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Reducing energy poverty through increasing choice of fuels and stoves in Kenya: Complementing the multiple fuel model

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ABSTRACT

Energy transition theory and its applications in energy policies and development interventions are dominated by the traditional theory of the energy ladder. The linear model predicts a positive relationship between socio-economic development and transition to more efficient, cleaner, and costly energy sources. This study demonstrates, however, that households do not follow the projected patterns. Instead, fuel and stove diversification is observed. Households use various energy carriers, modern and traditional, and devices to secure a continuous energy supply and counteract potential access and availability issues. Multifaceted demands of the households are an important driver of the diversification. Preference often concurs with the most efficient and best available stove and fuel for a particular task. Individual characteristics and social and cultural tradition influence the final choice. Therefore, broadening the range of available and accessible stove designs and fuels will help households to achieve energy security and greater efficiency in their consumption.

Introduction

Dependency on traditional biomass fuels such as firewood and charcoal as well as agricultural waste for various tasks such as cooking, lighting, or space heating is high in many developing countries (IEA, 2011; WHO, 2008; World Bank, 2011). Multiple links between energy consumption and the environment, human health, and poverty make it crucial to understand how people choose to adopt or reject a particular energy source (Modi et al., 2005). Insights in energy-related decision-making at household level are vital to build policy and technical interventions to effectively improve living standard, energy access and energy security in developing countries.

The dominant approach on which governmental and non-governmental activities are often based is the energy ladder model (e.g. Barnes and Floor, 1996; IEA, 2011). The linear model predicts a positive relationship between socio-economic development and adoption of and transition to more efficient, cleaner, and more costly energy sources. It implies complete transition from one fuel to another. The energy ladder model can be characterized by three stages: The lowest step is distinguished through the universal combustion of biomass in form of agricultural residues, dung and wood; the second phase is defined by the shift to so-called transitional fuels such as charcoal or kerosene; the adoption of 'clean' energy forms like LPG, natural gas, or electricity constitute the final step on the energy ladder model. The consumers are assumed to have inherent preferences for fuels types according to physical characteristics such as cleanliness, ease of use, cooking speed and efficiency as well as fuel costs (Akabah, 1990; Hosier and Kipondya, 1993; Leach, 1992; Reddy and Reddy, 1994).

Reality is more complex than what the energy ladder model predicts. Rather than a complete transition to increasingly modern fuels, households have been shown to diversify their energy consumption and utilize multiple fuels simultaneously from all levels of the energy ladder (e.g. Hiemstra-van der Horst and Hovorka, 2008; Pachauri and Spreng, 2003). The 'multiple fuel model' gives a set of factors that together explain why energy diversification may be a rational option for households (Masera et al., 2000). Different fuel or stove types are selected for a particular task due to their individual characteristics in terms of cost-effectiveness and efficiency (Evans, 1987; Martins, 2005; Tinker, 1980). Foster et al. (2000) use the multiple fuel model to develop the concept of '*different energy ladders for different types of applications*'. Energy diversification is not limited to cooking fuels. Information, communication and entertainment technology, lighting, and security are examples of end-uses that drive the demand for new energy carriers. Barnes and Floor (1996) suggest that 'broadening the range of energy technologies' could be an option for enhancing energy supply in rural developing countries. Energy use in different applications and for different end-uses is closely linked with human development (Modi et al., 2005).

According to PwC (2012) biomass energy accounts for around 70% of all energy consumed in Kenya. Overall, the average per capita energy consumption in 2008 was stated to be around 80 kg oil equivalent (UNdata, 2012). While around 95% of rural homes are reported to have access to kerosene and around 90% of whom use this fuel for

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lighting, grid electricity is available to only 13% of Kenyan homes — 45% of urban but only 3% of rural homes (HEDON, 2010). Countries such as Kenya have been subject to policies oriented towards enhancing energy access for several decades, and lessons learned suggest the importance of understanding locality, culture and existing consumption patterns and options prior to development interventions (Murphy, 2001; Sesan, 2012).

Energy development activities in Kenya include three regions where the German Gesellschaft für Internationale Zusammenarbeit (GIZ, formerly GTZ) are disseminating improved cook stoves (ICS). A range of stove options are available, both improved and traditional, which are optimized for different fuels. Technologies and energy carriers for lighting and communication are also increasingly accessible. Investigation of how people with different household characteristics choose and use energy in a semi-rural context with a range of needs and options available is pertinent. This is a context in which many of the world's energy poor find themselves.

The objective with this paper is to contribute new knowledge to contemporary theory on energy transition in developing countries by building on empirical evidence from Kenya. A survey among 320 households in rural and semi-urban areas makes the empirical basis for testing a new explanatory model for household decision-making related to overall energy use, combining technology adoption theory and the multiple fuel model.

Theoretical framework

The multiple fuel model is increasingly embraced as reflecting reality better than the linear energy ladder in countries as diverse as India (Pachauri and Spreng, 2003), Botswana (Hiemstra-van der Horst and Hovorka, 2008) and Mexico (Masera and Navia, 1997). Leach (1992) and Hosier and Kipondya (1993) indicate that in particular lower level fuels are kept for energy security reasons in the event of supply shortage or high prices of the preferred fuel. While income has an impact on the fuel choice, it is not the major factor but rather one of several motivations which together explain why many people decide to use multiple fuels (Campbell et al., 2003; Davis, 1998; Ezzati and Kammen, 2002; Soussan et al., 1990).

Masera et al. (2000) investigate what influences decisions at household level on energy use in situations of uncertainty and scarcity. The resulting multiple fuel model gives a rationale for energy diversification by integrating 1) economics of fuel and stove type and access conditions to fuels, 2) technical characteristics of cook stoves and cooking practices; 3) cultural preferences; and 4) health impacts. In contrast to the multiple fuel model which focuses on uncertainty and scarcity as the contextual features set as pre-conditions for utility, the emphasis in this paper lies in how multifaceted demands of households represent drivers of the multiple fuel and stove use in a context where different fuel and stove options are available. Rather than viewing multiple fuel use primarily as an indicator of household vulnerability, it emphasizes the positive contribution that availing multiple cooking options may have.

Materials and methods

Study locations

In Western, Central, and Transmara regions of Kenya (see Fig. 1) GIZ has undertaken a variety of programs in the field of sustainable development, including dissemination of improved cooking stoves. The three regions have high population density, high rates of poverty, as well as increasing woodfuel scarcity.

The ICS disseminated by the GIZ use primarily traditional biomass fuels but exhibit much higher resource-efficiency allowing savings of up to 50% of fuelwood compared to the traditional three-stone fire (GTZ, 2007). Since 1983 the GIZ has focused on promoting a commercial approach to stove activities at all levels: production, marketing and installation. Local entrepreneurs are trained as independent stove producers. Stoves such as the Jiko Kisasa, Fireless Cooker and Rocket Stove are all made of local materials. In addition to the ICS, Improved Cooking Tips are distributed illustrating advices how to cook efficiently in order to save further energy, time, and money (Häcker and Treiber, 2012).

Transmara region is marked by high shortage of firewood. Trees are cultivated inside private compounds. The local forest consists mainly of small bushes, but of good quality wood. Women collect or buy bundles of firewood or tins of charcoal from neighbouring farms. Despite the proximity of Kakamega forest in Western region, the availability of free firewood is limited to the household's own compound due to strict laws prohibiting tree cutting within the forest reserve. Nevertheless, illegal cutting and wood collecting is an issue. Trees are scattered in compounds in Western region. In Central region, many trees are planted in the individual compounds assuring the households a stable supply of firewood. Additionally, firewood and charcoal are also bought at the nearby shopping markets.

Fieldwork was undertaken from September 2011 to March 2012. From each of the three previously described regions one 'rurban' and one rural location was selected by systematic random sampling. Rurban is here defined as a semi-urban area between an urban and rural region, featuring a certain size, distance from and degree of connectivity to a major trading centre and tarmac road. The six selected locations include Shidodo and Shiasava in Kenya's Western region, Gatuya and Kamuiru in Central region, and Boronyi and Kipsingei in Transmara region (Treiber, 2012).

Data collection and analysis

The research used a dominant-less mixed methods approach (Johnson and Onwuegbuzie, 2004), including structured household questionnaires, location profiles, in-depth semi-structured interviews with households and institutions, and direct observation. The household survey with structured questionnaires among 320 randomly selected households was stratified across the six selected locations. For analysis questionnaire data were triangulated against location profiles, in-depth semi-structured interviews (15) and direct observation.

Sample size was determined to ensure a representative sample (confidence level >95%) out of the total population in the three regions using Raosoft Inc. (Raosoft Inc., 2004). A representative sample was obtained by following the 'random-walk sampling principle' (Hoffmeyer-Zlotnik, 2003; UN, 2005).

Quantitative data were processed in SPSS statistical software for analysis 17.0 (IBM, 2014). Table 1 shows the sample distribution for the household survey. Rurban–rural distribution of total number of sampled households was 49.1% to 50.9%; 'no-response' was ~30%. Statistical methods applied to analyse the data are descriptive statistics, ANOVA and Tukey's Honest Significant Difference (HSD) *post-hoc* test.

Research design and data collection were done in collaboration with GIZ, and included use of the organization's field staff as enumerators.

Results

Energy diversification

The household energy use patterns observed among the participants in the study give a relatively consistent picture across the three regions. Table 2 illustrate the diverse use of the individual energy carriers by households for the total sample and the sub-categories rurban/rural. Batteries are common due to the ubiquity of radios, flashlights and mobile phones. The use of the basic biomass fuels is widespread: firewood for example is used by 97% of the sample. A similar picture is drawn for kerosene, a fuel mainly used for lighting purposes and only rarely for cooking, used by 96%.