.5% of this potential has been harnessed (Sharma 1991, 1996). Thus, in the absence of economically feasible alternative energy sources, residents in Chitwan are likely to continue to rely on biomass energy sources such as fuelwood to meet their energy demands. Community forestry projects and community forest management are both active in Chitwan, but the majority of forest resources in this setting are not governed by such management strategies (Matthews, Shivakoti and Chhetri 2000). Moreover, the high demand for fuelwood has affected community managed areas as well as those managed by other means (Matthews et al. 2000). This heavy demand for fuelwood and other forest products has already had high cost in terms of decreasing plant density in the surrounding forest (Dhital, Paudel and Ojha 2002; Edmonds 2002; Matthews et al. 2000).

Empirical Predictions

In this setting, we expect access to nonfamily organizations and institutions in the community such as markets, schools, health care, and transportation to result in the reorganization of productive, consumptive, residential, recreational, protective, and socialization activities outside the family. As these activities of daily living are reorganized outside the family, we expect households to increase substitution of energy sources from firewood to alternative sources.

Nonfamily employment—We hypothesize that when nonfamily work is available to a community and individuals participate in this work, fuel substitution will increase. If there are no employment opportunities then the opportunity costs for collecting fuelwood may be low. Availability of nonfamily employment may increase the opportunity cost of time to collect fuelwood, and may lead to higher income thereby enabling the purchase of alternative fuel. In fact Bluffstone (1995) finds that a large off-farm wage increase causes households to withdraw from fuelwood consumption and switch to commercial fuels. Additionally, nonfamily employment may expose workers to new ideas encouraging fuel substitution.

Nonfamily consumption—The spread of markets in the community increases nonfamily consumption opportunities, which is likely to affect decisions about fuel substitution. Markets could reshape the cost structure of alternative fuels by lowering their price or by making them more obtainable. At a marketplace individuals may directly compare the costs of fuelwood collection to the prices of goods such as kerosene. Furthermore, at a marketplace individuals may engage in personal contact with sellers of alternative fuels, which may encourage their purchasing decisions.

Nonfamily banking—Greater accessibility of banks redistributes financial investments outside the family and promotes calculated decision making within a monetized

environment. Of course, calculated decision making is not new to the residents of Chitwan. Chitwan is largely an agricultural subsistence economy. These rural Nepalese farmers must be highly shrewd simply to survive—what crops to plant, how much of each, when to harvest. What is new, however, is that the residents of Chitwan have the opportunity to use these decision-making skills in an ever-expanding market, where the medium of exchange is legal currency. With the opportunity to save money in bank accounts or to acquire loans, individuals have the opportunity for their purchasing decisions to stretch over longer time periods than before. This may encourage the acquisition of alternative energy sources.

Nonfamily schooling—Schooling may promote fuel substitution through a variety of mechanisms. If children who are not in school are collecting fuelwood, then their attendance at school may reduce their contributions to the collection of fuelwood. This may encourage parents with children attending school to switch to fuel types that require less collection effort. Schools may also be sources of ideational change, providing new information about alternative fuel consumption technology. Because they are modeled on the British educational system, schools in Nepal may use teaching materials that illustrate alternative fuels as consumption options. With the spread of these ideas, those who have been to school outside the family or simply live near a school may be more likely to switch to alternative fuels.

Nonfamily health care—As government services have spread through Chitwan, many different health care activities have become organized outside the family. Chitwan now has a variety of medical facilities that did not exist less than a generation ago: a hospital, many local health posts and clinics, plus numerous pharmacies. Nonfamily health services may motivate individuals to use alternative fuels by offering educational materials conveying the respiratory hazards created by smoke from indoor cooking.

Nonfamily transportation—Even if nonfamily employers, markets, schools or health posts are not geographically nearby, improvements in community access to transportation may stimulate the reorganization of family life and promote fuel substitution. Availability of transportation affects employment opportunities if the transportation network links the community to the employers. For example, in Chitwan what might have been a three hour walk to Narayanghat may become a short bus ride, and commuting to nonfamily wage labor can now be part of the daily routine for residents of formerly remote communities. Similarly, improved transportation infrastructure allows residents of formerly remote communities to travel to markets, schools or health posts, each of which may increase fuel substitution. Additionally, improved infrastructure may advance the distribution of alternative fuels.

Nonfamily leisure—The introduction of cinema halls, markets selling televisions and radios, and new bars and tea stalls in market places are examples of increased leisure activities located outside the family. These leisure activities allow new ideas to spread and thus may promote the use of alternative fuels. For example, a movie or radio broadcast could provide information promoting clean energy. Furthermore, new nonfamily leisure activities may change cultural preferences or consumption aspirations. Because much of the mass media in Nepal originates in high income settings, this media may directly spread images publicizing modern fuel technologies, motivating fuel substitution.

Data and Methods

Within the Western Chitwan Valley, we examine community change and energy consumption in 151 neighborhoods using measures from the Chitwan Valley Family Study

(CVFS). The CVFS defined a neighborhood as a geographic cluster of 5 to 15 households. Given the rural setting, these neighborhoods contain a group of people who interact personally every day. The CVFS selected an equal probability, systematic sample of neighborhoods in Western Chitwan (Axinn, Barber and Ghimire 1997). The sampling strategy was designed to eliminate national and regional sources of variation by focusing on a single area, yet maximize neighborhood level variations by sampling neighborhoods from a setting with much local variation (Smith 1989).

The CVFS measured neighborhood context with the Neighborhood History Calendar method, which combines archival, ethnographic, and structured interview methods to gather detailed continuous measures of neighborhood change (Axinn et al. 1997; Axinn and Pearce 2006). In 1996 the CVFS also administered a household-level agriculture and consumption survey to 1,580 households in those neighborhoods, and achieved a response rate of 100%. To measure changes in household agriculture practices and consumption, this survey was repeated in 2001 with a response rate of 98%. The sample for this analysis includes 1,352 households that were surveyed in both 1996 and 2001.

Measures of Changing Fuelwood Consumption

The key dependent variable of interest is use of any fuel other than wood to cook with in 2001. This is constructed from the question: “What heating sources do you use in your house for cooking?” followed by a series of yes/no items asking about wood, electricity, gas, biogas, sawdust, kerosene, or other fuel. If the household reported using any fuel other than wood (electricity, gas, biogas, kerosene or another fuel) as a heating source for cooking, our measure is coded 1; if they use only wood or sawdust, it is coded 0.

We use a longitudinal research design to control pre-existing energy consumption in each household. We include in our model a measure of use of any fuel other than wood in 1996 with questions from the baseline agriculture and consumption survey that are identical to those asked in 2001. This strategy of controlling for previous energy consumption allows us to focus on *change* in energy consumption over the five years between interviews. Because the dependent variable in our model is use of any fuel other than wood in 2001, including this control for use of any fuel other than wood in 1996 transforms other measures in the model to predictors of change in fuel wood use between 1996 and 2001.

Of course, there is a substantial history of studying the diffusion of innovations, such as use of alternative energy sources, especially in rural agrarian settings (Rogers 2003). In that area of scholarship diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. Diffusion is a special type of communication in which the messages are about a new idea (Rogers 2003). Thus diffusion is a kind of *social change*, defined as the process by which alteration occurs in the structure and function of a social system. In our research this concept applies to changes in the use of new energy sources, or diffusion of alternatives to fuel wood. Our study measures aspects of this process at a point in time – by controlling for 1996 use of alternatives to fuel wood we examine change in diffusion of use of alternative energy sources between 1996-2001 within levels of pre-existing diffusion as of 1996.

Measures of Changing Community Context

We use information from the Neighborhood History Calendar to construct dichotomous measures of whether each neighborhood has an employer, bank, school, health post, bus stop, or movie theater within a 15 minute walk, and a market within a 10 minute walk.¹ The somewhat loose definition of market enables many services spread throughout the study area to meet the minimum criteria needed to be called a market; thus for this variable we use a

lower distance threshold of 10 minutes. These measures of access to seven key nonfamily organizations are constructed from the neighborhood's distance to the nearest service. For example, respondents were asked whether the nearest employer is within a 15 minute walk of the neighborhood. "Yes" is coded 1; "no" is coded 0. The other measures of community context are coded similarly.

To summarize these seven measures of access to nonfamily services, we construct a composite measure by adding responses to the seven questions about whether each service is within a 15 minute walk (for this composite measure, we use the 15-minute distance threshold for all services including markets). This yields a variable ranging from 0 to 7 which counts the total number of nonfamily services within a 15 minute walk of the neighborhood.²

Household Electric Appliances

The number of electric appliances owned by the household may be an endogenous intervening mechanism linking nonfamily services to use of alternative fuel. We measure household possession of electric appliances in 2001 by constructing a count with a series of dichotomous variables. For example, respondents were asked "Do you have a radio in your house?" This measure is coded 1 if the respondent answered yes and 0 if the respondent answered no. Similar questions were asked about a television, a telephone, a sewing machine, a VCR, a computer, a refrigerator, an electric rice cooker, an electric fan, and an iron. We add responses to these questions, and code the variable so it ranges from 0 to 6 or more.

Controls

In order to properly specify our models, we control for various factors that may be confounders between nonfamily organizations in the community context and the likelihood of use of alternative fuel. We control for cash income because wealthier households are less likely to be constrained by the usually higher costs of non-biomass fuels and therefore more inclined to make the transition to more sophisticated alternatives (Campbell et al. 2003). We construct an ordinal income scale coded from 0 to 5, derived from responses to the question "Thinking about your total household income from all sources, including wages, salaries, pensions, income from selling crops, animals, or goods, income from renting houses, land or equipment, business income, or income from gifts or other payments. Since...(month)...last year, would you say that the total income you received from all sources was 50,000 rupees or less, or more than 50,000 rupees?" After that opening question, respondents were asked follow-up questions to narrow down their total income based on their previous answers. For example, respondents who answered "50,000 rupees or less" to the opening question were then asked "Since...(month)...last year, would you say that the total income you received from all sources was 25,000 rupees or less, or more than 25,000 rupees?" From these responses we construct an ordinal scale with 0 indicating no income, 1 indicating 10,000 rupees or less, 2 indicating between 10,000 and 25,000 rupees, 3 indicating between 25,000

¹An employment opportunity is the nearest employer who employs ten or more individuals for pay. A market place is the nearest location of two or more contiguous shops where goods and services are sold for money, including tea shops. A bank is any institution that has the legal right to operate a financial transaction such as maintaining an account, issuing a check and running cash transaction. A school is the nearest location of nonfamily instruction and socialization aimed at children and youth. This includes religious schools and schools without a physical building. A health post is any facility that provides medical services or supplies, including hospitals, family planning clinics, and pharmacies. Bus service is the nearest location where a resident could board a public motorized vehicle and ride for a fee (including tractors and jeeps). A movie theater is any place that shows big screen movies for business on a regular basis.

²Varying these distance thresholds produces no substantive changes in the interpretation of our results. Lower thresholds of five or ten minutes generally produce slightly weaker effects for most nonfamily services. However, the effects of markets and bus stops increase when we use lower thresholds.

and 50,000 rupees, 4 indicating between 50,000 and 100,000 rupees, and 5 indicating more than 100,000 rupees.

Because much of the Nepalese economy is not monetized, we include another measure of affluence focusing on house plot ownership. We consider this an indicator of wealth because it can be a source of long-term wealth; ownership of a house plot gives residents the opportunity to grow fruits and vegetables for home use and to conduct businesses (such as a small store) that would otherwise require rental property. We measure house plot ownership with a dichotomous variable coded 1 if the respondent reports that the household owns the land on which their home is built and 0 otherwise.³

Generally household size is expected to increase fuelwood consumption because of increased energy demand and increased laborers available for fuelwood collection (Liu et al. 2003). The impact of household size on use of alternative fuels is ambiguous, because greater household size means increased demand for energy but also increased possibility of fuel substitution. We control for household size with a measure of the number of residents of the household age 15 or older, and code this variable so it ranges from 1 to 8 or more. A resident of a household is defined as having eaten or slept in the household for at least three of the past six months at the time of the study.

In addition to the size of the household, the gender composition of the household may have consequences for fuel substitution. Since women tend to be the main gatherers of fuelwood, a household with female laborers available to do the collection may be less likely to switch to alternative fuel. We code a dichotomous variable 1 if the adult population of the household is more than 25% female and 0 otherwise. We also test the interaction between the household gender balance and the number of nonfamily services within a 15 minute walk of the neighborhood.

We include controls for two neighborhood characteristics likely to affect fuel choice. These measures come from the Neighborhood History Calendar. We control for whether electricity is available to the neighborhood, because electrification status among towns has been found to promote fuel substitution from wood to alternative sources (Campbell et al. 2003). A dichotomous variable is coded 1 if the neighborhood has electricity and 0 otherwise. We also control for distance to Narayanghat, the urban center of the Chitwan Valley. We include a continuous variable measuring the number of miles between the neighborhood and Narayanghat, which was computed using GPS.

We expect fuel substitution to be a rational response to increased resource scarcity and increased wood collection time. It has been found that when forests are scarce and collection time for fuelwood is increased, households respond by substituting fuels from private sources for fuelwood (Heltberg et al. 2000). We measure scarcity of nearby forests indirectly, with a retrospective question about wood collection time. At the 1996 baseline survey respondents were asked “Three years ago, how long did it take to travel to the place where the firewood was, collect it, and then bring it home (in minutes)?” We divide responses by 60 so that the variable is coded in hours.

We control for ethnicity because Nepalese ethnic groups are related to key cultural factors affecting the relationship between individuals and their natural environment. This approach is consistent with previous research linking ethnicity and cultural differences to consumption patterns (Lutzenhiser 1993; Lutzenhiser and Hackett 1993; Lutzenhiser, Harris and Olson

³We also estimated the effects of other potential indicators of wealth, including a measure of the number of stories in the house and the household number of livestock. Neither of these measures had a significant impact.

2001). Ethnicity in Nepal is complex, multifaceted, and interrelated with religion (for detailed descriptions of these groups see Acharya and Bennett 1981; Fricke 1986; Gellner and Quigley 1995; Guneratne 1994). We use five dichotomous indicators of ethnicity: Upper Caste Hindu, Lower Caste Hindu, Newar, Hill Tibeto-Burmese, and Terai Tibeto-Burmese. In our multivariate models Upper Caste Hindu status is the omitted category; effects of belonging to the other ethnic groups are relative to this group. The means and standard deviations of these variables are presented in Table 1.

Estimation Technique

We use logistic regression procedures to estimate multivariate models of use of alternative fuel. We report parameters from logistic regression equations in the form

$$\ln [p / (1 - p)] = \alpha + \sum (\beta_k) (X_k),$$

where p is the probability that a household uses fuel other than wood to cook with, $p/(1-p)$ is the odds that a household uses fuel other than wood to cook with, α is a constant term, β_k represents the effects parameters of the explanatory variables, and X_k represents the explanatory variables in the model. Coefficients in a logit model give the change in the log-odds of using alternative fuel for a unit change in the explanatory variables. To facilitate interpretation of the coefficients, we report the exponentiated log-odds coefficients, or the odds ratios, which are interpreted as the amount by which the odds of using alternative fuel are multiplied for a unit change in the explanatory variable. Thus odds ratios equal to 1 represent no effect, odds ratios greater than 1 represent positive effects, and odds ratios less than 1 represent negative effects.

Finally, to examine community level influences on household fuel use we study 1,352 households clustered into 151 neighborhoods. Because of the correlated error structure among households within neighborhoods, we use a multilevel logit model (Goldstein 2003; Raudenbush and Bryk 2002). Recent research demonstrates that this modeling strategy is suitable to these data because it accounts for their hierarchical structure (Barber et al. 2000). That research also demonstrates that the high number of neighborhoods, low number of households per neighborhood, and low levels of spatial autocorrelation in these specific data produce very low levels of within neighborhood correlated error structure (Barber et al. 2000)⁴. Nevertheless, we employ the multilevel modeling approach to insure our results are properly specified for the multilevel nature of these data.

Results

In Table 2 we present models of the overall relationship between neighborhood services and use of alternative fuel. Recall that models treat a 2001 measure of alternative fuel use as the dependent variable while controlling for the same measure from 1996. We include this control so that our models estimate the impact of neighborhood services on *change* in fuel use between 1996 and 2001. Each context measure indicates whether the respondent's neighborhood has that service within a 15 minute walk (10 minutes in the case of markets) in 1996. For example, the odds ratio of 1.39 for nonfamily employment means that respondents who had a wage labor employer within a 15 minute walk of their neighborhood in 1996 have 39% higher odds of using fuel other than wood in 2001 than respondents without nearby employers. These longitudinal measurements provide evidence that having nonfamily employment opportunities nearby reduces fuelwood consumption over time. This

⁴In fact one level models that ignore these clustering issues produce virtually identical results for the specific models presented here.

finding is consistent with our hypothesis that the spread of nonfamily services in the community increases the use of alternative energy sources in the household.⁵

The estimates in Table 2 consistently show that new nonfamily services increase the odds of using fuel that is not wood. The pattern is remarkably strong and consistent. Almost all of these nonfamily organizations and services have a significant positive effect on use of fuel other than wood: employment opportunities, markets, banks, schools, health posts, and bus stops. Schools have a particularly strong effect on use of alternative fuel: respondents who had a school within a 15 minute walk of their neighborhood at baseline have 142% higher odds of adopting alternative fuel use over the following five years than respondents without a school nearby. The only services that do not have significant effects are movie theaters.⁶

As the results show, community context is a key determinant of the transition from fuelwood to alternative energy sources. Hypotheses focused on household fuel choices tend to imply strong effects of income and household size. The findings displayed in Table 2, however, emphasize the significant impact of nonfamily services in the community context on changing household energy decisions. Nonfamily services change household patterns of energy use in a way that increases the substitution of alternative energy sources for fuelwood.

In the last column we present our composite measure, which is simply a sum of seven dichotomous measures, indicating the number of nonfamily services within a 15 minute walk of the respondent's neighborhood in 1996. As expected it too has a significant positive effect on use of any fuel besides wood in the following time period. In fact, because the coefficient is multiplicative, the magnitude of this effect is enormous. For example, respondents with *one* nonfamily service within a 15 minute walk have 34% higher odds of using fuel other than wood than respondents without any nonfamily service nearby. But respondents with all *seven* nonfamily services within a 15 minute walk have 676% higher odds (1.34 raised to the power of seven) of using fuel other than wood than respondents without any of these services nearby. These findings show strong support for our hypothesis that local nonfamily organizations increase households' use of non-forest fuels. These findings are also consistent with our general modes of social organization framework. Access to nonfamily organizations and services alters the social organization of daily life so that many activities occur outside the family. This type of community context promotes the indirect consumption of resources, changing patterns of household energy consumption. The result is increased use of alternative fuels over time.

In these same models, household income has a strong impact on change in use of alternative fuels, also promoting use of fuels other than wood. A greater number of adults in a household has a small positive relationship with use of alternative fuels, and gender composition predicts alternative fuel use independent of household size per se. Households whose adult population is more than a quarter female are less likely to make the fuelwood transition than households with relatively fewer females. This result is consistent with previous literature describing women as the main gatherers of fuelwood. As expected, respondents living in neighborhoods farther from Narayanghat are less likely to use alternative fuels.

We also investigated the possibility of an interaction between our measure of household gender balance and our composite measure of the number of nonfamily services within a 15

⁵These results are consistent with previous research which finds that households with more nonfamily organizations nearby are more likely to purchase fuel rather than collect all of the fuel that they consume (Axinn et al. 2010).

⁶In a separate model we included all seven services. Markets, schools, health posts, and bus stops retained positive independent effects (analyses not shown).

minute walk. This is an interesting extension of the relevance of gender for energy consumption. The result from a model including this interaction term shows that the interaction between a household's adult population being more than a quarter female and the number of nearby nonfamily services has a statistically significant, negative effect on the odds of using fuel other than wood (not shown in tables). This means that the effect of the number of nearby nonfamily services is lower for households with an adult population more than a quarter female. This interesting finding has a sensible substantive interpretation that extends what we have learned about the relationship between gender composition and fuel choice at the household level. Nonfamily services increase the likelihood of using non-wood fuels, but these effects are stronger for households with relatively more male adults. Access to nonfamily services has less influence on households with an adult population that is at least somewhat female, because these females can collect fuelwood no matter what nonfamily services are nearby.

Note that in models of change in non-wood fuel use, the effect of the control for use of non-wood fuel in 1996 is quite large. This is because 1996 to 2001 is a relatively brief time interval, and thus variation in alternative fuel use in 1996 explains a great deal of variation in alternative fuel use in 2001. Thus controls in the model which may affect the level of alternative fuel use are statistically insignificant in these models because they are not predictors of *change* in alternative fuel use. However, the significant effects of nonfamily organizations during this brief time interval highlight the fact that nonfamily organizations in the local community context *are* related to changes in energy consumption.

Also note from Table 2 that ethnicity does affect change in the odds of non-wood fuel use. Lower Caste Hindus and Terai Tibeto-Burmese have lower odds of non-wood fuel use than Upper Caste Hindus, even when household income and size are controlled for. A detailed exploration of the nature of the relationship between ethnicity and domestic fuel use is beyond the scope of this paper. Nevertheless, these results suggest that this relationship may be a fruitful avenue for future research. Moreover, the significant differences among ethnic groups in fuel use confirm our hypothesis that it is necessary to control for pre-existing cultural differences in patterns of interaction with the environment when estimating the influence of social changes on fuel choice at the household level.

In Table 3 we test our model with a measure of electric appliances as a possible intervening mechanism. That is, it may be that a community context with nonfamily services promotes the use of fuels other than wood because this context promotes the use of electrical appliances. To make the comparison more clear, in Model 1 of Table 3 we re-estimate the model presented in Model 8 of Table 2, which shows that the number of nonfamily services has a large influence on use of alternative fuel. Next, Model 2 of Table 3 shows that the household's number of electric appliances has a significant positive effect on use of alternative fuel. As with the coefficient for nonfamily services, the coefficient for electric appliances is multiplicative and thus has a strong effect. For example, respondents whose households have *one* electric appliance have 63% higher odds of using fuel other than wood than respondents whose households do not have any electric appliances. But this variable ranges from 0 to 6 or more with a mean of only 1.7, so even a modest change of *three* electric appliances produces 333% higher odds (1.63 raised to the power of three) of using fuel other than wood than respondents whose households do not have any electric appliances.

Furthermore, Model 2 of Table 3 shows that household number of electric appliances seems to play only a small role in transmitting the effects of nonfamily services. We hypothesized that a reason why nonfamily services increase household use of alternative fuel is because they increase the likelihood of a household acquiring more electric appliances, by granting

the household information about or access to these technologies. Including these two measures in the same model slightly reduces the magnitude of the effect of nonfamily services. In Model 1 households with one nonfamily service within a 15 minute walk have 34% higher odds of using alternative fuel. Once electric appliances are added to the model in Model 2, households with one nonfamily service within a 15 minute walk have 30% higher odds of using alternative fuel. This suggests that the number of electric appliances explains approximately 12% of the influence of nonfamily services. However, the effect of nonfamily services remains large and significant even after electric appliances are controlled. Other intervening mechanisms are likely also at work.⁷

By contrast, as one might expect, ownership of electric appliances does seem to be an intervening mechanism explaining the effect of household income on use of alternative fuel. In Model 1 an increase in one unit of household income results in a 51% increase in the odds of using alternative fuel. Once electric appliances are added to the model in Model 2 the effects of income drop substantially: an increase in one unit of household income results in a 30% increase in the odds of using alternative fuel. This suggests that the number of electric appliances explains approximately 41% of the influence of household income on use of alternative fuel. In other words, income impacts use of alternative fuel partially because income is related to how many electric appliances a household owns. This is consistent with previous literature and with our reasoning that wealthier households are able to afford more expensive electric appliances, thus leading them to transition to alternative fuel.⁸

We also tested household ownership of a gas stove or a gobar gas plant as intervening mechanisms, because improved stoves have been found to reduce household fuelwood consumption (Amacher, Hyde and Joshee 1993; Amacher et al. 1996). However, we found that adding these variables into the model creates a tautology; that is, asking if the household owns a modern stove and asking if the household uses any fuel besides wood is redundant. In fact, less than 1% of respondents report owning a gas stove and using wood as their only heating source for cooking. Therefore including a measure of whether the household owns either a gas stove or a gobar gas plant in the same model with the number of neighborhood services does not yield insight into the mechanisms of why neighborhood services influence the use of alternative fuels.

Clearly we have not captured all the mechanisms that transmit these contextual effects. Unfortunately, exploring the full range of possible intervening mechanisms is beyond the scope of the present study. However, our results may have several conceptual implications for finding the mechanisms that explain how nonfamily organizations increase households' transition toward alternative energy sources. Other nonfamily experiences, beyond those which we have measured here, may be important. Or, other aspects of the nonfamily experiences used in this analysis may capture how they increase use of alternative fuel. For example, the combined amount of nonfamily work experience among household members may transmit the effects of a nonfamily employment opportunity being within a short walk. Finally, it may be that dynamics other than physical experiences are what link changes in community context to the increased use of alternative fuels. Ideational change in

⁷Of course, error in our measurement of electric appliances (such as measuring only a subset of the many possible electric appliances) may also play a role in preventing this variable from being able to explain more of the impact of nonfamily services on use of alternative fuel.

⁸Sometimes when measures of household income are not available in agricultural societies, researchers use measures of standard of living as a proxy for income. Items like the number of electric appliances are commonly included in measures of standard of living. In this analysis, however, we separate out electric appliances from income because we have both measures and because electric appliances are clearly a mechanism affecting energy use. Creating an index incorporating household income and electric appliances does not align with our belief that standard of living is a product of income, not a cause of income.

consumption preferences or consumption aspirations may explain the impact of community context on household fuel substitution.

Discussion

Like dozens of other rural agrarian populations around the world, a massive energy use transition is underway in Nepal. Rural Nepalese live under conditions similar to millions and millions of other poor people in rural Africa and Asia, and particularly similar to rural China and rural India.

This huge portion of the world's population historically used biomass fuels, especially fuelwood, for heating and cooking. That is changing rapidly now, and scientists have new opportunities to better understand the factors promoting this important transition. Our results indicate that in settings like this, increased exposure to nonfamily organizations in the local community has important consequences for change and variation in household fuel choices. Employment opportunities, markets, banks, schools, health posts, and bus stops substantially increase the household's propensity to transition from fuelwood to alternative energy sources. These results clearly point to new nonfamily organizations and services in the local community context as an important factor in households' increasing use of alternatives to wood fuels over time.

The strong empirical evidence we present is consistent with theoretical predictions based on the modes of social organization framework. In this rural Nepalese setting, most of the fundamental social activities of daily life have historically been organized within the family (Axinn and Yabiku 2001), and residents have relied heavily on fuelwood to meet their energy demand. The proliferation of nonfamily organizations and services changes daily life so that more activities are organized outside the family, thereby changing patterns of consumption (Coleman 1990; Thornton and Fricke 1987). As a result, households located closer to nonfamily organizations are more likely to use fuel that is not wood. In fact, this relationship between social change and fuel substitution is net of the conventionally studied relationships among income, electrification and fuel substitution.

The strength of our empirical results also adds to our confidence that this theoretical framework for the study of energy use transitions is an important and useful tool. The framework we propose builds directly on a number of recent contributions to the energy consumption literature (Shove and Warde 2002; van Vliet, Chappells and Shove 2005). This framework focuses on the type of energy consumed rather than the amount of energy consumed. The framework takes an explicitly multilevel and longitudinal approach to understanding this fundamental energy use transition. It identifies the specific dimensions of contextual change – the spread of new nonfamily organizations and services – most likely to reorganize daily life in rural agrarian populations to shape energy use and transitions in energy use. The framework goes on to identify specific mechanisms linking each different dimension of contextual change to change and variation in individual and household consumption behaviors. Because the framework identifies both specific dimensions of social and economic change likely to produce these effects and key mechanisms through which the effects occur, it has broader application than energy use per se. The framework constitutes a useful tool for studying the relationship between macro-level social changes and either individual or household practices in numerous settings characterized by the expansion of nonfamily organizations and services.

The analysis we present also investigates the role of household electric appliances in transmitting the effects of living near nonfamily organizations on the transition away from fuelwood use. We found evidence to support this hypothesis, but this evidence explains only

a small portion of the total effect of nonfamily services on use of alternative fuels. Other possible mechanisms, such as knowledge of fuel choices or attitudes toward different types of fuels, may help to explain the full impact of nonfamily services on fuel substitution. Direct measurement of such ideational factors will be necessary to document these potential mechanisms.

A better understanding of the determinants of households' adoption of alternative energy sources is essential for sustainable development and for informing forest policies in countries where a large fraction of the population is dependent on natural forests for energy (Heltberg et al. 2000; King et al. 2006; Mont and Dalhammar 2005; OECD 2002; Sener and Hazer 2008). The strong effects of nonfamily organizations in the local community context demonstrated here have important implications for policies aimed at reducing deforestation, particularly in contexts in which dependence on firewood for fuel remains high and access to nonfamily organizations remains low. Throughout the world agricultural populations are highly dependent on local resources, especially wood from forests, for a significant portion of their livelihood (Schmink 1994). Increased pressures on tropical forests have become particularly concerning because the soils that support them are usually more sensitive to changes induced by human interference, and less able to recover their productive capability unaided (Blaikie and Brookfield 1987). Our results suggest that policies and projects aimed at preserving remaining forests (e.g. reforestation, stricter rules of access to commons and state forests) might be more effective if implemented in conjunction with policies supporting the spread of new nonfamily organizations. Forest policies might seek to induce substitution away from fuelwood toward alternative fuels by promoting new services in the community.

Finally, this study demonstrates the capacity of social science to contribute to environmental research. Sociology has great potential to advance our theoretical understanding of the links among social organization, social actions, consumption, and the environment (Burkett 1999; Clausen and Clark 2005; Foster 1999; Foster and Burkett 2000). The mode of social organization framework has been a fundamental theoretical tool for studies of family change and demographic behavior (Axinn 1992; Axinn and Yabiku 2001; Thornton and Fricke 1987; Thornton and Lin 1994). We demonstrate the usefulness of this theoretical framework for environmental research as well. This framework is ideal for studying contextual impact on household consumption patterns, because it identifies key types of macro-level contextual changes and explicitly links these multiple changes to individual behavior. On the whole, it is a flexible framework that can generate empirical predictions across a broad set of substantive research areas. The above case study of Nepal illustrates this potential, and yields important insights into the processes linking community context to household fuel substitution. These results are only a starting point for such investigations in this relatively new field. We argue that the theoretical and methodological tools utilized here will prove to be useful in improving models of the connections between humans and the environment.

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Highlights

- We examine the transition from household reliance on fuelwood to alternative fuels.
- Focus on community-level social organization.
- Dimensions of community context shape the transition net of household factors.
- Changes in social organization have the potential to shape changes in energy use.

Table 1

Means and Standard Deviations of Variables Used in the Analyses (N=1352)

<i>Variables</i>	Mean	Standard Deviation	Minimum	Maximum
Use of Any Fuel besides Wood in 2001	0.34	0.47	0	1
Community Context:				
Nonfamily Employment	0.52	0.50	0	1
Nonfamily Consumption	0.65	0.48	0	1
Nonfamily Banking	0.06	0.23	0	1
Nonfamily Schooling	0.90	0.30	0	1
Nonfamily Health Care	0.52	0.50	0	1
Nonfamily Transportation	0.71	0.45	0	1
Nonfamily Leisure	0.03	0.18	0	1
Number of Nonfamily Services	3.53	1.44	0	7
Household Number of Electric Appliances	1.71	1.62	0	6
<i>Control Variables</i>				
Household Income	2.14	1.36	0	5
Household Owns Home Land Plot	0.88	0.32	0	1
Number of Adults in Household	3.75	1.81	1	8
Household Adults more than 25% Female	0.95	0.23	0	1
Electricity Available to Neighborhood	0.33	0.47	0	1
Distance to Narayanghat	9.22	3.74	0.04	17.70
Time to Collect Wood in 1993 (hours)	5.90	3.52	0.08	17
Use of Any Fuel besides Wood in 1996	0.27	0.44	0	1
Ethnic Group:				
Upper Caste Hindu	0.45	0.50	0	1
Lower Caste Hindu	0.13	0.33	0	1
Newar	0.05	0.21	0	1
Hill Tibeto-Burmese	0.15	0.36	0	1
Terai Tibeto-Burmese	0.22	0.41	0	1

Table 2

Multilevel Logistic Regression Estimates of the Effects of Neighborhood Services on Use of Any Fuel Besides Wood in 2001

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Nonfamily Employment	1.39 [*] (1.76)							
Nonfamily Consumption		1.72 ^{**} (2.99)						
Nonfamily Banking			1.80 [†] (1.56)					
Nonfamily Schooling				2.42 ^{**} (2.50)				
Nonfamily Health Care					1.84 ^{***} (3.40)			
Nonfamily Transportation						1.73 ^{**} (2.66)		
Nonfamily Leisure							1.75 (1.21)	
Number of Nonfamily Services								1.34 ^{***} (4.74)
<i>Control Variables</i>								
Household Income	1.50 ^{***} (7.93)	1.51 ^{***} (8.00)	1.49 ^{***} (7.88)	1.50 ^{***} (7.89)	1.49 ^{***} (7.78)	1.50 ^{***} (7.99)	1.50 ^{***} (7.90)	1.51 ^{***} (7.94)
Household Owns Home Land Plot	1.04 (0.16)	1.04 (0.18)	1.06 (0.27)	1.02 (0.10)	1.03 (0.14)	1.05 (0.23)	1.04 (0.19)	1.05 (0.22)
Number of Adults in Household	1.07 [†] (1.60)	1.07 [*] (1.76)	1.06 [†] (1.57)	1.07 [*] (1.66)	1.07 [*] (1.69)	1.07 [†] (1.64)	1.07 [*] (1.65)	1.07 [*] (1.76)
Household Adults more than 25% Female	0.65 [†] (-1.47)	0.65 [†] (-1.44)	0.64 [†] (-1.50)	0.64 [†] (-1.52)	0.66 [†] (-1.37)	0.65 [†] (-1.47)	0.64 [†] (-1.52)	0.68 (-1.28)
Electricity Available to Neighborhood	1.00 (-0.01)	1.06 (0.29)	1.03 (0.12)	1.13 (0.58)	0.96 (-0.21)	1.13 (0.59)	1.02 (0.09)	0.97 (-0.15)
Distance to Narayanghat	0.95 [*] (-1.77)	0.94 [*] (-2.06)	0.94 [*] (-2.27)	0.95 [†] (-1.63)	0.95 [*] (-1.66)	0.95 [*] (-1.84)	0.94 [*] (-2.02)	0.96 [†] (-1.43)
Time to Collect Wood in 1993 (hours)	1.00 (-0.20)	1.00 (-0.14)	1.00 (-0.04)	1.00 (-0.20)	0.99 (-0.31)	1.00 (-0.21)	1.00 (-0.16)	0.99 (-0.30)
Use of Any Fuel besides Wood in 1996	4.40 ^{***} (9.38)	4.45 ^{***} (9.46)	4.37 ^{***} (9.35)	4.46 ^{***} (9.44)	4.38 ^{***} (9.33)	4.20 ^{***} (9.08)	4.38 ^{***} (9.34)	4.23 ^{***} (9.13)

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Ethnic Group: ^a								
Lower Caste Hindu	0.38*** (-3.87)	0.40*** (-3.71)	0.39*** (-3.77)	0.40*** (-3.70)	0.34*** (-4.23)	0.39*** (-3.84)	0.39*** (-3.76)	0.35*** (-4.24)
Newar	1.07 (0.22)	1.09 (0.28)	1.07 (0.21)	1.08 (0.25)	0.95 (-0.17)	1.07 (0.23)	1.10 (0.29)	0.99 (-0.02)
Hill Tibeto-Burmese	1.11 (0.48)	1.17 (0.76)	1.08 (0.34)	1.14 (0.63)	0.99 (-0.05)	1.08 (0.37)	1.06 (0.29)	1.01 (0.06)
Terai Tibeto-Burmese	0.19*** (-6.54)	0.18*** (-6.90)	0.18*** (-6.68)	0.21*** (-6.11)	0.18*** (-6.84)	0.20*** (-6.40)	0.19*** (-6.56)	0.19*** (-6.77)
N	1352	1352	1352	1352	1352	1352	1352	1352
-2 Log-Likelihood	6504.1	6504.6	6491.1	6523.1	6527.4	6503.3	6497.0	6537.3

Note: Numbers in parentheses are t-ratios

^aReference Group is Upper Caste Hindu

† p<.10

* p<.05

** p<.01

*** p<.001 (one-tailed tests)

Table 3

Multilevel Logistic Regression Estimates of the Effects of Neighborhood Services and Electric Appliances on Use of Any Fuel Besides Wood in 2001

<i>Independent Variables</i>	Model 1	Model 2
Household Number of Electric Appliances		1.63 *** (9.18)
Number of Nonfamily Services	1.34 *** (4.74)	1.30 *** (4.23)
<i>Control Variables</i>		
Household Income	1.51 *** (7.94)	1.30 *** (4.82)
Household Owns Home Land Plot	1.05 (0.22)	0.86 (-0.63)
Number of Adults in Household	1.07 * (1.76)	0.99 (-0.13)
Household Adults more than 25% Female	0.68 (-1.28)	0.65 † (-1.42)
Electricity Available to Neighborhood	0.97 (-0.15)	0.79 (-1.17)
Distance to Narayanghat	0.96 † (-1.43)	0.95 * (-1.99)
Time to Collect Wood in 1993 (hours)	0.99 (-0.30)	1.01 (0.30)
Use of Any Fuel besides Wood in 1996	4.23 *** (9.13)	3.47 *** (7.62)
Ethnic Group: ^a		
Lower Caste Hindu	0.35 *** (-4.24)	0.46 ** (-3.06)
Newar	0.99 (-0.02)	0.79 (-0.75)
Hill Tibeto-Burmese	1.01 (0.06)	1.03 (0.12)
Terai Tibeto-Burmese	0.19 *** (-6.77)	0.25 *** (-5.59)
N	1352	1352
-2 Log-Likelihood	6537.3	6703.8

Note: Numbers in parentheses are t-ratios

^aReference Group is Upper Caste Hindu

†
p<.10

*
p<.05

**
p<.01

p<.001 (one-tailed tests)