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Original Research

Determinants of Rural Household Energy Choices: An Example from Pakistan

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Abstract

'Multiple fuels-multiple choice' is a common notion associated with the energy choice theory. Following the same theoretical framework, this study aims to identify:

(i) existing sources of energy

(ii) the associated factors that determine a household choice of a particular source of energy.

The study is based on primary data collected from 100 randomly selected households in two villages in northwest Pakistan. The study found that rural households, though having access to multiple sources of energy, persistently depend on biomass fuels for domestic energy consumption. Nonetheless, rural households exhibit inter-fuel switching according to changes in their socioeconomic conditions. The study concludes that income is not the only determinant of transition from traditional to more convenient forms of energy, other factors such as access to alternative energy sources and consumer preferences also account for a household energy choice.

Keywords: energy choice, energy-ladder, fuel-switching, fuel-stacking, Pakistan

Introduction

Providing clean and affordable energy for household consumption in rural areas, essential for poverty alleviation [1], is a major contemporary problem facing developing countries. That is why global energy policies increasingly focus on developing sustainable and renewable energy (RE). Besides a highly effective means of conserving energy, RE also contributes to reducing carbon emissions and decelerating climate change. Hence, in recognition of the importance and sensitivity of worldwide energy issues, continuous efforts are being made to develop RE-based sustainable energy policies [2]. However, the energy sector, particularly in developing countries, is characterized by uneven distribution of modern energy supplies coupled with widespread inefficient use of traditional biomass fuels. Lack of access to modern and convenient energy services affect as much as 90% of the population of many countries [3]. About 2.5 billion people worldwide depend on woody and non-woody (dung, agricultural waste, twigs and shrubs) biomass fuel and coal for cooking, heating space, and lighting purposes [4-9]. Similarly, 1.6 billion people today are without electricity [10, 11]. This is a serious threat to achieving the Kyoto Protocol's objectives of emissions reduction and sustainable development in developing countries.

Incessant reliance on biomass fuels is common in the developing world. The intensity of biomass use, however, increases in areas where people have relatively low income levels and live close to forest. Although biomass fuels provide an easily accessible and affordable source of domestic energy to rural populations in developing countries, its combustion poses several environmental and health-related hazards. About 3% of the global burden of diseases is caused by indoor pollution, which results in 1.6 million premature deaths every year, including 0.9 million children

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under age 5 [12-15]. Millions more face other problems such as chronic respiratory diseases, asthma, breathing difficulties and wheezing, reduced lung functions, stinging eyes, sinus problems, and low-birth-weight babies [16-21].

In addition to the health hazards, several social and economic problems are also associated with the use of biofuels, particularly in inefficient ways[1]. The drastic effects of biomass use are often graver for the most vulnerable groups in a society, i.e. women, children, and low-income groups [8, 22, 23]. Studies have shown that women in developing countries spent a considerable time on fuelwood collection [22, 24]. Women in Pakistan sometimes spent up to 6 hours per day collecting fuelwood [25]. Likewise, extra physical and financial efforts rendered to post-cooking cleaning and washing are among other notable repercussions of biomass fuels. This reflects on the higher opportunity cost of fuelling practices in rural areas of developing countries.

While it is explicitly evident that inefficient fueling practices have emerged as a significant threat to the environment, quality of life, and human health, the question remains what makes people choose a particular source of energy in rural areas? A vast literature contributes to household energy choices in the developing world [1, 26-29]. The underlying fuel choice theory explains the determinants of household fuel choices in detail.

Household Fuel Choice: A Theoretical Perspective

Energy shortage, global warming, and climate change are among important issues confronting governments and development agencies worldwide. Consequently, there is a shift in government policies to increase energy efficiency and to develop low-carbon economies. Hence, the development of renewable energy (RE) is deemed an increasingly important source of alternative energy. Nonetheless the development of RE technology is constrained by high R&D cost, long-term planning processes, and high investment risks and uncertain returns [30]. These limitations thrust developing governments to reliance on provisions of traditional energy carriers to their populations.

Household fuel choice theory is often based on the 'energy-ladder' model [31] and the associated notion of 'fuel-switching.'[2] This model places heavy emphasis on income in explaining fuel choice [32, 33]. Based on household income, a household energy choice undergoes a linear-three-stage switching process [34]. The first stage of this process is marked by large dependence on centuries old biomass fuels. The second phase is a 'transition phase' involving the use of kerosene, coal, and charcoal. The last stage of the model, use of LPG, natural gas, or electricity, is a function of the increased economic prosperity of a household [15].

The simple nature of this model placing emphasis on wealth and substitution is criticized by a number of studies [27, 35, 36]. These studies have provided evidence that rural households often do not fully ascend the 'energy ladder' but rather prefer 'fuel-stacking,' which means traditional fuels are not completely discarded with an increase in income, but rather are used in conjunction with modern fuels. There is also growing evidence that determinants other than household income, distance of the household from biomass sources [37, 38], increased availability of fuelwood [39], and fuelwood shortage as result of deforestation [40] may also be important determinants of household energy choices.

It is worthwhile to consider the exceptions from the general energy model. In rural areas of many developing countries, a large number of well-off households who in principle could afford modern and convenient forms of energy continue to rely fully or partly on traditional biomass fuels [31]. A number of factors, such as family size and the good taste and texture of food cooked with fuelwood, are taken into consideration for this very choice.

The latest form of the household energy choice theory, therefore, suggests that income, although important, is not the only factor determining a household's particular energy choice. A multitude of other factors, both on demand and supply side of household energy, are also important factors influencing household fuel choice. For example, Lee and Shih [2] reported that public policies for sustainable energy must enact systematically devised legal and regulatory mechanisms in order to accelerate supply and reduce demand of various forms of energy. The present study is an effort to establish a framework of the consumer energy choices in rural northwest Pakistan. The qualitative nature of the study could further be used as a guideline to establishing a potential formal model of household energy choices in rural areas. The type of study may be replicated quantitatively following the models and frameworks such as an options-based policy evaluation framework [2], real-option model [30, 41, 42], and a multi-logit model for fuel shifts in the domestic energy sector [26].

Research Problem

Pakistan is an energy-deficient country [43]. Electricity from the national grid and natural gas reserves are not sufficient and affordable, particularly for the relatively low income rural population. However, studies such as Lee and Shih [44] provide empirical evidence of improved short-term predictions of power generation costs. The work presents a novel gray-based cost efficiency (GCE) model that integrates the gray forecasting model into a two-factor cost efficiency curve model for renewable energy (RE) technologies and identifies the optimal forecasting model for the power generation cost of RE technologies in Taiwan.

[1]Inefficient use of biomass implies practices of biomass use and not the biomass itself. It means using cooking devices with high biomass consumption, low per-unit energy production, and increased emissions of smoke and particulate matter.

[2]Simply defined as the choice between traditional solid fuels and modern non-solid fuels. Fuel switching implies choosing one energy source that displaces the fuels used hitherto [31].

The analytical framework of the proposed GCE model can be applied during the early developmental stages for RE technologies. The same model can be adopted to improve energy costs in the already energy constrained economy of Pakistan.

The energy supply situation in Pakistan is more adverse in the case of petroleum-based fuels for their high prices. This has forced people largely to depend on traditional biomass fuels to satisfy their domestic energy needs. Like other rural areas in developing countries, multiple sources of energy are available to the local population. However, inter-fuel switching is quite slow in rural areas in Pakistan for a variety of reasons. The major aim of this study is to explore the factors that contribute to household energy choices in the research area.

The study was carried out with the following specific objectives.

1. To study the patterns of energy consumption in the area.
2. To identify the available alternative energy sources in the area.
3. To pinpoint the existing barriers in switching to cleaner energy options in the area.

Survey Design and Data Sources

The study was conducted in two villages in Swat District of Khyber Pakhtunkhwa Province in Pakistan. The socioeconomic characteristics, demographic structures, topographic conditions, land tenure system, livelihood structures, and living conditions are almost the same in all neighboring villages of Swat. Therefore, the findings of the study could potentially be generalized to all villages in the area. The data for the study was collected from selected households in the area. Semi-structured questionnaires were administered to collect primary data. The questionnaire was pretested at the outset of the fieldwork, and information pertaining to some important aspects of energy consumption was included. The questionnaire principally focused on information such as the socioeconomic characteristics of the people, energy consumption patterns, available energy sources in the area, and the barriers in switching from one to another form of energy. The data was analyzed using SPSS (ver. 16). The descriptive analysis of the data highlights the percent distribution of households having access to a particular energy carrier, factors accounting for 'use' or 'no use' of a particular source of energy, and perception of the communities about choice of a particular source. From each village, 50 households were randomly selected for interviews. Due to the social barriers and strict observance of pardah[3] in the area, the interview was restricted to male respondents only. The overall sample size for the study was 100 households. In order to ensure validity and reliability of data, some important secondary information was also collected from the local political leader and NGOs working in the area.

Results and Discussion

In this section, a brief discussion is provided about the available energy sources in the research area, determinants of the use of a particular source, and potential barriers to use other alternatives available in the area.

Access to Various Energy Sources

Rural people in developing countries have access to multiple energy sources such as woody and non-woody biomass, coal, charcoal, LPG (liquefied petroleum gas), CNG (compressed natural gas), LNG (liquefied natural gas), and kerosene [15, 32]. People use one or more of these fuels for domestic purposes like cooking and boiling water, space heating, and lighting. This research depicted that biomass, electricity, and gas (LPG) were the major sources of energy available in the area (Fig. 1). However, detailed analysis of energy consumption in the area found that utilization of electricity and gas was very limited. Although 98% households had access to electricity from the national grid, its use was limited to use of gas as a function of improved economic conditions of a household only for lighting purposes for its high tariffs. The use of gas was limited for its low availability. Therefore, people primarily relied on woody biomass fuels for domestic consumption purposes (Fig. 2).

Utilization of Different Sources of Energy

The use of multiple sources of energy is common in rural areas worldwide [31]. Fig. 2 illustrates a village's wise consumption of a portfolio of energy sources. In Barkaley, for instance, 78% households used woody biomass for cooking, whereas 74% used the same for space heating. These statistics, however, do not portray the intensity and frequency of biomass use for a particular purpose. Out of the total households, 34% and 20% used gas together with biomass for cooking and heating, respectively. An important cultural factor of using biomass for cooking was the taste and texture of food associated with biomass cooking.

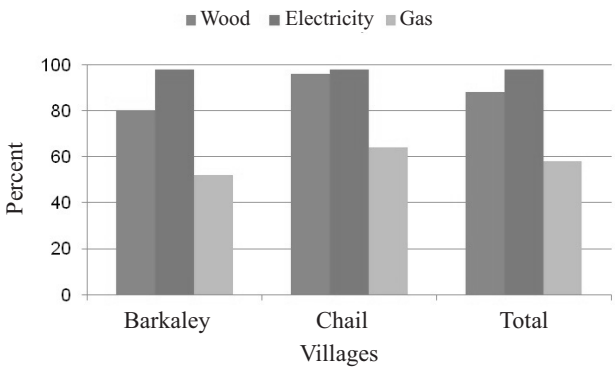

Fig. 1. Access to different sources of energy in rural northwestern Pakistan, 2010.

[3]The social as well as religious obligation that keeps women segregated from men [45]. The observance of Pardah is very strict in the Pakhtun society living in the research area.

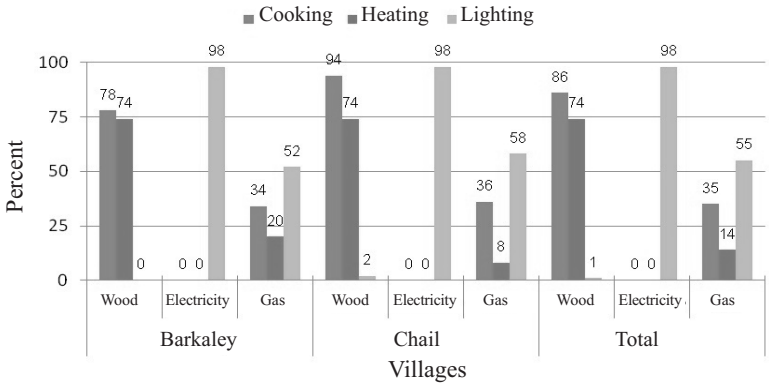

Fig. 2. Village uses of different sources of energy in rural northwestern Pakistan, 2010.

The figure further reveals that almost all people in the area had access to electricity. Nonetheless, electricity was exclusively used for lighting purposes, as reported by 98% of households. In addition, another 52% noted the use of gas for lighting purposes. It is worth mentioning that the study was conducted immediately after devastating floods in the area, so that the higher percentage of respondents using gas for lighting was because of the disruption of electricity due to floods. In normal days when the electric supply will be restored, the proportion will fall to as low as zero. The situation in Chail and the overall area was almost the same, as is clear from the figure below. This shows that in the research areas, as in case of many developing countries, rural populations use biomass primarily for cooking purposes because of its accessibility and affordability [25, 46, 47], and electricity for lighting due to its superior lighting [31, 48]. In the case of improvement in household economic conditions, gas is preferably used for cooking because of its 5-10 times more cooking efficiency than biomass fuel [3, 15].

Determinants of Biomass Use

Biomass constitutes a major portion of energy consumption by rural people in developing countries. A number of factors – although varying in different socio-cultural and economic circumstances – contribute to the increased use of biomass in these areas. A large proportion of the population in the research area reportedly use biomass for its

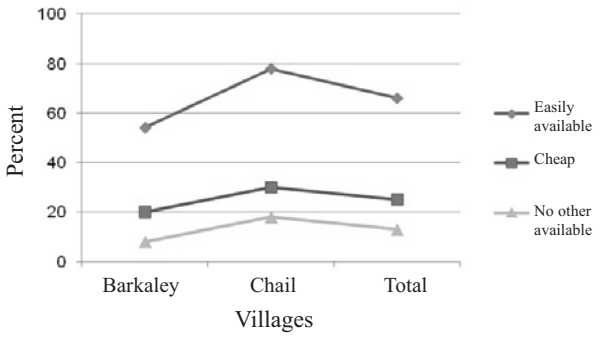

Fig. 3. Reasons for biomass use in rural northwestern Pakistan, 2010.

'easy availability'. Fig. 3 provides the village-wide comparison in this connection. The figure shows that 54% of respondents in Barkaley noted this reason as compared to 78% in Chail. The second important reason for biomass use in the area, as confirmed by 25% of the population, was its 'low cost.' Similarly, 13% responded that they use biomass because of availability of no other alternatives. Nevertheless, it reflected on respondents' personal perception, which was based either on their limited knowledge about other sources of energy in the area or their inability to access them. On the real grounds, however, alternative fuels such as gas was available in the research area.

Alternative Energy Sources in the Area

The availability of multiple energy sources is often common in rural areas. People shift from one source to another with increasing income. This section is based on knowledge of the respondents about alternative energy sources available in their areas. As is clear from Fig. 4, a total of 70% of households recorded that gas was the only alternative available to them. Another 17% confirmed that no alternatives were available in the area, whereas 13% reported that both gas and electricity was available. The 'no alternatives' response reflects on the personal perception of the respondents, who perhaps had no access to the resource.

What Determines Preferences for a Particular Source of Energy?

Fig. 5 indicates that almost all respondents in the research area opted for gas as the best alternative source available to them. Their response was based mainly on three reasons: efficient cooking, availability of gas, and gas being pro-environment. Most of the respondents were aware of the relatively clean nature of gas so that 58% of households preferred gas for its 'environmental impacts.' Since GHG emissions from gas are comparatively lower than biomass fuels, the respondents preferred gas for this very reason. Another main reason for gas preference was its efficient cooking. A total of 32% preferred gas because of its 'efficient cooking.' Similarly, 10% preferred gas for its 'easy availability.' However, availability of gas in the required quantity was a serious concern to the communities.

Main Barriers to Using Gas

Availability of multiple energy sources to populations in rural areas is not as serious a concern as their inability to switch to a particular efficient source of energy. In the research area, although gas was available to the population, its use was limited for a number of reasons. Fig. 6 highlights the main barriers to use gas in the research area. The figure clearly illustrates that a large number of respondents reported 'unavailability' as the main barrier to use gas. The unavailability in this case, however, refers to the lack of enough quantity required to meet the needs of the local population. A total of 53% respondents reported that they do not use gas for its limited supply in the market. Similarly, 42% responded that the main barrier to adopt gas was its 'cost'. Only 5% of respondents confirmed that there were 'no barriers' to use gas as a source of energy. These were, however, the households that were already using gas for cooking and lighting.

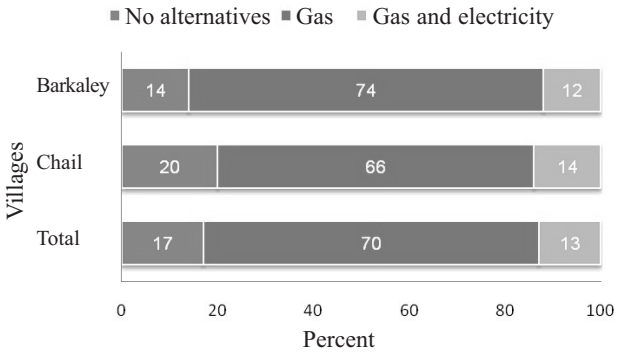

Fig. 4. Availability of alternative energy sources in rural northwestern Pakistan, 2010.

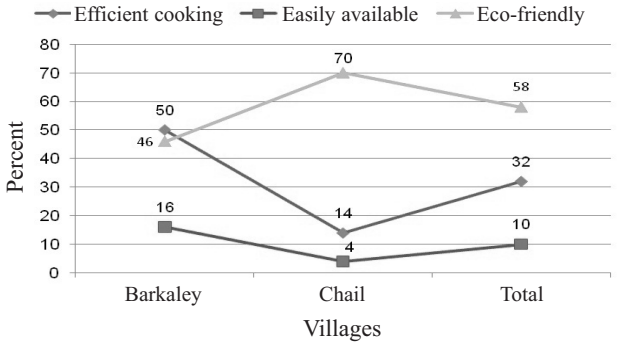

Fig. 5. Determinants of gas being the best alternative source of domestic energy in rural northwestern Pakistan, 2010.

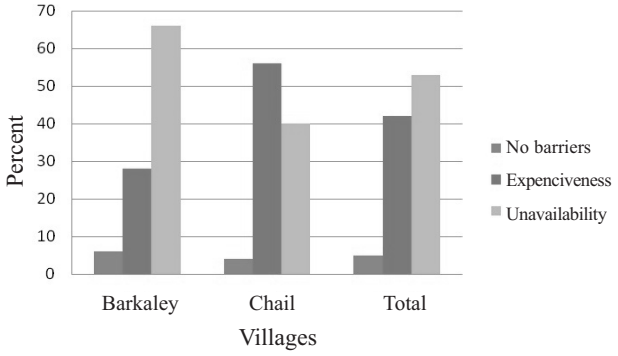

Fig. 6. Barriers to using gas in rural northwestern Pakistan, 2010.

Conclusions

This paper, based on the underlying theoretical framework of the energy choice theory, provides an overview of the determinants of a household's choice for inter-fuel transformation in Pakistan. The main findings of the study reveal that rural households in the area have access to multiple sources of energy. However, the adoption of efficient sources of energy depends on socioeconomic factors of the population. It was observed that a large proportion of the population uses traditional biomass fuels for cooking and heating and electricity for lighting purposes. Besides, a majority preferred gas over biomass fuels for being efficient and environmentally friendly. However, the use of gas was limited due to its availability. The study provides empirical evidence that rural people do not fully ascend the 'energy-ladder' but rather prefer 'fuel-stacking,' which means that traditional fuels are not completely discarded with an increase in income, but rather are used in conjunction with modern fuels [35].

Our paper provides a foundation for some solid policy implications. While developing and extending modern energy supplies, energy strategy in the area may be designed to make production and use of traditional energy more sustainable and efficient. To improve the energy situation, quality of life, and alleviate local environmental problems in the area, government and non-governmental organizations (NGOs) may continue to finance sustainable ways of producing and consuming biomass fuels. Moreover, not only markets for gas and renewable energy technologies may be strengthened but also consumer preferences be taken into account while formulating energy transformation policies. There is also a need for local institutional building for long run policy development.

Beside a useful effort to provide important policy implications, the study encountered some limitations. Due to some social limitations in the field, the interview was restricted to male respondents only. The qualitative nature of the study poses another serious limitation. However, the study may be improved if replicated quantitatively using formal models of energy choices in the research areas as well as in other rural areas of developing countries.

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