Fuel and stove diversification in the light of energy transition and technology adoption theory

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FUEL AND STOVE DIVERSIFICATION IN THE LIGHT OF ENERGY TRANSITION AND TECHNOLOGY ADOPTION THEORY

August 2012

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DECLARATION

I, Michael U. Treiber, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Weimar, 12 August 2012

ABSTRACT

In energy transition theory the dominant approach is the energy ladder model which emphasizes household's income as major driver and implies a complete transition from one fuel to another. In reality, however, households diversify their energy consumption and utilize a variety of fuels simultaneously. Social, cultural and individual characteristics have been identified to play a crucial role in household's fuel choice. Despite these notions, no alternative model has been developed for interpreting and understanding energy transition and associated technology adoption that incorporates these forces.

This thesis proposes a framework illustrating the dependencies driving fuel and stove adoption and explaining the multiple fuel and stove approach whereas a second model pictures the process of adoption by households. The underlying assumption of these frameworks - the intended task's nature and context determine stove and fuel choice and that hence the multifaceted demands of the households are the major driver fuel diversification - has proven to be the case for the particular study area in three regions in Kenya. Most households own and use a variety of different fuels for a particular task but have in every case a preference for a particular one. Energy security was often stated to be an important reason for such fuel diversification. However, context and situation of the fuel and stove use was much emphasized to shape the stratum of potential fuels and stoves and proves the assumption of task dependency. Households strive to be prepared for every situation and context where different fuels have to be applied. The effect of income was found to be rather about the quantity of energy consumed and not about its quality. Availability and access to a particular stove and fuel have been identified to play a much greater role. Cultural and traditional issues such as local cuisine are demonstrated to highly influence the stove and fuel choice while personality traits such as age or education were not found to be statistically relevant but are assumed to have a certain weight on household's selection.

Keywords: *Energy transition, technology acceptance, household energy, Kenya*

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LIST OF ABBREVIATIONS

ADNOC	Abu Dhabi National Oil Company
BMZ	German Federal Ministry for Economic Cooperation and Development
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
DED	German Development Service
GDP	Gross Domestic Product
GIZ	German Agency for International Cooperation
GTZ	German Technical Cooperation
IAP	Indoor Air Pollution
ICS	Improved Cooking Stove
IDT	Innovation Diffusion Theory
IEA	International Energy Agency
InWEnt	InWEnt - Capacity Building International
KNBS	Kenya National Bureau of Statistics
MDG	Millennium Development Goals
N_2O	Nitrous oxide
NO_x	Nitrogen oxide
PIC's	Products of incomplete combustion
PSDA	Private Sector Development in Agriculture
SO_x	Sulphur oxides
TAM	Technology Acceptance Model
UTAUT	Unified Theory of Acceptance and Use of Technology
WHO	World Health Organisation

1 INTRODUCTION

The dependency on traditional biomass fuels such as firewood or charcoal as well as agricultural waste is in many developing countries excessively high. According to the International Energy Agency [IEA] over 2.7 billion people are without clean cooking facilities and are relying on the traditional use of biomass for cooking (IEA 2011). By 2030, the number of households using traditional biomass fuels is estimated to rise even further by 100 million more people (IEA 2010). Such dependency is not without negative effects on human health as well as the environment. Over 10 million people fall sick of illness due to the biomass combustion and the associated Indoor Air Pollution [IAP]. Furthermore, IAP accounts for about 2.7% of the global burden of disease (WHO 2004, 2006). The dangerously increasing rate of deforestation leads to land erosion, loss of watershed, and desertification and affects the biodiversity of the regions. Additionally, deforestation accelerates the rate of climate change due to the changed land cover albedo as well as the reduction of the forest's carbon stock potential (Schlag & Zuzarte 2008, Wood & Baldwin 1985).

The transition from these traditional biomass fuels to more modern, cleaner and efficient energy sources will hence affect and benefit a vast number of people as well as the environment. Understanding the underlying forces affecting energy transition is therefore crucial. Governmental policies and actions as well as development interventions by various organisations often involve vast amounts of resources and might lead to adverse outcomes in the case of bad design. Especially the poor are highly dependent on cheap energy sources and hence vulnerable to any influencing policy. The dominant approach on which most governmental and non-governmental activities and policies are based on is the energy ladder model which emphasizes household's income as major driver and implies a complete transition from one fuel to another. This theory is widely acknowledged and utilized in explaining energy consumption behaviours (e.g. Akabah 1990, Barnes & Floor 1996, Hosier & Dowd 1987, Leach 1992). However, various authors have criticised the frameworks and presented contrary research results. Rather than a complete transition, households seem to diverse their fuel consumption and utilize multiple fuels simultaneously from all levels of the energy ladder. Furthermore, it is demonstrated that the impact of income on the fuel choice and transition to cleaner fuels is positive but not the major factor but rather one of many forces. Social, cultural and individual characteristics are put more into focus of recent research which has indicated their importance for the understanding of energy transition (Arnold et al. 2006, Hiemstra-van der Horst & Hovorka 2008, IEA 2002, Masera et al. 2000, Pachauri & Spreng 2003). All in literature proposed concepts implemented within the framework of the energy ladder model without offering an alternative framework for interpreting and explaining energy transition. Furthermore, literature still does not give a reasonable answer why households choose or dismiss particular fuel types and technologies and use or possess more than one fuel or stove (e.g. Hiemstra-van der Horst & Hovorka 2008, Masera & Navia 1997, Masera et al. 2000).

Foster et al. (2000) proposed the hypothesis of "*different energy ladder for different types of applications*" but did not extended and elaborated that idea. By this, households choose their cooking stove relative to its characteristics and their various preferences. Based on this thought and in connection to general technology adoption theory, this thesis offers an alternative model based on the assumption that tasks, their nature and context are the determining factors affecting stove and fuel choice by households. Furthermore, the hypothesis gives freedom to explain the frequently observed fuel diversification by households. Here, it is assumed that the multifaceted demands of the households are the major driver of the household's stove and fuel diversification and ownership of multiple stoves and fuels.

This research intends to test the hypothesis and model while also trying to identify further dynamics influencing the household's choice and behaviour. For that reasons, the research strives to answer whether a fuel and stove diversification can be observed in the context of the rural and rurban Kenya and how this can be explained in light of the energy transition and technology adoption theory and in the proposed framework. Based on literature, the research and its results, it is aimed to present a further framework modeling the adoption process.

The thesis is structured into seven chapters where the 'Introduction' is followed by the 'Background' giving a general overview about traditional biomass consumption in developing countries and its complications. Additionally, a brief description of Kenya, the study country, is given as well as an introduction to the 'Gesellschaft für Internationale Zusammenarbeit' [German Agency for International Cooperation, GIZ] in which the research study was assimilated into. Chapter 3 reviews and summarizes the main literature on energy transition theory as well as technology adoption and acceptance. The proposed model is introduced and explained in 'Chapter 4 Methodology and approach' where also the study areas and villages are described in detail. Further, research methodology and design and its limitations are expressed. The result section in Chapter 5 is followed by a critical review and discussion ending in Chapter 7 'Conclusion'. Bibliography and the appendices are attached at the end containing further information such as interview guides and the questionnaire.

2 BACKGROUND

2.1 HOUSEHOLD ENERGY CONSUMPTION IN DEVELOPING COUNTRIES

The household energy pattern in many developing countries is characterised by the predominant use of traditional biomass fuels. According to the International Energy Agency [IEA] 2.7 billion people are without clean cooking facilities and are relying on the traditional use of biomass for cooking (IEA 2011). Especially in Sub-Saharan countries the consumption of these solid fuels is extremely high where 76% of the population uses biomass for their everyday cooking (IEA 2006). In rural areas the reliance on these traditional fuels is said to be higher with more than 90% depending on such energy sources (Bruce et al. 2000, Schlag & Zuzarte 2008). Figure 2-1. is drawn by the World Health Organisation [WHO] (2006) and illustrates the use of biomass fuels worldwide. By 2030 the number of households using traditional biomass fuels is estimated to rise even further by 100 million more people (IEA 2010).

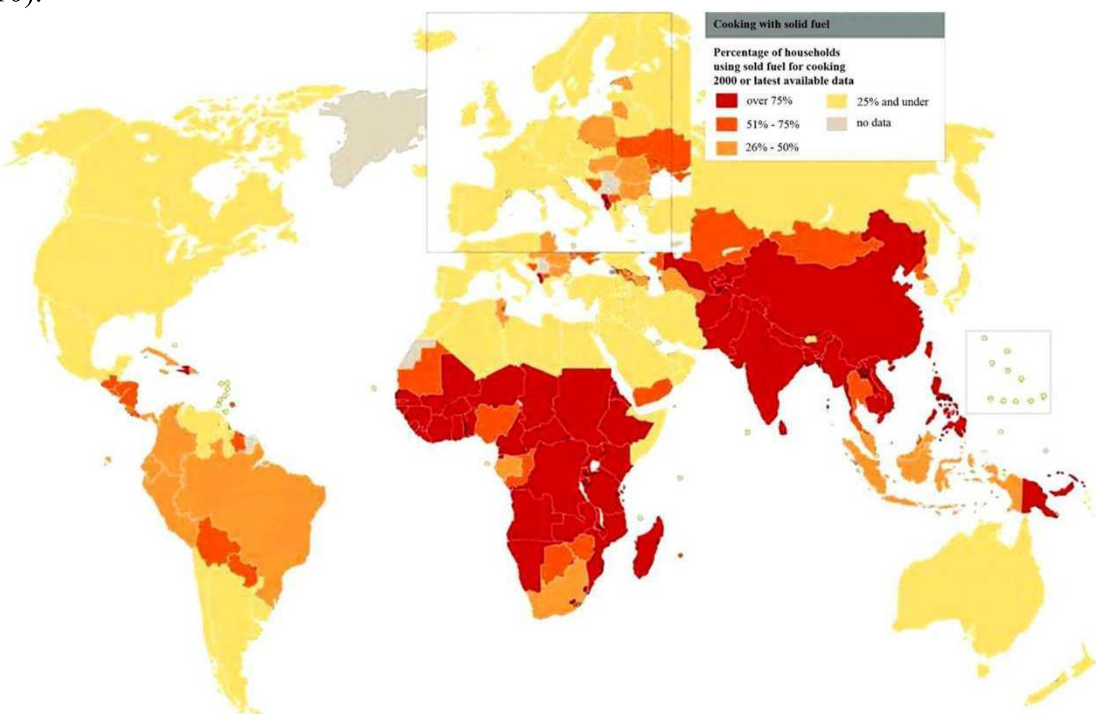

Figure 2-1. *Percentage of households using traditional solid fuels for cooking (WHO 2006)*

The most common energy sources are woodfuels such as firewood and charcoal but households also fall back on agricultural residues or animal wastes in the event where alternatives are unavailable. The dominance of firewood is explained due to its low cost or being free for collection in many cases as well as due to the lack of suitable alternatives. Charcoal is widely used in rurban and purely urban environments but also increasingly used in many rural areas. This is a direct result of households' preferences since charcoal emits less smoke, is more energy efficient and has a relative advantage in transport and storage compared to firewood (Schlag & Zuzarte 2008). The use of these woodfuels is, however, associated with a series of implications which are discussed in brief below.

2.1.1 Traditional Biomass Consumption & Environment

The use of traditional biomass fuels has mainly two sources of environmental impacts: first, those effects arising from harvest and production of traditional biomass fuels, and secondly, those associated with the combustion of the fuels.

The widely and for long time accepted relationship between the use of traditional biomass fuel and forest depletion got challenged in the mid 1980's. It was argued that instead, land clearances for agricultural activities and timber harvesting were the main drivers of deforestation (Arnold et al. 2006). According to Chidumayo (1997) it was assumed that the firewood collection was largely in form of dead wood or twigs and did not include cutting the entire tree. However, this approach got disproved in recent years. The increasing pressure on forests through the reliance on firewood as energy source by many households got formulated by Smith (1994) and it was shown that much of the native forest in many countries has already been exploited for charcoal production (e.g. Rose et al. 2009). Schlag & Zuzarte (2008) summarize literature that a reduction in households' dependency on woodfuels has the potential to reduce the rate of Sub-Saharan deforestation greatly. With the expected increase in demand for charcoal however, forest covers are most likely to deplete even further. With the growing rate of deforestation, its impacts will be enhanced as well. According to Wood & Baldwin (1985) the unsustainable biomass collection can lead to land erosion, loss of watershed, and desertification which in return places pressure on local agricultural productivity and hence food security demanding for more forest areas being cleared. Furthermore, animal habitats and in general biodiversity will be further pressured and lost to some extent. Finally, deforestation accelerates the rate of climate change due to the changed land cover albedo as well as the reduction of the forest's carbon stock potential (Schlag & Zuzarte 2008).

The combustion of traditional biomass fuels worsens the problem of climatic change further. In addition to significant levels of carbon dioxide [CO_2], the burning of solid fuels causes the emission of compounds often referred to as products of incomplete combustion [PIC's] which include methane [CH_4], carbon monoxide [CO], and nitrous oxide [N_2O] (Schlag & Zuzarte 2008). The IPCC Fourth Assessment Report (2007) measures the warming potential of methane and nitrous oxide to be 25 and 298 times higher as that of carbon, respectively. Recent research has put emphasize on the emission of further particles such as black carbon which are better known as the soot from the combustion of solid biomass and their effects on the climate (Smith 2009). Bond et al. (2007) indicate that 20% of the atmospheric black carbon concentration is linked with residential sources, mainly cooking stoves. However, due to its short half-life time of few days to few weeks in the atmosphere, a reduction of traditional biomass combustion might also be a short term solution for climate mitigation (Bond et al. 2008).

2.1.2 TRADITIONAL BIOMASS CONSUMPTION & HUMAN HEALTH

Smoke and resulting Indoor Air Pollution [IAP] resulting from the combustion of solid biomass fuels causes according to the World Health Organisation around 1.6 million deaths per year (WHO 2006). This is almost congruent with the figures given by the International Energy Agency (2010) in Figure 2-2. below which indicates that the premature death rate from IAP is much higher than the number of premature deaths from Malaria or Tuberculosis. Furthermore, it is projected that due to the lack of interventions the number will even rise in the future and overtake the number of HIV/Aids premature annual deaths. Additionally to the number of deaths, 10 millions more fall sick of illness due to IAP (WHO 2004). Overall, Indoor Air Pollution accounts for 2.7% of the global burden of disease (WHO 2006).

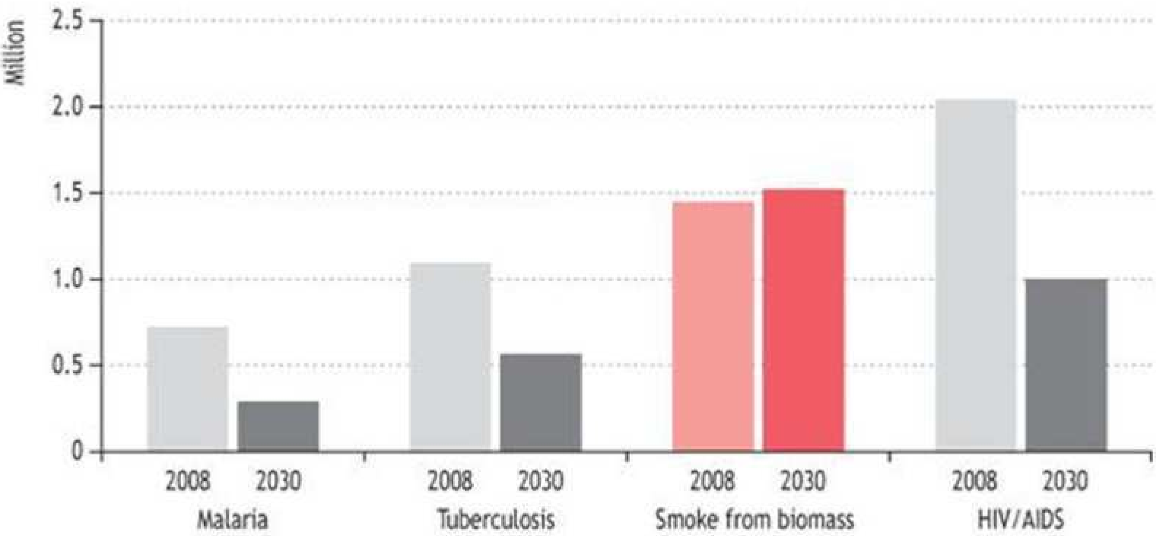

Figure 2-2. *Premature annual deaths from Malaria, Tuberculosis, HIV/Aids and biomass combustion (IEA 2010)*

The main victims of IAP are women and children. Since in many developing countries cooking is done mainly by women, they are directly exposed to the smoke produced during the combustion of biomass fuels. Bad ventilation at the indoor cooking place and/or no separate cooking house or room intensifies the women's exposure. Young children are the second high-risk group affected by IAP since they often stay in the kitchen to be close to their mothers and do not have developed a strong immune system yet to withstand the toxic effects of smoke (Bruce et al. 2000, Budds et al. 2001). The WHO (2004) indicates that nearly half of all pneumonia casualties of young children are a result of smoke exposure. The combustion of solid biomass fuels emits several substances which can cause severe damage on human health such as: Nitrogen oxide [NO_x], carbon monoxide [CO], sulphur oxides [SO_x], and various carcinogens [formaldehyde & benzene] (Bruce et al 2000, Budds et al. 2001). The accumulation of these gases in the households leads to concentrations that are up to 100 times higher than the standards recommended by the WHO and in some settings even more (WHO 2011). Furthermore does the atmospheric concentration rise in the region which affects neighbours and others outside the cooking place. Besides gases, small particles are emitted which range from a diameter of 2.5 microns[$PM_{2.5}$] up to 10 microns [PM_{10}] and obstruct airways and lungs and impair immune response. Besides weakening the immune system, IAP causes a series of serious human health problems. Acute respiration infections might result in further illness such as asthma, chronic obstructive pulmonary disease, and lung cancer or child pneumonia. Furthermore, the exposure to smoke and its compounds is associated with heart diseases, low birth-weights for unborn and much greater susceptibility to tuberculosis and cataract which might lead to blindness (Bruce et al. 2000, Budds et al. 2001, WHO 2006). A study by Ezzati & Kammen (2002) found that a complete transition from firewood to charcoal would reduce the incidence of acute respiration infections by 65%. Further transition to even cleaner fuels such as LPG is expected to decrease the acute respiration infections significantly. However, if the prevailing patters do not change, Bailis et al (2005) estimate that diseases attributable to IAP will cause 9.8 million premature deaths by 2030.

Another major risk connected with the use of biomass fuels are injuries. There is an estimate by the International Society of Burn Injuries of around 300,000 deaths each year due to burns and scalds from open fires that lead to disfiguring injuries, excruciating burns, infection, and in some cases death. Again, small children are at greatest risk to suffer from burns and consequences due to the open fires or unstable metal or clay cookstoves which are often positioned on the ground and hence in reach of small children. Furthermore, head and spinal injuries are highly associated with the fuelwood consumption and its collection. Women and girls who are mainly responsible for the fuel collection often carry heavy loads of firewood or other fuels on their back and may suffer from pain, skin disorder, dehydration and even heart palpitations (Burki 2011). The International Energy Agency estimates the average load of firewood in Sub-Saharan Africa to weigh 20kg (IEA 2006). The weight of the fuel causing anatomical changes through the constant load may result in pregnancy complications and an increased maternal mortality. Furthermore, while collecting the women and girls are at much higher risk to suffer from axes, tree stumps, snake bites or poisonous insects (PREDAS 2009).

2.1.3 Traditional Biomass Consumption & Socio-cultural Factors

There is a clear disproportional burden distribution associated with the consumption of traditional biomass. Women and men do not bear the environmental and human health problems associated with the biomass fuel combustion to the same extend. It is mainly women and girls in many developing countries who are responsible for the fuel collection and the preparation and cooking of food. They therefore suffer the most from the impacts of the use of woodfuels (Schlag & Zuzarte 2008, WHO 2006).

The time spent cooking on inefficient cooking stoves as well as the collection and processing of the fuels is of major concern. According to UN Women Watch (2009) women in developing countries spent between two and 20 hours or more per week on exhausting walks for wood collection. In the case of Kenya, McPeak (2009) estimated for the northern regions an average of 70 minutes which women spent per day for collecting firewood. Fuel scarcity and natural resource depletion force women to walk increasingly longer distances, often into isolated and dangerous areas. Besides the increased potential of animal attacks, women have to face a considerably higher risk of gender-based violence while in these areas collecting woodfuels. Josette Sheeran of the UN World Food Programme has put it that way: *"My awaking moment was being in Dafur, meeting with the women, and realizing they're getting raped trying to cook the food we bring them"* (GACC, 2011). The relationship between gender-based violence linked to the collection of wood is due to the stigma of rape with great likelihood even higher than reported.

Additionally to the risk and the time spent for the actual food preparation and cooking, the hours of actual fuel collection represent a great opportunity costs[1] for women. Cecelski (2000) describes the role of women in such environments and indicates that these activities are rarely counted as productive or compensated work. However, such crucial actions strive away valuable time which women could spend for their personal advancement through education or income-generating activities. This expedites the vicious circle. The initial lack of income leads to the dependence of collecting the fuels resulting in diminished opportunities to generate income. Furthermore, young girls are often asked to help their mothers in the collection and food preparation and hence cannot attend school which means no education and no provided nutritious school meal (Joon et al. 2009, Schlag & Zuzarte 2008). In the cases where there are no free resources or work forces available for collection, the purchase of traditional biomass fuels constitutes a high economic burden on households in developing countries. To purchase sufficient fuel for cooking a daily's meal households have to spend up to 30% of their scare income (GACC, 2011). This drives important capital and leaves no income to buy medicine, food, start a business, or pay school fees. When fuel and hence money can be saved through e.g. the use of an Improved Cooking Stove, these savings are collected by women and are reinvested into a second daily meal, or in other family or community interests (OECD 2008).

2.1.4 MODERN ENERGY ACCESS AND DEVELOPMENT

The consumption on traditional biomass fuels is according to the literature (see e.g. Barnes et al. 2005, Karekezi 2002, Leach 1992) highly linked to the socio-economic class and hence the financial means of the particular household. This dependency is on one hand seen as a result as well as the cause for poverty. In the year 2000, the Millennium Development Goals [MDGs] were formulated to give all international development interventions a common goal and approach. Although the MDGs do not address access to energy directly, the increased use of such modern energy services is widely acknowledged to tackle a variety of MDGs (e.g. Meisen & Akin 2008, Schlag & Zuzarte 2008, UN Millennium Project 2005, WHO 2006). Schlag & Zuzarte (2008:4) define these modern cooking fuels *"to be those that have a high*

[1] Opportunity cost is referred to as the forgone benefit related to a set of several mutually exclusive choices among which one option has been picked. In the above context, the opportunity cost represents the women's time e.g. gathering wood. This time could have been spent in a different way like creating a value through labour. The monetary value symbolizes the women's lost benefit, the opportunity costs. For more details see e.g. Perman et al. (2003).

Millenium Development Goal	Contribution of improved household energy practices
Goal 1: Eradicate extreme poverty and hunger	➢ Saving time spent being ill or having to care for sick children will cut health care expenses and increase earning capacities. ➢ Where fuels are purchased, increasing fuel efficiency and thus cutting down on the quantity of fuel needed will ease constraints on already tight household budgets. ➢ Improved household energy technologies and practices will open up opportunities for income generation. ➢ Access to electricity will provide a source of light for economic activities in the evening and a source of energy for operating, for example, a sewing-machine or refrigerator.
Goal 2: Achieve universal primary education	➢ With less time lost in collecting fuel and due to ill health, children will have more time available for school attendance and homework. ➢ Better lighting will allow children to study outside of daylight hours and without putting their eyesight at risk.
Goal 3: Promote gender equality and empower women	➢ Alleviating the drudgery of fuel collection and reducing cooking time will free women's time for productive endeavours, education and child care. ➢ Reducing the time and distance that women and girls need to travel to collect fuel will reduce the risk of assault and injury, particularly in conflict situations. ➢ Involving women in household energy decisions will promote gender equality and raise women's prestige.
Goal 4: Reduce child mortality	➢ Reducing indoor air pollution will prevent child morbidity and mortality from pneumonia. ➢ Protecting the developing embryo from indoor air pollution can help avert stillbirth, perinatal mortality and low birth weight. ➢ Getting rid of open fires and kerosene wick lamps in the home can prevent infants and toddlers being burned and scalded.
Goal 5: Improve maternal health	➢ Curbing indoor air pollution will alleviate chronic respiratory problems among women. ➢ A less polluted home can improve the health of new mothers who spend time close to the fire after having given birth. ➢ A more accessible source of fuel can reduce women's labour burdens and associated health risks, such as prolapse due to carrying heavy loads.
Goal 6: Combat HIV/AIDS, malaria and other diseases	➢ Lowering levels of indoor air pollution levels can help prevent 1.6 million deaths from tuberculosis annually.
Goal 7: Ensure environmental sustainability	➢ Where biomass is scarce, easing the reliance on wood for fuel through more efficient cooking practices will lessen pressures on forests. ➢ Moving up the energy ladder and using improved stoves can increase energy efficiency and decrease greenhouse gas emissions.
Goal 8: Develop a global partnership for development	➢ Recognition in development agendas and by partnerships of the fundamental role that household energy plays in economic and social development will help to achieve the Millennium Development Goals by 2015.

Table 2-1. *Contribution of improved household energy in achieving the MDGs (adopted from WHO2006)*

energy density, high combustion efficiency and high heat-transfer efficiency with sufficient heat-control characteristics". Table 2-1. gives an overview how the access to better energy sources can contribute to achieving the MDGs. The use of modern cooking fuels provides several advantages. Firstly, through the implied higher efficiency and hence lower demand it may save financial capital directly, as well as save valuable time which can be used for personal advancements such as income-generating activities or further education. The lower emission of particles and gases into the atmosphere and immediate environment of the person cooking due to the fuels' high combustion efficiency and the reduction of open fires will reduce the disease, injury and death incidences associated with fuel combustion. This will also save money initially spent on medicine and increase the individual's productivity. A more detailed description to each individual Millennium Development Goal and how modern energy services can contribute in achieving it are described in Table 2-1.

In the past there are various development approaches that tried to increase the access to modern energy sources in order to accelerate sustainable development within the regions. Some governmental interventions include policies to increase access and affordability to these fuels such as the 'Butanisation programme' in Senegal which began in the 1970s with the aim to replace traditional biomass fuels with LPG. Senegal's approach was to offer subsidies on small units of fuel which were financed through taxes on other petroleum fuels. The great success of the programme - adoption of the urban population today is greater than 70% (ANSD 2006) - has to be treated with caution as price incentives normally only benefit urban areas and are less successful in rural environments (Schlag & Zuzarte 2008). According to the ANSD (2006) over 90% of the rural population in Senegal depends on woodfuel. This indicates that not only affordability but availability of the fuel plays an important role. An alternative approach is given by the UN programme 'Sustainable Energy for All' and the 'Global Alliance for Clean Cookingstoves', an initiative established by the UN Foundation. Both aim to provide a universal framework for organisations in order to increase the modern energy service penetration in the highly diverse market environments. The 'Global Alliance for Clean Cookingstoves' constitutes a global network of individual Improved Cooking Stove projects such as the one by the German GIZ which is active all around the world trying to introduce improved cooking stoves that are much cleaner, safer and more efficient as the traditional cookstoves.

2.2 KENYA COUNTRY DESCRIPTION

Surrounded by Tanzania in the South, Uganda in the West, South Sudan in the North-West, Ethiopia in the North, and Somalia in the North-West, Kenya is situated in the Northern East of Sub-Saharan Africa as illustrated in Figure 2-3. The 38,610,097 Kenyans inhabit a total area of 582,646 km² with its greatest population density in the south-western parts of the country where living and economic conditions are most favourable (KNBS 2010, 2012). All over the country, an estimate of 42 different ethnic and linguistic communities are found with a majority being Kikuyu [22%], followed by the second biggest groups, Luhya [14%], and

Figure 2-3. Map of Africa with Kenya being highlighted (ISRV 2010)

Luo [13%] (CIA 2012). While each tribe has its own language resulting in numerous indigenous languages, English and Swahili are the two official languages in Kenya. Around 20% of the total population lives in urban settings and almost 80% of the Kenyan households are classified to live in rural areas. The overall Gross Domestic Product [GDP] per capita in 2009 was listed at 739 US$ or 1,573 [PPP $] of which agriculture and forestry is stated to contribute with 24% the greatest share employing nearly 80% of the population (KNBS 2012, UN Data 2012, UNDP 2011). Due to the environmental conditions and cultural backgrounds, tea and maize constitute the greatest proportion of crops being planted. Together with flowers and coffee they constitute one of Kenya's biggest foreign exchange earning sector. The Human Development Index of Kenya in 2011 is with 0.509 above the regional average of Sub-Saharan Africa of 0.463. However, out of 187 countries with comparable data Kenya is placed on rank 143 with around 46% of its inhabitants living below the national poverty line (UNDP 2011, World Bank 2012). Furthermore, around half of the population lacks access to improved sanitation, clean water or modern fuels (UNDP 2011).

According to PwC (2012) biomass energy accounts for around 70% of all energy consumed. These are mainly woodfuels such as firewood or charcoal but also agricultural residues and animal dung are used as energy source. Petroleum fuels and electricity account in the total energy mix for only 21% and 9% respectively. Overall, the average per capita energy consumption in 2008 was stated to be around 80.0 kilograms oil equivalent (UN Data 2012). There are, however, great differences in consumption due to the rural and urban conditions such as availability and access. While around 95% of rural homes are reported to have access to kerosene and around 90% of whom use this fuel for lighting[2], grid electricity is available to only 13% of Kenyan homes - 45% of urban but only 3.1% of rural homes (HEDON 2010). These use the battery charging services available at small shops in order to charge their mobile phones or other devices. Almost 10% of the population charges lead-acid batteries at

[2] The use of kerosene in Kenya is mainly limited to lighting due to high fuel prices. However, after the Kenyan Government had removed all taxes on kerosene - hence lowering its price - it became price-competitive with other fuels such as charcoal in terms of a cooking fuel. Many urban households switched to use kerosene for cooking purposes resulting in about 56% of the urban population utilizing such fuel (Schlag & Zuzarte 2008).

such small shops to power their TV and radio (HEDON 2010). The overall energy consumption in the country in 2011 was 6,273.6 GWh according to the Kenya National Bureau of Statistics [KNBS] (2012) of which over 40% were generated by hydro power: Kenya's main source of electricity supply becomes highly volatile especially in the summer when water reserves dry out causing frequent electricity shortages in the summer months. Although there are several electricity producers on the Kenyan market, KenGen accounts for more than 82% of the country's total installed electricity generation capacity (UNDP 2006). The total consumption of petroleum fuels reached 3,857.9 thousand tonnes in 2011 (KNBS 2012). Steadily increasing prices for Murban crude oil imported into Kenya from Abu Dhabi National Oil Company [ADNOC] have peaked in July 2008 with an average price of 137.35 US$ before dropping back to around 40 to 50 US$. Kenyan price policies helped to stabilize the sales price of petroleum products to some extent. However, in March 2012 the prices peaked again at around 127.00 US$ after a long steady price increase (ADNOC 2012, PIEA 2012). According to the news agency Reuters (2011), Kenya has no strategic oil reserves and relies solely on oil marketers' 21-day oil reserves required under industry regulations. The recent discovery of oil in the northern parts of the country near Lake Turkana will change the country's dependency on the international market and benefit its own economy.

2.3 ‚GESELLSCHAFT FÜR INTERNATIONAL ZUSAMMENARBEIT'

Being founded in 2011, the German ‚Gesellschaft für Internationale Zusammenarbeit' [German Agency for International Cooperation, GIZ] has arisen from a collaboration of the German Development Service [Deutscher Entwicklungsdienst, DED], the German Technical Cooperation [Deutsche Gesellschaft für Technische Zusammenarbeit, GTZ], and InWEnt - Capacity Building International [Internationale Weiterbildung und Entwicklung gGmbH, InWEnt]. In its function as federal enterprise, the GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development. The Federal Ministry for Economic Cooperation and Development [BMZ] is the GIZ's main funding source while it also operates on behalf of other governmental departments, international donors like the European Union, World Bank or the United Nations, partner countries and the private sector. In total, the GIZ is active in more than 130 countries all over the world and carries out various projects under the following headlines: Management services, Rural development, Sustainable infrastructure, Security, reconstruction and peace, Social development, Governance and democracy, Environment and climate change, and Economic development and employment (GIZ 2012).

In Kenya, the GIZ undertakes a variety of programs in the field of sustainable development. One of them is the 'Private Sector Development in Agriculture' [PSDA] which is a bilateral development program between the GIZ on behalf of the German Government and various Kenyan ministry departments. It "*aims at promoting private sector development in agriculture by improving the access to markets for small and medium agro-industrial entrepreneurs, by building sustainable structures for needs-oriented service provision as well* *as by supporting the development of conducive framework conditions with regard to value chain related policies, legislation, regulations, economic and social infrastructure*" (GTZ 2008:4). The PSDA has identified three strategy components whereby it targets firstly to support a conductive policy framework for private sector development in agriculture, secondly, implement a value chain development in a maximum of eight agricultural value chains, and finally, promote resource-friendly technologies within the areas. These latter include biogas installations as well various types of Improved Cooking Stoves [ICS] which still use the prevailing traditional biomass fuels but exhibit much higher resource-efficiency. According to the GTZ PSDA (2007a) their ICS save up to 50% of fuelwood compared to the traditional three-stone fire. Their dissemination can therefore reduce poverty as time and money is saved as well as alleviate the biomass energy crisis and environmental degradation faced in some parts of Kenya. Since 1983 the GIZ PSDA focuses in Kenya on promoting a commercial approach to stove activities at all levels: production, marketing and installation. For this purpose, individuals are trained to become independent stove builders or producers allowing them to start their own business besides their agricultural activities or as a full-time employment. These stoves are made completely locally in the main part out of clay, bricks, or metal.

The Jiko Kisasa [a) in Figure 2-4.] made completely out of mud and clay is a fixed stove with a burned clay inlet. This liner is also the base of the Portable Kisasa seen in b) where it is surrounded by metal for stability. Both stoves work most efficiently with firewood using only a third of the resources demanded by a three-stone fire. However, other fuels such as agricultural residues have been observed to be applied as well. The standardized liner inlet gives the stove its form and ensures insulation of the fire place. The added pot-rests guarantee a firm stand for pots directly over the fire. Due to the higher insulation and design of a rather closed system with the pot as ceiling and hence efficient combustion, the Jiko Kisasa

Figure 2-4. *A sample of Improved Cooking Stoves promoted by the GIZ PSDA in Kenya: a) Jiko Kisasa, b) Portable Kisasa, c) Rocket stove, d) Portable Rocket stoves, e) Lorena stove, f) Ceramic Jiko, g) Fireless Cooker*

demonstrates significant smoke reduction of 30% relative to the three-stone fire (GTZ PSDA 2007a). In c) pictured, the Rocket stove is available in two versions: one made out of mud and clay, and the second one uses bricks. However, in the past, the latter version became more and more popular and today there are only few mud stoves present. The two versions were initially developed to allow the stove adoption in regions where either material is missing as well as to offer a less expensive option with the mud stove. Both stoves have similar to the Kisasa stoves a clay inlet to preserve the heat and direct the fire directly to the cooking place. Through its design, the Rocket stove reaches a maximum energy efficiency of almost 95% compared to 48% of the traditional three-stone fire (GTZ PSDA 2007a). Especially the construction made out of bricks is extremely durable - its lifespan is set at around 5 years (GTZ PSDA 2009a) - and highly cost-effective as well as efficient. An additional inlet has been designed for the Rocket stove which is placed from above directly into the firing chamber and allows for the use of charcoal. Furthermore, there are also two portable versions of the Rocket stove illustrated in d), one made out of clay and one out of metal. However, the first option is very fragile and is said to break easily while the latter is due to the materials very expensive in relation to others. The Lorena stove is similar to the Rocket stoves made either out of mud or bricks with the differences that here on firing entrance serves two cooking places at the same time. This may enhance effectiveness when both cooking places are used but may cause drastic efficiency losses when only one of the two holes is sealed with a pot. Furthermore, the Lorena has a chimney directly installed the stove leading to the outside through a connection in the wall. The Ceramic Jiko in f) is the oldest models already been promoted by the GTZ back in the 1980s. Unlike the others, this stove uses primarily charcoal and is often used for roasting maize or meat or space heating due to the characteristics of charcoal. The final stove is the Fireless Cooker which works as a heat preserver. While it holds warm readily cooked food, it also allows for fuel savings as the cooking process can continue over time using the heat contained in the food itself when place in the

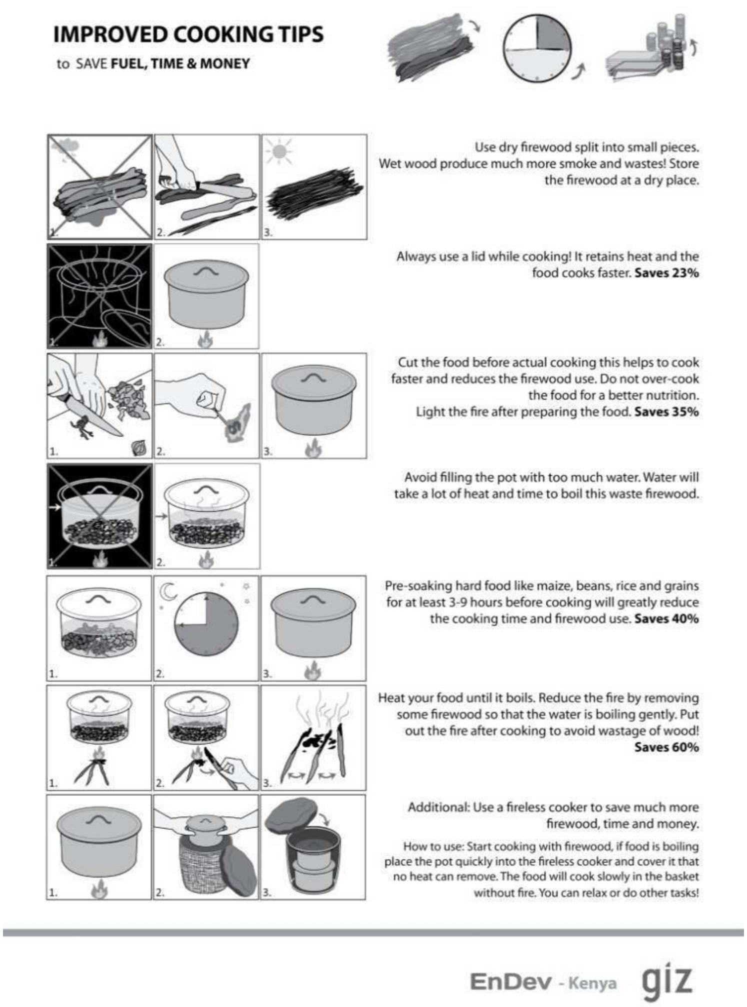

Figure 2-5. *Improved Cooking Tips leaflet (GIZ 2012)*

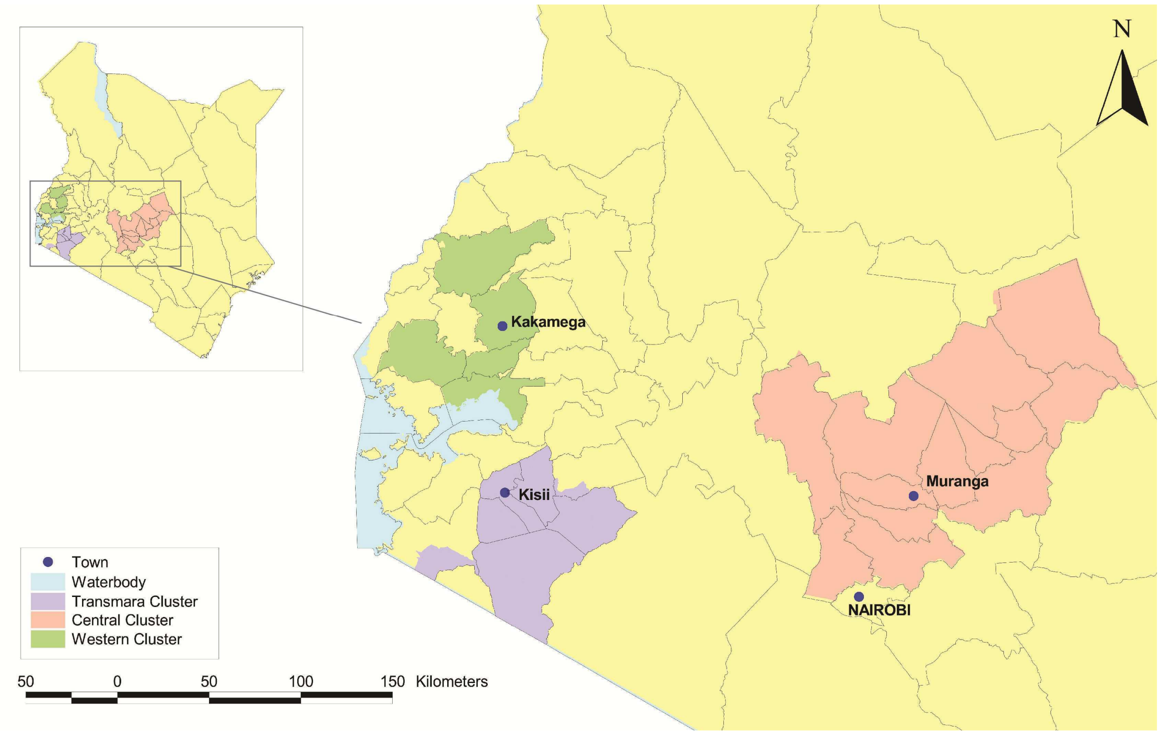

Figure 2-6. *Map of the GIZ PSDA clusters with ICS activities (data retrieved from GIZ & WRI)*

basket. Rice or maize dishes, rather hard foods, normally need to simmer for very long time hence consumes a lot of energy. Through the use of the Fireless Cooker, the actual cooking time on the stove can significantly be reduced allowing for energy saving of 33% when cooking rice and even 83% for pre-soaked dry maize and beans compared to being cooked without such device (GTZ PSDA 2007b). Together with the Fireless Cooker and the other ICS, the GIZ PSDA publishes and distributes other means of energy saving methods. One leaflet illustrating these Improved Cooking Tips is shown in Figure 2-5 on the previous page. In addition to the ICS, these Improved Cooking Tips are meant to educate the households in order to save fuel and thereby time and money. For reaching the illiterate, these tips have been translated into icon series that comprise the messages. For example the second icon sequence explains to always use a lid as heat will be kept within the pot and food is being cooked faster saving up to 23% of fuel. Similarly, all other series illustrate advice of how to cook in order to save energy, time, and money.

The GIZ PSDA, or before the GTZ, has been active in Kenya for a long time and has focused its stove activities as well as the dissemination of the Improved Cooking Tips to the south-western areas of Kenya. These regions have been selected by the GIZ PSDA due to the high population density and high rates of poverty as well as the rising woodfuel scarcity. Figure 2-6. gives an overview of the three Clusters where the GIZ PSDA is actively promoting resource-friendly technologies. North of Nairobi lays the Central Cluster, while the other two, Transmara Cluster and Western Cluster, lay in the South-West of the country in the Rift Valley and at Victoria Lake respectively. A more detailed description of the individual Cluster and the particular study sides is found in Chapter 4.2.

3 LITERATURE REVIEW

In most rural and semi-urban or 'rurban'[3] communities wood fuel is still the dominant energy source which is used for various tasks such as cooking, lighting, or space heating (Hiemstra-van der Horst & Hovorka 2008, Masera & Navia 1997). With expanding urbanization these areas will experience an enhanced access to a greater range of energy forms. Due to increasing availability of information and resources in rural areas, the knowledge about households' technology and fuel choice becomes more relevant than ever. The multiple link between energy consumption and the environment, human health, poverty, and in general the Millennium Development Goals, makes such understanding crucial for any related policy aiming to improve the macro- and micro-level conditions of a country. The following review elaborates the literature on the question of households' technology and fuel choice with focus on a critical assessment of the household energy transition theory.

3.1 HOUSEHOLD ENERGY TRANSITION THEORY

For over 30 years researchers have been trying to understand households' energy transition from one type of fuel to another, more efficient and cleaner energy form. The current knowledge is largely based on case studies with mainly focusing on socio-economic factors as key driver for transition. Although many times challenged and criticized for not including social and cultural considerations (Arnold et al. 2006, Campbell et al. 2003, Dovie et al. 2004, Kersten et al. 1998, Odihi 2003), several studies suggested such economic relationship (e.g. Barnes & Floor 1996, Barnes et al. 2005, Hosier & Dowd 1987, Leach 1992, Smith 1987). Two main models have been formulated and structure the discourse of energy transition theory: the energy ladder and the multiple fuel approach.

3.1.1 THE ENERGY LADDER MODEL

The 'energy ladder' is still the dominant approach in the transition theory since it was developed in the 1980s. Since then it was supported with various studies and widely utilised to explain different behaviours (e.g. Akabah 1990, Barnes & Floor 1996, Hosier & Dowd 1987, Leach 1992). It describes the positive relationship between socio-economic level and modern fuel uptake. The linear model suggests as illustrated in Figure 3-1. that an increased income is positive correlated with the adoption of and transition to more efficient, cleaner, and more costly energy sources. The energy ladder model can be characterized by three stages: The lowest step is distinguished through the universal combustion of biomass in form

[3] Rurban = Transition area between urban and rural settings encompassing the characteristics of both.

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.

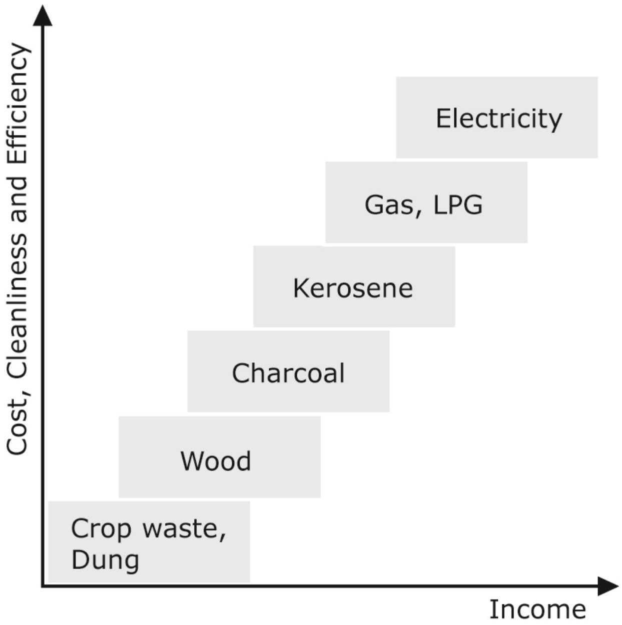

Figure 3-1. *'Energy ladder' model (adapted from Duflo et al. 2000)*

The model implies a neoclassical consumer who chooses rationally the best available and affordable fuel in order to maximize own utility[4]. The consumers are presumed to have inherent ranked preferences for the different fuels ordered by their physical characteristics such as cleanliness, ease of use, cooking speed and efficiency as well as fuel costs (Akabah 1990, Hosier & Kipyonda 1993, Leach 1992, Reddy & Reddy 1994). The opportunity cost[5] of women's time for acquiring the fuel has been identified to be an important factor for fuel switching (Sathaye & Tayler 1991, Heltberg et al. 2000). On the other hand, Masera (1990) finds in his research that while some women recognize the opportunity cost, most do not assign an economic value to this activity. The study by Troncoso et al. (2007) confirms this picture although they note that the fuelwood savings and hence reduced collection time was reported as main benefit after having adopted to an improved stove. According to Masera et al. (2000), the different fuels and stoves carry a social status as well. Hence the greater costs of advanced technologies are on one hand compensated by the greater fuel efficiency and cleanliness of the stove but also by the strived increase in societal status. Agricultural waste and firewood is perceived as the "*energy of the poor*" which is used out of necessity rather than choice and it is assumed that consumers will strive to the most sophisticated energy form they can afford (Hiemstra-van der Horst & Hovorka 2008, Soussan et al. 1990). The fuel switching process of the neoclassical consumer along the ladder is therefore dictated by the available financial means where an income increase permits ascending whereas a reduction commands descending on the ladder (Akabah 1990, Campbell et al. 2003, Hosier & Dowd 1987, Hosier & Kipyonda 1993, Martins 2005).

[4] The standard model of neoclassical economics implies a fully-informed consumer with complete, transitive, and continuous preferences upon which a rational choice is made, i.e. maximizing own utility. For more details about neoclassical economics see e.g. Vatn (2005).

[5] Opportunity cost is referred to as the forgone benefit related to a set of several mutually exclusive choices among which one option has been picked. In the above context, the opportunity cost represents the women's time e.g. gathering wood. This time could have been spent in a different way like creating a value through labour. The monetary value symbolizes the women's lost benefit, the opportunity costs. For more details see e.g. Perman et al. (2003).

Over the past years, several authors indicated factors constraining the potential upwards movement on the energy ladder. Key reasons have been identified to be fuel availability and access to it (Davis 1998, Hosier & Kipyonda 1993, Leach 1992, Milukas 1993). Such incident might be due to seasonal conditions like increased rainfall resulting in a poor infrastructure (Bouwer & Falcão 2004). Underdeveloped and poor infrastructure in general and roads in particular, is seen as a major obstacle for the dissemination and hence adoption of clean cooking technologies and fuels in Sub-Saharan Africa (Schlag & Zuzarte 2008). Leach (1992:120) states that "*access problems may outweigh all other considerations*", especially for the poor. Access however, may not only be understood as physical factor but also as the fuel's and associated technology's affordability. Such transition barriers have been formulated by e.g. Akabah (1990) and Edwards & Langpap (2005) who indicated high up-front costs for a stove unit to be a potential hurdle. Households which might be able to overcome other burdens as relative fuel prices (Fisher 2004, Hosier & Kipyonda 1993) or high fuel unit costs (Kebede et al. 2002, Leach 1992), might not adopt a 'cleaner' fuel but remain at a given level of the energy ladder because they cannot afford a new stove that could burn the particular fuel (Dovie et al. 2003, Karekezi & Majoro 2002, Odihi 2003).

However, the model's focus on income solely as explaining variable and its implicit assumption of the rational consumer moving from one fuel linear in an upwards trend to the other was criticized in various studies. A large energy survey conducted by Kaul & Liu (1992) with rural households in China revealed no clear fuel switching patterns that could be explained by the energy ladder. Research by Hiemstra-van der Horst & Hovorka (2008) demonstrated that the use of firewood is not dependent on income and hence the hypothesis of the energy ladder model is not always followed: Their study in Maun, Botswana revealed that firewood is burnt in almost every household regardless its socio-economic level. It is mentioned that despite the implicit ranking of fuels on the energy ladder model with agricultural waste and firewood being at the lowest stage, that "*no fuel is an inferior good"* (Kebede et al. 2002:1040). According to Kebede et al. (2002), an increased income could cause even a growth in demand for traditional fuels. Although Barnes et al. (2005:103) do support the upwards trend on the energy ladder related to an income increase in urban settings, they state that *"where wood is inexpensive and readily available, people continue to use it extensively, even in more well-off households"*. In Kenya, for instance, the main consumer of sawdust and scrap wood from sawmills are medium and better-off households (Milukas 1993). According to Arnold et al. (2006:559), *"the effect of income of fuelwood consumption in most studies appears to be small"*. For the top end of the ladder model, Campbell et al. (2003) note that the energy-use patterns are said to look similar regardless the income level. They state with support by Barnes et al. (2005) that in an urban environment even the poorest utilise electricity if they had access to it. The overall picture is affirmed by e.g. Dovie et al. (2004) and Kersten et al. (1998) who illustrates that while income increases the transition to modern fuels does not have to take place at all or can even be adverse (Arnold et al. 2006, Odihi 2003). Furthermore, the energy ladder assumes perfect substitution of one fuel for another where households abandon fuels completely when ascending on the energy ladder. This, however, is not the case as proven by Masera et al. (2000) and confirmed by others (IEA 2002, Pachauri & Spreng 2003). Instead a different consumer strategy was observed: the multiple fuel use approach.

3.1.2 MULTIPLE FUEL USE APPROACH

The multiple fuel use approach was first formulated by Masera & Navia (1997) who investigated the energy patterns in rural Mexican households. Masera et al. (2000) elaborated this concept as a critic and alternative to the linear energy ladder. The theory suggests that most households in developing countries do not apply the single-fuel substitution and linear transition suggested by the energy ladder but rather employ a variety of fuels simultaneously potentially including all levels indicated on the energy ladder (e.g. Arnold et al. 2006, Bouwer & Falcão 2004, Campbell et al. 2003, Davis 1998, Martins 2005, Masera & Navia 1997, Milukas 1993). Research by Masera et al. (2000) manifested this concept stating that "*rural households do not 'switch' fuels, but more generally follow a multiple fuel or 'fuel stacking' strategy by which new cooking technologies and fuels are added, but even the most traditional systems are rarely abandoned"*. The approach is illustrated in Figure 3-2. with a modified version of Figure 3-1. While income level increases and HHs might move upwards the 'energy ladder', they still keep lower level fuels and use them simultaneously or as supplement. Joon et al. (2009) revealed that rural households in Haryana, India that had been using LPG for many years still consumed agricultural waste and firewood as main cooking fuel due to financial limitations. Similar observations have been made by Davis (1998) in South Africa or PREDAS (2009) in many Sahelian countries.

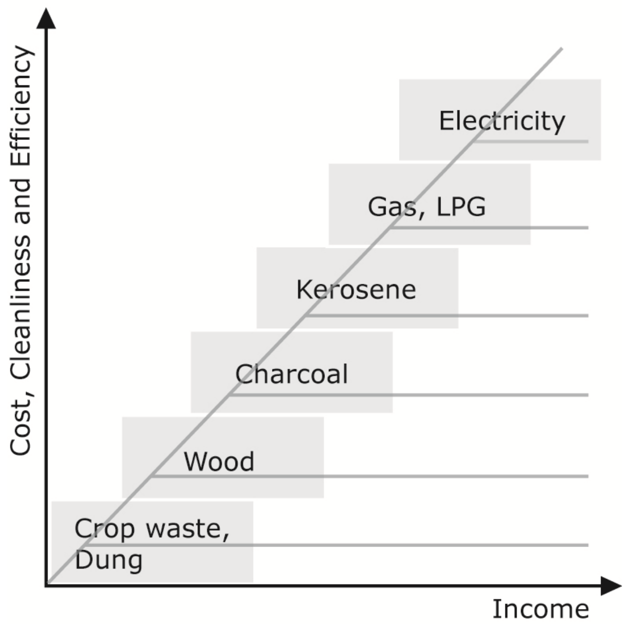

Figure 3-2. *'Multiple fuel use approach' (modified from Duflo et al. 2000)*

This fuel stacking behaviour has mainly been interpreted in the tradition of the energy ladder with focus on factors constraining the consumer rather than concentrating on his preferences. Similarly, fuel availability and access is observed as main driver (Campbell et al. 2003, Davis 1998, Hosier & Dowd 1987, Milukas 1993). Leach (1992) and Hosier & Kipyonda (1993) indicate that in particular lower level fuels are kept and exploited for energy security reasons in the event of supply shortage or associated high prices of the preferred fuel. Or as Soussan et al. (1990) note that "*consumers prefer kerosene, gas or electricity, but use what they can get"* in order to fulfil their needs. In result, households follow a fuel diversification strategy to ensure reliable energy supply (Pachauri 2011).

Another related factor for technology adoption is the associated social and cultural characteristics of the consumer. The Ceramic Jiko[6] for example, an improved ceramic stove suitable for more efficient burning of charcoal, was very successfully introduced in Kenya among others. It gained widespread use and popularity partly because it was designed and produced by local artisans ensuring to meet local consumer preferences. When it was initiated in the neighbouring country Tanzania it failed to meet these demands. The stove was rather unsuccessful until the design was modified in order to meet the Tanzanian local needs (Barnes et al. 1993:127, Budds et al. 2001:30). Unfortunately, the literature does not deepen these thoughts and elaborates the specific cultural differences. Masera et al. (2000) and Soussan et al. (1990) on the other hand did detect and specify a particular cultural influence on the choice for fuel and cooking stove. It is examined that gas stoves are in particular not used in the rural Mexican regions for preparing tortillas due to inefficiency and taste. Instead, a traditional stove and firewood is applied on which four to five times more tortillas can be prepared simultaneously and with better taste. Even in households that have been using gas for many years, firewood still plays a role in cooking resulting in a multiple fuel use (Masera et al. 2000). In an earlier study, Masera & Navia (1997) discover that rural Mexican households have distinctive fuel and stove preferences associated with type of dish and cooking task. While cooking beans and heating large quantities of water fuelwood is mostly used, LPG is mainly applied when boiling small amounts of water. Especially in the morning, the LPG stove is preferred for preparing Coffee as it is much faster. A similar impression is given by Hiemstra-van der Horst & Hovorka (2008). They state that firewood is dominantly consumed for traditional foods like hard beans or stamps which have to simmer for long time while light foods such as tea, coffee, rice, or small pieces of meat are prepared using gas. Masera et al. (2000) summarized this phenomenon as the interaction of the stove's technical characteristics and consumer's demand.

The traditional stoves such as the three-stone fire, in practice an open fire, are mentioned to play an important role in the cultural and social lives of rural and rurban communities as a gathering place. Bonfil-Batalla (1990) formulated the sensation of rural communities persistently using traditional stoves as a result of the 'autonomous culture' in order to keep their culture alive against the wave of adopting western values and technologies. Several households in Maun, Botswana stated in interviews held by Hiemstra-van der Horst & Hovorka (2008) that their firewood consumption was also due to its familiarity and tradition. On the other hand, focus group discussions conducted by the GTZ (2009) indicate that women generally using newer stoves such as ICS for cooking experienced an improvement of their social lives. They stated that due to the related reduction of smoke, children and men would spend more time in the kitchen and chat which they rarely did before. Besides these social benefits, the reductions of smoke and harmful gas emitted into households' living area and associated health benefits have been indicated to be a reason on its own for the transition to newer stoves (Barnes et al. 1994, Ezzati & Kammen 2002). Furthermore, household characteristics have been identified to be correlated with an up- or downwards trend along the energy ladder. Chambwera (2004) and Gebreegziabher et al. (2009) demonstrate that

[6] For picture see p. 12 or Appendix VI, p. 97.

household size is besides income an important determinant of a household's fuel choice. Barnes et al. (2005) mentions that while in a rural setting lager families are a financial asset, they might become economically unsustainably in cities if family members struggle to provide an income. They conclude that the environment and given characteristics determines whether the size of a household is positively or negatively correlated with the modern fuel transition. Together with Heltberg (2004), Gebreegziabher et al. (2009) indicate on one hand the positive relationship of the family's educational level and ascending the energy ladder whereas the age of the household's head or decision maker is negatively correlated (Gebreegziabher et al. 2009, Muneer & Mohamed 2003). On the contrary, Troncoso et al. (2007) did not find any relationship between stove or fuel adoption and neither age or educational level. Although these variables are assumed to be correlated with income, they also have to be considered on their own as well as in conjunction with the household's socio-economic status.

However, there is a trend shifting away from the focus on income solely. Masera et al. (2000) already mentioned the interaction of the stove's and fuel's characteristics with the cultural and social context of the consumer which determines the particular device and fuel choice. In this sense, Foley (1995) rephrases the original 'energy ladder' and formulates the 'ladder of energy demand' (1995:17). He argues that at the ground level of subsistence households only demand fuel for cooking purposes, usually in form of gathered wood. But as households' economic conditions improve they will expand their demands, e.g. including lighting, space and water heating and even brewing. Foley therefore shift away from the sole monetary value of an income increase and focuses on the side effects such an increase might bring along. According to a range of authors, households use their cooking stoves in general for various tasks besides solely cooking (GTZ 2009, Hiemstra-van der Horst & Hovorka 2008, Martins 2005, Masera & Navia 1997). Observations by Karekezi & Majoro (2002) and others suggest that the individual tasks are often operated by using particular types of fuel (Leach & Mearns 1988, Marufu et al. 1997). A similar phenomenon was also mentioned by Masera & Navia (1997) who observed a food-fuel preference by the households. This gives the notion that fuels may not be perfectly inter-substitutable (Martins 2005). As some fuels and associated technologies may be more efficient and cost-effective in providing a service such as space heating, others will prove to be superior for e.g. cooking (Martins 2005). Evans (1987) and Tinker (1980) conclude that fuels are used in a particular task where they prove to be best.

Foster et al. (2000) expand Foley's (1995) idea and combine the three models with *"different energy ladders for different types of applications"* (Martin 2005). Figure 3-3. tries to illustrate this approach. As household's income level increases, new demands evolve besides cooking such as lighting, or space and water heating with each being provided by different fuel or stove types due to the their particular characteristics and in general, household's preferences. While general cooking might follow a linear upwards trend, households will apply wood stoves such as the three-stone-fire for traditional cooking practices due to e.g. taste or ritual. Another case might be the lighting or space heating demand which arise at a particular income level and then might experience a steeper or shallower trend. For lighting, electricity might be the most favourable; hence households strive to reach that stage faster, whereas for space heating, charcoal could be perceived as appropriate and sufficient. In essence, the ladder leans on the households' personal characteristics and the technological characteristics of the fuel or stove rather than the household's socio-economic status solely. The literature is still unclear as this approach lacks deeper analysis and further elaboration.

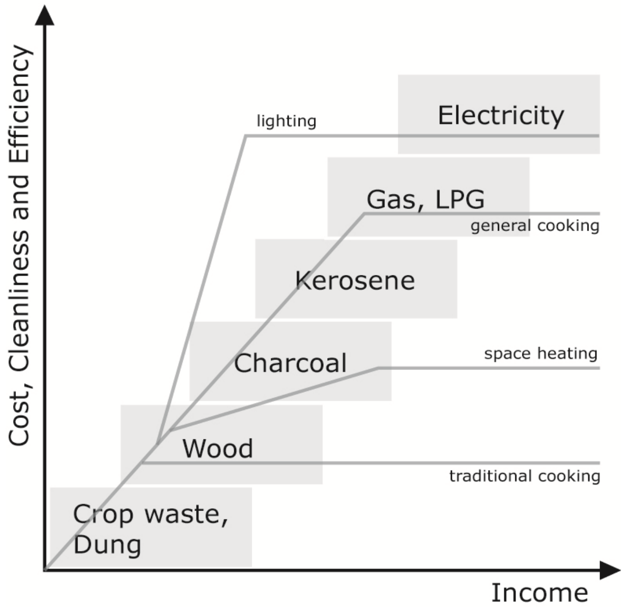

Figure 3-3. *'Different energy ladders for different types of applications' (modified from Duflo et al. 2000)*

The majority of researchers have concluded that instead of the single-fuel energy ladder a multiple fuel transition is experienced with households moving up and down because of their economic possibilities (Campbell et al 2003, Davis 1998, Hosier & Kipyonda 1993, Leach 1992, Martins 2005, Soussan at el. 1990). However, a number of authors also highlight that economic reasons or energy security are not the sole factor that determines fuel transition. Individuals and therefore households do not always act rationally. It is emphasized that social and cultural aspects do play a role but that general fuel transition is still not well understood and formulated (Brouwer & Falcão 2004, Joon et al. 2009, Martins 2005, Masera & Navia 1997, Masera et al. 2000). Due widespread appearance and acceptance of the multiple fuel approach, the issue is not only about the transition to cleaner fuels but more about fuel adoption and/or the acceptance of the associated technology. Especially, the further upwards the energy ladder, the greater is the dependency between fuel and technology. LPG for instance can only be utilized in devices specifically designed for this fuel while the traditional three-stone fire exhibits great versatility in the actual fuels used. Hence, to comprehend the transition to cleaner fuels, and understanding of the individual forces affecting acceptance and adoption of either fuel and/or stove are important.

3.2 General Technology Adoption Theory

Although being the foundation for energy transition theory, adoption theory did not find actual application in that particular field but rather in understanding and predicting the adoption of information technologies. In general, the theory investigates the reasons for an individual's choice to accept or reject a certain technology and aims to predict adoption behaviours. It concentrates on the individual with his or her characteristics and preferences as well as acknowledges the social and cultural context. Adoption is here understood as a process of conscious behaviour change that comprises the acceptance, selection and finally use of a technology by an individual (Carr 2001, Rogers 2003, Straub 2009).

Rogers' (1962) *Diffusion of Innovation* and his model 'innovation diffusion theory' [IDT] for understanding individual and collective technology adoption have become fundamental in general adoption theory. The adoption process is explained through five stages. Awareness of the technology by the individual results in phase two, persuasion. Here the individual gains knowledge about the technology in order to make a decision, stage three. The implementation of the decision, step four, is followed by station five, the re-evaluation of the choice leading to either continuance or abruption of the technology adoption. Rogers (2005) indicates that besides the technology itself with all its features, the social and cultural characteristics of the individual are highly influential for technology adoption.

In his 'perceived attribute theory' Rogers (2005) states that a technology is judged upon five attribute: observability, trialability, relative advantage, compatibility, and finally, complexity. It is noted that the greater the observability of the technology, i.e. its visibility, the greater the effect of the social sphere on the adoption. In IDT social systems are defined as context, culture, and environment in which the individual participates and their norms and structures are believed to influence the individual's technology adoption. Straub (2009:641) quote Rogers with "*adoption is innately social, influenced by peers, change agents, organizational pressure, and social norms*". Brown & Venkatesh (2005) and others indicated the effect of the individual's family size and composition of members on its consumption and technology adoption patterns. In the context of cooking technology and fuel, household size was demonstrated to be an important determinant of a household's fuel choice and cooking technology (Chambwera 2004, Gebreegziabher et al. 2009). Furthermore, research has shown that individual's willingness to adopt a technology is related to others' decisions (Rogers 2005, Song and Walden 2003). According to Bandura (1977), people observe others and infer about the usefulness of the behaviour or technology. The gained knowledge is used to revise own attitudes towards a particular behaviour or technology and to take action. This is enhanced through modern mass media but also through direct communication from person to person. The trialability of a technology which is described as its accessibility to an individual for experimentation supports observability. With greater trialability, people can experience the technology practically before adopting it and hence gain first-hand information. The potential and opportunity to test a technology will facilitate its adoption (Straub 2009). However, in order to be adopted, the technology must demonstrate to be better compared to similar ideas. Only the technology with a perceived advantage will be adopted. In the context of energy and stove technology, the physical characteristics such as cleanliness, cooking speed and efficiency or costs could be employed for comparison. Compatibility is the perception that the technology is similar and harmonious with the circumstances into which it will be introduced. The technology has to be compatible with the attitudes, beliefs and needs of the potential user. For cooking stoves, the typical traditional stove in rural areas is the three-stone fire which can be recognized by its non-specificity to fuel. It can facilitate cooking with agricultural residues as well as other biomass and is also free and can be assembled anywhere. In order to be competitive, any new stove technology must consider this flexibility and versatility of the three-stone to which the households are used to. Furthermore, the three-stone fire has also a social value as meeting and gathering place which also must be addressed then by the new technology. The importance of technology's compatibility has strongly been supported by Karahanna et al. (2006). In response, the concept of the 'appropriate technology' was developed in the early seventies for ensuring technology designs that satisfy rural people needs (Shumacher 1973). Under that definition, a technology is 'appropriate' when it responds to the users' need while respecting their culture and tradition. Meyer & Rowan (1977) mention that some practices are continued simply because of tradition rather than verified benefits. Great changes relative to the individual's context might compete with his or her tradition and hence hinder technological adoption. An appropriate technology is meant to be built employing local resources and labour and using the materials in a rational and renewable way. Furthermore, it is stated that the technology should be simple (Aguilar 1990). The complexity has also been mentioned by Rogers (2005). Although the technology must satisfy various requirements, the technology may not become too complex to understand or use. Rogers (2005) points out a negative correlation between the perceived complexity and adoption of a technology.

A similar statement has been formulated in the 'Technology Acceptance Model' [TAM] by Davis (1989) who declared the 'perceived ease of use' of a technology to be the major determinant of technology adoption. He defines it as the *"degree to which a person believes that using a particular system would be free of effort"* (Davis 1989:320). The second aspect is 'perceived usefulness' which is the *"degree to which a person believes that using a particular system would enhance his or her [...] performance"* (Davis 1989:320). Adams et al. (1992) and Hendrickson et al. (1993) replicated Davis' work and confirm his methodology and findings. The TAM has been very influential in adoption theory since it shifted attention towards the individual's perception of a technology. However, it is criticized for not considering the different individuals' characteristics which are seen as antecedent of 'perceived ease of use' (Agarwal & Prasad 1999, Hong et al. 2002). The TAM is based on the 'Theory of Reasoned Action' as well as its successor, the 'Theory of Planned Behavior'. Both theories are designed to explain and predict the behaviours of individuals in a specific situation (Legris et al. 2003). It is stated that attitude towards behaviour, subjective norms, and perceived behavioural control, together shape an individual's behavioural intentions and behaviours and therefore technology adoption (Ajzen 1991). These, however, are in return affected by the individual's characteristics. In order to grasp these elements, Venkatesh et al. (2000) extended the TAM by accounting for prior experience, age, gender, and others and formulated the 'Unified Theory of Acceptance and Use of Technology [UTAUT] (Venkatesh et al. 2003). In the context of cooking stoves, Gebreegziabher et al. (2009), Heltberg (2004), and Muneer & Mohamed (2003) have confirmed the relationship between experience or education, age and gender with stove adoption. Furthermore, the individual's character features and personality traits are acknowledged to play an important role as they determine how individuals think and behave in different situations. According to Hirunyawipada and Paswan (2006:184) a personality trait is defined as *"any characteristic by which a person* *differs from another in a relatively permanent and consistent way".* Mischel (2004) and Pulford & Sohal (2006) present among others evidence for the significant role of personality traits in forming beliefs and behaviour. It is therefore suggested that these character features cause people to adopt or reject a particular technology (Agarwal & Prasad 1998, Wood & Swait 2002).

Within the framework of the UTAUT, a human's 'voluntariness of change' or as others label it 'resistance to change' is seen to be critical for technology acceptance (Nov & Ye 2008, Venkatesh et al. 2003). Any introduction and adoption of a new technology implies some form of change for the user. The importance of a technology's compatibility with the individual's environment and needs was already mentioned by Rogers (2005). The 'resistance to change' trait of an individual has been linked to people's behaviour under changing conditions in a variety of contexts (Cooper & Zmud, 1990, Markus, 1983, Oreg 2003). While Oreg et al. (2005) use the 'resistance to change' trait of an individual to explain why some people tend to resist or adopt new technologies more than others, Rogers (2005) applies a comparable concept: that of an individual's innovativeness. According to Rogers and Shoemaker (1971:27) innovativeness is the *"degree to which an individual is relatively earlier in adopting an innovation than other members of his system".* Research by Kim (2008) concludes that consumers' innovativeness in general is an important factor in adoption. Muneer & Mohamed (2003) who apply this idea in the context of cooking stove adoption come to a similar conclusion. Categorising individuals upon their innovativeness, six distinct categories of adopters and their adoption behaviour are identified: 'Innovators', 'Early Adopters', 'Early Majority', 'Late Majority', 'Late Adopters' and 'Laggards' (Rogers 2005, Moore 1991a). Figure 3-4. illustrates the distribution of the six groups of adopters across time. Innovators and Early adopters share similar characteristics. Both are connected in interdisciplinary communities of shared interest and can be labelled as experimentalists or visionary users with great interest in technology (Geoghegan 1994). While Innovators are more interested in the technology itself than its application, the Early Adopters are driven by the technology's potential improvement. Geoghegan (1994) defines them as risk-takers that are not averse to occasional failure. On the contrary, the Main Majority, distinguished by the Early and Late or Mature Majority, is increasingly risk averse. The Early Majority are pragmatic users that are fairly comfortable with technology and look for solid references of

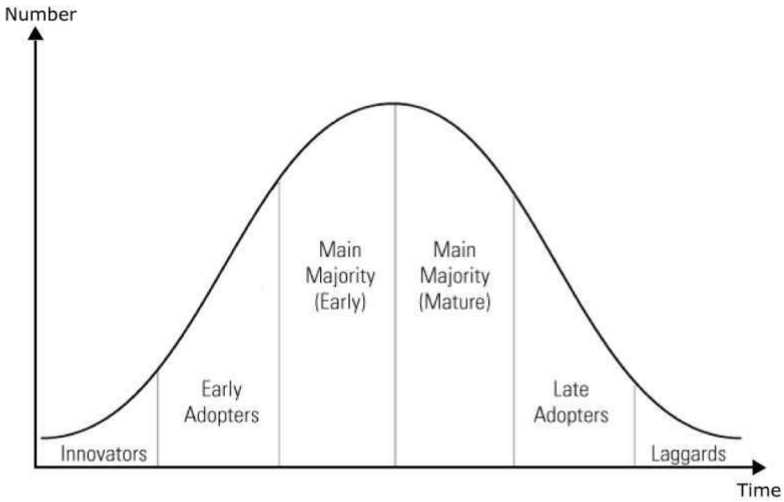

Figure 3-4. *Technology adoption lifecycle (adapted from Moore 1991b)*

proven tools before adoption. The Late or Mature Majority are less knowledgeable with technology and are described as rather conservative or sceptical (Geoghegan 1994). Moore (1991a) highlights their preferences of complete, pre-assembled technology-solutions. The Late Adopters and Laggards, which constitute the last 15% of the potential adopter population, are even more 'radical' than the Late or Mature Majority. It is stated that they will most likely never adopt a particular technology at all (Geoghegan 1994).

Straub (2009:626) summarizes his analytical review of existing adoption theories by suggesting three conclusions: *"a) technology adoption is a complex, inherently social, developmental process; b) individuals construct unique (but malleable) perceptions about technology that influence the adoption process; and c) successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns."*

4 METHODOLOGY AND APPROACH

This study aims to fill the uncertainty in literature about the reasons for energy diversification and diversity. The research strives to answer whether a multiple fuel approach can be observed in the context of the rural and rurban Kenya and how this can be explained in light of the energy transition and technology adoption theory. For that reason and in order to understand the individual forces affecting acceptance and adoption of either fuels and/or stoves, an alternative interpretation framework is presented based on the assumption that it is not income alone defining fuel and stove choice but the nature of the intended task and its context. Hence, it is assumed that the multifaceted demands of the households are the major driver of the multiple fuel and stove use.

4.1 AN ALTERNATIVE FRAMEWORK

The transition from one fuel to another, cleaner fuel becomes with progression on the energy ladder more and more a question about the household's technology acceptance. The literature review and especially Chapter 3.2 has already shown the possible applicability of the general technology adoption theory in the context of the energy transition. An alternative framework to combine both concepts it presented below in Figure 4-1. It is not meant to replace the energy ladder model but to give a framework for interpretation of the individual factors that influence household energy transition.

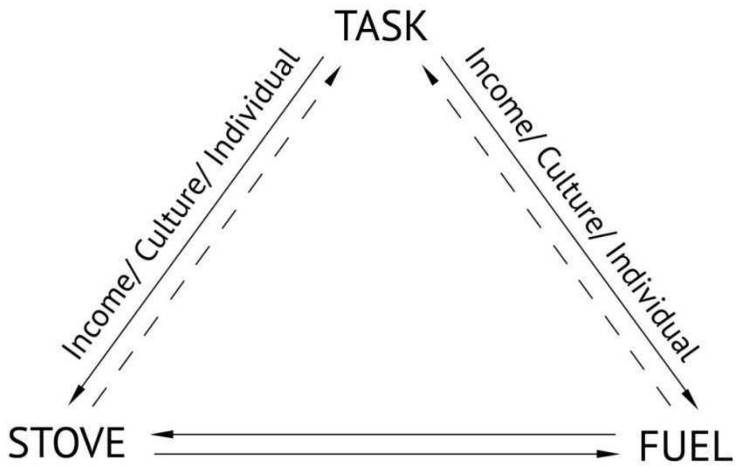

Figure 4-1. *An alternative framework to explain and illustrate fuel and stove adoption*

The relationship between stove and fuel choice becomes stronger as one progress to more efficient and cleaner fuels and stoves. Especially the efficiency is gained through the limitation of the fuel's or stove's versatility to be used with other stoves or fuels. Some stoves are only designed to hold one particular type of fuel, e.g. charcoal, kerosene, or LPG. These stoves cannot be used with any other fuel at all or without compromising their particular gains in efficiency, effectiveness, or cleanliness. The presence of a particular stove or fuel will also affect to some extend its use, hence influence the presence and/or nature of a particular task. Space heating for example might not have been intended before or have been done rather as a side effect. The presence of a charcoal stove might develop this need and wish to consciousness due to its efficiency and effectiveness in that particular task. This idea is based on Foley (1995) who indicate that households will expand their demands as their conditions change. Such relationship, however, is judged to be relatively weak in comparison to the other connections. As Leach & Mearns (1988) and Marufu et al. (1997) indicate along others, households use a particular fuel or stove for a specific task hence the nature of the task determines the fuel and stove choice. This is supported through the *"different energy ladders for different types of applications"* concept by Fosters et al. (2000). It is stated that different fuel or stove types are selected for a particular task due to their individual characteristics in terms of cost-effectiveness and efficiency (Martins 2005, Evans 1987, Tinker 1980). Another important factor according to Agarwal & Prasad (1998) and Wood & Swait (2002) and others for the adoption of a technology or fuel is the individual's character features and personality traits as it is formulated in technology adoption theory. These are defined as any attribute by which one individual differs from the other. In the particular case of energy transition, the relationship between age and education and the transition to cleaner energy forms has been shown in several cases (e.g. Heltberg 2004, Gebreegziabher et al. 2009, Muneer & Mohamed 2003). In Figure 4-1. it is assumed that the intended task pre-sorts the potential fuel and stove options in terms of their technical characteristics while the individual's personal characteristics and preferences influence the final decision. These are assumed to be determined by the decision-maker's age, education, occupation, and a constant standing for the person's experiences and preferences. Furthermore, is the culture or social background of importance for the person's choice. Urban, rurban, or rural areas might experience different levels of availability and access to the potential options or the cultural backgrounds of the individuals limit the choice for a particular task. Additionally, family size might be an issue in the stove and fuel choice. In the end, the final allocation of stove and fuel to a particular task is then limited by the financial means the household can supply. In sum, these three keywords, income, culture, and individual, and their associations are influencing the household in the final choice of their task-stove and task-fuel whereas stove and fuel are then interacting and influencing each other again.

4.2 STUDY SETTING

The research study was placed within the three Cluster areas of Western, Central, and Transmara set by the GIZ PSDA program[7]. All potential locations [regions] with a certain diversity in terms of social, cultural, and socio-economic means that were in a 2h-car-drive-distance of the base-office in each cluster were categorized into urban, semi-urban, and rural. Crucial features for this classification were distance and connectivity to a mayor trading centre and tarmac road, and its size. Two locations per Cluster were randomly chosen out of

[7] For map see Chapter 2, p. 14.

the potential pool, assuring one semi-urban[8] and one rural location each. Every region consists of several sub-locations from which one each was selected at random. The resulting six locations and sub-locations are summarized in Table 4-1 below. Within the sub-locations two particular villages were picked by chance for the survey. In some cases these had to be extended by a third or even fourth in order to fulfil the sampling requirements[9]. An introduction to the individual sites is given below[10].

Cluster	Rurban/rural	Location	Sub-location
Western	Rurban	Khayega	Shidodo
	Rural	Shibuye	Shiasava
Central	Rurban	Gatuya	Gatuya
	Rural	Maragua Ridge	Kamuiru
Transmara	Rurban	Kiogoro	Boronyi
	Rural	Ndanai	Kipsingei

Table 4-1. *Overview of the surveyed locations and sub-locations*

4.2.1 WESTERN CLUSTER

The rurban location Khayega lies within the Kakamega District of the Western Cluster. The local language in this area of the Western cluster is called Isukha. The location comprises four sub-locations and has an estimated population of 35,807[11] individuals and a total of 7,902 households. In the selected sub-location Shidodo, 10,804 people live within 2,338 households spread over 15 villages. The study area of Mathare and Ilala had to be extended by a third, neighbouring village, Shidodo village, in order to fulfil the sampling method. Mathare and Ilala hold roughly 105 and 110 households respectively. Their distance to the main district city Kakamega is on average 10 km whereas the distance to the closest trading centre, Khayega market, is 3 km from Mathare and 2 km from Ilala. While Ilala lies almost directly at the highway[12], Mathare is in a distance of 2.5 km. Figure 4-2. on the next page gives a descriptive picture of the study area in the Western Cluster. Main cash crops in this area are tea, sugar cane, and maize whereas latter is also main food crop besides vegetables and beans. Although the two raining periods of long rains in March till May and short rains in July till September would allow for two harvests per year, most people do harvest only once a year. The second harvest is stated to be normally poor and hence not worth the effort due to lack of water in December and January. However, in December 2011 Khayega experienced heavy and frequent rain allowing farmers to grow a rich harvest. Despite the proximity of

[8] Later on referred to as 'rurban'.
[9] For sampling methodology see Chapter 4.3.3, page 36.
[10] The data collection guideline for the location information is found under Appendix I, page 79.
[11] All present population and household data for locations are based on the 2009 Kenyan *Population and Housing Census Vol.1A*. by the Kenya National Bureau of Statistics (KNBS). Data on the sub-location level were mostly extracted from the same source. In some cases, however, data needed to be acquired together with those for village level from local sub-location chiefs and village leaders.
[12] Highway = main tarmac road.

Kakamega forest, the availability of free firewood is limited to the household's own compound due to strict laws prohibiting tree cutting within the forest reserve. Many scattered trees are observed on the compounds within the area. Nevertheless, illegal cutting and wood collecting in the forest reserve is still an issue.

Shiasava sub-location in the location Shibuye is one of four sub-locations and entails 7,250 people living in 1,505 households of the total population of 34,545 in 7,420 households. Out of the 15 villages, Chopkombe and Shagungu had to be added to the initially chosen Mungotso and Itumbu in order to satisfy the sampling requirements. The number of households for Mungotso and Itumbu was stated to be 104 and 73 respectively. All villages are located on a sand road leading into the countryside. Itumbu and Shagungu are situated 2 km closer to the highway and trading centre than Mungotso and Chobkombe which are both roughly in a distance of 9 km to the highway and 4 km to Shinyalu market. The district's main city Kakamega is 17.5 km away from Mungotso and 15.5 km from Itumbu. The steady rain from mid-February till June/mid-July with a peak and heavy rains in April till May, allows the farmers for two growing seasons per year. Main cash crops are tea, sugar cane, as well as bananas and trees for charcoal. However, since the majority of people are small-scale and subsistence farmers, most foods are produced for own consumption and only the surplus is sold. Main food crops are maize, cassava, and beans while some also grow sweet potatoes, millet, and bananas. Firewood is mainly cut and collected within the own compound or similar as in Shidodo sub-location bought at the market or neighbourhood. However, also from Shiasava sub-location illegal tree cutting and wood collection is taking place in the Kakamega forest.

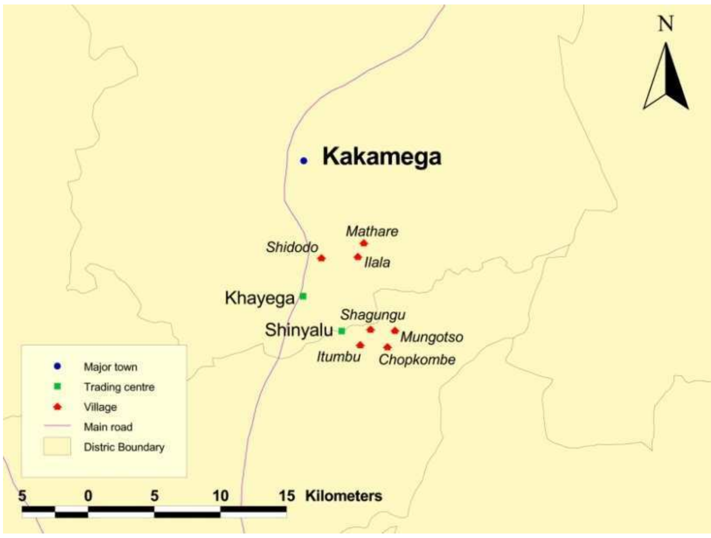

Figure 4-2. *Study area in the Western Cluster (data retrieved from GIZ & WRI)*

4.2.2 CENTRAL CLUSTER

The Central Cluster is inhabited mainly by the Kikuyu tribe with their local language Kikuyu. In Gatuya location, the sub-location Kiajogu was initially randomly chosen. However, the sub-location had to be dismissed due to some active groupings of the Mungiki within this area. The country-wide known group has been described as an organised criminal party that does not shy away from heavy violence. It was strongly advised from various sites not to visit this area as the group would constitute a potential danger to the whole research team. Therefore another rurban sub-location, Gatuya, was selected which is inhabited by around

1,000 households living in three villages. Kairichi and Gathima have been chosen randomly, each of a size of roughly 300 households. Gatuya sub-location as well as the whole location Gatuya is a very mountainous and wet area with fertile soil lying at high altitude. Heavy rain fall is experienced regularly between April and July and light rain in the months of October and November. However, sporadic rain falls also during the rest of the year. The only cash crop coffee is harvested annually while all food crops - maize, beans, bananas, and vegetables - are grown and harvested twice a year. Many trees are planted in the individual compounds assuring the households a stable supply of firewood. Nevertheless, firewood is also bought at the nearby shopping centres. Both villages have their own small trading centre although the assortment in Kairichi is rather basic consisting mainly of food and small charcoal tins. For any greater need the households have to visit Gathima in 2 km distance or Murang'a, a Cluster's main city, which is 23 km further away. The current sand road leading to Murang'a is under construction and is apart for the first 3 km already a finished tarmac highway. The locations of these villages as well as of the other selected sub-location are illustrated in Figure 4-3.

The rural location Maragua Ridge is located south of Murang'a and has an estimated population of 7,000 people. In contrast to Gatuya it is a very dry and hot area without any specific rain season. However, some rain is expected in April and May and more intensive precipitation in the months of October till November. The sandy soil on top of the long hills excludes intensive, diverse agriculture. Nevertheless, the area is more than suitable for growing annually Mangoes as cash crop. Food crops are limited to maize, beans, and some vegetables while bananas are planted in the river valleys where the soil is more fertile. All food crops yield twice a year. Trees are rather scare and scattered; farmers regularly suffer from firewood scarcity. Kamuiru, the selected sub-location of the two in Maragua Ridge, has around 3,000 residents and six villages from which Gituamba and Ngaini were picked. Both have an approximate population of 500 individuals and 100 households. Gituamba is situated directly at the main sand road in Maragua Ridge, about 1 km away from the highway and 8 km from Murang'a town. Its own shopping centre is located directly at the sand road at one corner of the village. Despite its good accessibility and good location within the region, the shops in the market are only small stands offering basics such as some foods or few household articles. Ngaini is found further in the countryside and is reached by a 4 km drive over a small rough road.

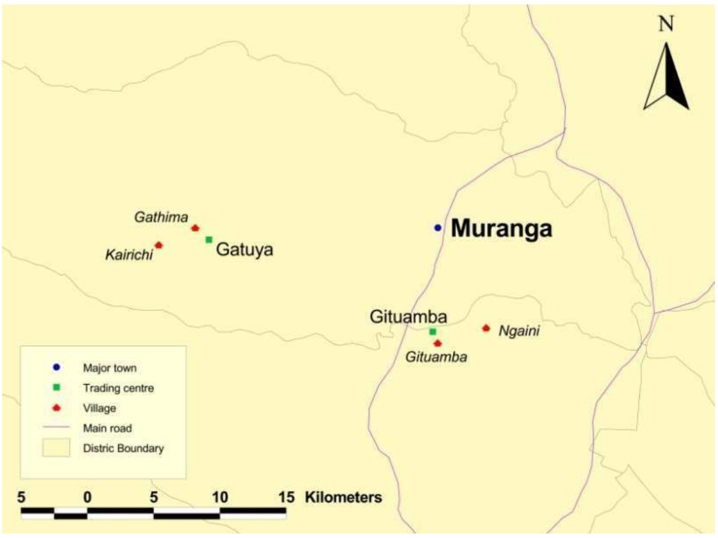

Figure 4-3. *Study area in the Central Cluster (data retrieved from GIZ & WRI)*

4.2.3 TRANSMARA CLUSTER

The Boronyi is with a population of 9,000 human beings the biggest of the four sub-locations in the rurban location Kiogoro which comprises almost 14,000 individuals. The local language in this area is called Ekegusii. Around 57 and 174 households respectively live in the two surveyed villages Amareba and Chinche which have been selected randomly from the total of 21 villages. Both are located directly at the highway in a distance of 7 - 8.5 km to Kisii, the Clusters main city. Despite some small shopping opportunities in Amareba which consists mainly of small stands and private persons, most people do use the facilities at Kisii or Chinche which is situated only 1.5km away. The countryside is characterised by well organised and maintained farms with many trees which are partly used for own supply as well as cash crop. Other economic yields are mainly tea and only little coffee due to low financial returns. Major food crops include maize and bananas in addition to wimbi and sorghum. The regular light rain throughout the year peaking in March till May with heavy rainfalls provides best condition for a rich harvest biannually. The only consistent dry period in December and January lasts only for around two to three weeks.

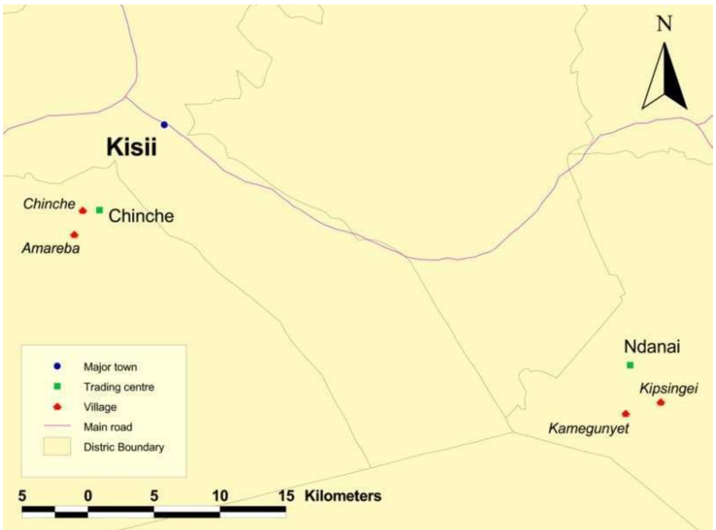

Figure 4-4. *Study area in the Transmara Cluster (data retrieved from GIZ & WRI)*

The local language spoken in the rural Ndanai and all its four sub-location including Kipsingei is called Kipsigis. The map in figure 4-4. pictures the setting. The location is rather dry during the months of January, February, and March, followed by dense rains till June. The second wet season of light rainfall starts in October and lasts till December. Land and precipitation limit the growing seasons to one harvest per year. The 6,500 people living in about 1,000 households survive primarily from their well-organised farms growing mainly maize, sorghum, millet, and beans. Only few households plant some coffee as cash crop. Trees are scare and scattered throughout the countryside and rather small. Slightly denser but still small tree cover is found in the forest near the two villages Kamegunyet and Kipsingei. Unfortunately, population data for these villages was unavailable. Further, the household figures given by the responsible location and sub-location chiefs as well as village leaders ranged from 250 to 400 for Kamegunyet and from 300 households to 500 for Kipsingei. Both villages are sited 67 km East from Kisii, and are reached from the highway over a 26 km long rough sand road. The first 22 km up to the nearest trading centre, Ndanai, were already under construction and are expected to become soon a tarmac highway. The last 4 km lead into the countryside and are not planned to be developed.

4.2.4 ORGANISATION

All research activities in the study country were planned from end of August 2011 till February 2012. Due to internal GIZ matters, adjustments had to be made to the initial time schedule and the total stay in Kenya was extended until end of May 2012. The actual field visit took place from 19th of November till 8th of December 2011 in Western Cluster, 5th of January 2012 till the 24th in Central Cluster, and finally in Transmara Cluster from 26th of January till 18th of February 2012. All survey activities took place six days a week from morning till evening while Sundays were used for further interviews, data digitalization, and preparation of the following actions.

Prior to the actual field work all three Clusters had been visited in October 2011 for meeting the enumerators, discussing the survey questions and selecting suitable locations after detailed consultation with the Cluster managers. Based on these meetings, the survey design and questions were adjusted to suit the particular environments. The stay was further used to become acquainted with the areas as well as sensitizing and convincing the responsible location and sub-location chiefs as well as the village leaders for the intended research in order to receive their support. Besides their necessary approval, the chiefs were very cooperative and helpful with their knowledge about the regions and people. Their input was very useful for completing the Criteria Papers[13] which were used for the initial household categorisation into a socio-economic class as well as the Location Profiles[14] describing the associated characteristics of the individual locations.

The survey was administered by a team of two enumerators in each location. In the Transmara cluster two teams were necessary since the local languages in the two chosen locations differed from each other. In total, the help of eight enumerators was used to conduct the survey[15] compromising GIZ stove builders and producers, public servants, and private individuals. Although all enumerators had some previous experiences with collecting survey data, each team had to be trained in a three-day workshop for the required surveying techniques. Nevertheless, at the end of each day every questionnaire had to be proof-read for inconsistencies. The surveys were printed in English, though translated by the enumerators into Swahili or one of the local languages [Isukha, Kikuyu, Ekegusii, Kipsigis]. All in-depth interviews[16] were held personally only with households that were able to speak and understand English without need for alien translation. The Location Profiles were completed mostly personally and only occasionally with help in form of translation by one of the enumerators.

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[13] For Criteria Paper see Appendix V, p. 94.
[14] The Location Profile is found under Appendix I, p.79.
[15] For Questionnaire see Appendix II, p.81.
[16] For Interview Guides see Appendix III, p. 90 and Appendix IV, p.92.

4.3 METHODOLOGY AND DESIGN

The study is designed as a comparative case study between the three Cluster areas of Western, Central, and Transmara set by the GIZ PSDA program. The overall aim is to apply the various energy transition models into the context of the rural and rurban Kenya and how it can be applied in light of the general technology adoption theory. For that reason and in order to understand the individual forces affecting acceptance and adoption of either fuels and/or stoves, an alternative interpretation framework is presented based on the assumption that it is not income alone defining fuel and stove choice but the nature of the intended task and its context. The three Cluster areas were set by the research-funding organization GIZ and allow for comparing the individual regions and assessing the importance of the local characteristics on the energy transition and technology adoption. The research relies on a dominant-less mixed methods approach including a set of instruments: structured household questionnaires[17], location profiles[18], in-depth semi-structured interviews with households[19] and institutions[20], and observations. Such multi-method approach is often referred to as triangulation allowing for validation of data against each other and a more complete perspective on a topic. The emphasis of this study is put on the quantitative surveys while the location profiles, in-depth structured interviews, and observations are meant to supplement, support, and potentially extend the research.

Quantitative research allows for comparative results that are easy to interpret with the potential to draw general conclusions. For the underlying study, a quantitative survey is the most appropriate. Any further information such as additional reasons for diversity in stove types that has not been included in the survey will be revealed through the qualitative part of the research, either through semi-structured interviews or observations. Qualitative research fits well when exploring a rather uncertain or unknown topic and in this case further unidentified reasons for behavior. The research's social setting will be caught best with the supplement of qualitative research. Additionally, personal observations will round up the assessment. In total, 320 households were surveyed and 15 in-depth interviews were held with households and four interviews with restaurants. Furthermore, basis data was collected in every location for the location profiles and observations were held in several households.

4.3.1 QUANTITATIVE METHODS

Structured household questionnaires

The structured household questionnaires were conducted in 320 households in the six selected sub-locations of Shidodo and Shiasava in Western Cluster, Gatuya and Kamuiru in Central Cluster, and Boronyi and Kipsingei in Transmara Cluster. Households were selected

[17] For Questionnaire see Appendix II, p.81.
[18] See Appendix I, p. 79.
[19] See Appendix III, p. 90.
[20] See Appendix IV, p. 92.

upon the random walk principle[21]. The survey took place from 19th of November till 8th of December 2011 in Western Cluster, 5th of January 2012 till the 24th in Central Cluster, and finally in Transmara Cluster from 26th of January till 18th of February 2012. It was administered by a team of eight enumerators.

The structured household questionnaire which is attached in Appendix II, page 81 was divided into five sections:

- SECTION A: Personal information
- SECTION B: Stove information
- SECTION C: Improved Cooking Stoves (ICS)
- SECTION D: Fuel information
- SECTION E: Cooking information

The household survey aims partly to answer the research question as well as to assess the GIZ stove program in terms of effectiveness and efficiency. In particular, the adoption and usage rate of ICS are of interest as well as the stove's condition and the household's attitudes towards it. Furthermore, several questions are meant for formulating practical recommendation aiming to expand the GIZ program's stove dissemination. Here, the focus lies on marketing and promotion potentials as well as potential stove design improvements. For that reason some additional questionnaires and in-depth interviews were held with ICS producers, installers, and retailers. Since these are not subject of the underlying analysis, they will not be elaborated any further. The focus, however, of the questionnaire was to gather a statistically representative data set on household energy practices and information on their technology adoption patterns in order to assess the research questions.

Location Profiles

The location profiles were completed in every location partly with the help of the location and sub-location chiefs as well as the village leaders. Data on fuel and stoves was collected in the nearest trading centres of each surveyed village. For this purpose several stands and small shops were asked for assistance. The template is found under Appendix I, page 79.

The profiles is divided into three parts: first, some statistics of the area are assessed such as distances or household and population data which were also used for the household sampling; secondly, the region and livelihoods of the surveyed sample were to be described; and thirdly, stove and fuel availability was evaluated within the locations as well as their price in the markets for the different units available. These figures describe the context of the individual research areas and enrich the assessment as the environment and external variables are stated in the literature to play an important role for households' energy transition and technology adoption. The statistical and descriptive data are summarized in Chapter 4.1 on the previous pages.

[21] For more details see Chapter 4.3.3, page 36.

4.3.2 Qualitative Methods

Household interviews

In every location households that already participated in the survey were asked about their willingness to be interviewed in depth about their stove and fuel choices. Besides their proficiency to speak English without need for translation, the presence of an ICS was of importance for the GIZ related questions. In total, 15 in-depth semi-structured interviews were held in the six locations. The interview guide is provided in Appendix III, page 90. It is divided into two sections asking about the household's stove and fuel preferences. Since the preceding survey covers similar issues, the printed questions are meant for guidance only and may be altered to fit the circumstances or deepen the already documented information of the questionnaire. Here it was very important, in contrast to the questionnaire, to allow the interviewee free expression and limit own control. The aim was the deeper understanding of the household's preferences and behaviour patterns which are used to support, extend, or disprove the analysis.

Institutional interviews

Additionally the household questionnaires and interviews, four in-depth semi-structured interviews were conducted with institutions such as restaurants. As these are 'professional' and intensive stove and fuel users such interviews provide more elaborated information. Although not being the focus of the assessment, the gained knowledge will round off the argument. The interview guideline is attached in Appendix IV, page 92 and is divided into three segments. First, some general information is documented. The second part is based on the household questionnaire asking about the stove presence and condition as well as fuel usage and therefore covering the basis data of the questionnaire. The final questions are similar to the household's interview aiming to understand the institution's stove and fuel use patterns and reasons for the choices made. The purpose of these interviews was a deeper insight into the matter that allows for a more detailed household analysis.

Observations

While conducting interviews and household questionnaires or being invited for lunch or tea, observations were made within the households and recorded later on. Although no previously standardized format was used, focus was on household's cooking behaviours and fuel use patterns. Since most households are cooking, simmering, or using the stove and fuels for other purposes throughout the day, various stimulating notes could be made which are used to extend and enrich the study.

4.3.3 Sampling Methodology

The three Cluster areas of Western, Central, and Transmara were set by the GIZ PSDA program. Since they experience great population density and hence pressure on the natural resources they constitute a good sampling area. All potential locations were identified that were in a 2h-car-drive- distance of the base-office in each cluster and had certain diversity in terms of social, cultural, and socio-economic means. These then were categorized into urban, semi-urban, and rural. Out of the potential pool of the stratified random sample, one semi-urban and one rural location per Cluster were randomly chosen and one sub-location was selected at random for each location. Within the sub-locations two particular villages were picked by chance for the survey.

At the village level, one of the four corners was randomly chosen as starting point. By rolling a dice at every junction the further direction was selected. Although the random-walk sampling principle did face same critiques concerning its randomness and validity as it is often combine with specific quotas, the form applied within this research without quota sampling is legitimate (Hoffmeyer-Zlotnik 2003, UN 2005). Households were given an equal chance to be surveyed by picking every n_{vil}th household along the path and either holding the questionnaire or indicating a non-response and continuing with the next n_{vil}th household until X questionnaires are held. The value for n_{vil} is determined through

$$n_{vil} = {}^{N_{vil}}/_{X} \tag{1}$$

with N_{vil} being the total number of households in the particular village and X the amount of planned questionnaires in that village. While N_{vil} is given by responsible location or sub-location chiefs and village leaders, X is defined by

$$X = {}^{n_{tot}}/_{V} \tag{2}$$

where $V = 12$, the total number of surveyed villages. In some cases conflicting values of N_{vil} were given by the responsible authorities. Here, the mean was used for the calculations. However, the often higher stated figures for N_{vil} and hence greater n_{vil} resulted in the villages being fully sampled before completing the amount of planned questionnaires in that village. Since there is a continuous flow of households and compounds between the villages, in these occasions, the neighbouring village and households were used in order to continue with the next n_{vil}th household along the path. The total survey sample size n_{tot} was calculated using a sample size calculator by Raosoft, Inc. with

$$n_{tot} = {}^{N_{tot}x}\Big/_{([N_{tot} - 1]E^2 + x)} \tag{3}$$

with a total population $N_{tot} = 38{,}610{,}097$ (KNBS 2010) and the variable x given by

$$x = Z\left({}^{c}/_{100}\right)^2 r(100 - r) \tag{4}$$

where $Z(^{c}/_{100})$ is the critical value for the confidence level $c = 95\%$ and $r = 50\%$, the fraction of responses interested in which values were suggested by the literature. The initially targeted sample size of $n_{tot} = 240$ was increased to ensure a smaller margin of error E which is defined as

$$E = \sqrt{\left[{(N_{tot} - n_{tot})x}\Big/{n_{tot}(N_{tot} - 1)}\right]} \tag{5}$$

Further accounting for 5% recording error and some household non-responses the final sample size was increased to a minimum of $n_{tot} = 312$ and thus $E = 5.55\%$. Both, the total sample size and household selection methodology allow for the assumption that the surveyed sample is representative of the three Clusters.

The participants for the household interviews were chosen out of the potential pool of English-speaking households that were willing to spend some more time after the questionnaire and had an ICS. The initial aim to interview at least a quarter of participants in each location [$N_{int} \geq 13$] and the total number being decided by saturation was not possible due to the lack of suitable candidates as well as time constraints. The final number of institutional interviews was limited by the same reasons and the lack of cooperative establishments. Institutions were selected by their size and intensity of cooking promising an elaborated and diverse use of a number of stoves and fuels.

4.3.4 DATA ANALYSIS

All data was captured on paper and encoded into SPSS using a predefined set of codes. These, however, had to be extended by additional answers that had not been considered before. To allow for different interpretation angles a number of different databases were established. In result, the general household database was extended by a stove, fuel, and food database. In regard of the various open-ended questions within the survey, initially patterns suggested by the literature are used. Progressively extended by further and other patterns generated throughout the qualitative analysis, these patterns are ordered thematically into categories. All identified groups are then coded in an appropriate manner. During the coding stage awareness of avoiding fragmentation and de-contextualization of the coded data was necessary. A sample of the transcriptions was proofread to ensure accuracy of the transcription process.

For the qualitative assessment which is meant to support and extend the quantitative research, tape recordings are transcribed becoming the raw data used for analysis. These are supported by marginal notes taken during the interviews describing the setting or participants' behaviour and interaction. Due to the limited number of conducted interviews the initially planned methodology of pattern analysis as described for the open-ended survey questions had to be changed. Instead, within the analysis individual cases are presented in anonymised form for comparison, support, or extension of the quantitative assessment and its argumentation. The recorded observations contextualise and support the reasoning similar to the interview data.

4.3.5 Limitations

The initial research schedule for all field activities had to be changed and re-planned several times due to some internal GIZ matters. Originally, all field research was arranged before the Christmas break but lastly had to be split in two trips leading to one stage accomplished before and two Clusters completed after the Christmas period. Another organisational set backs were the theft of electronic hardware containing most of the initial works and complications with renewing the Visa for Kenya which lead to a compulsory leaving of East Africa. Personal sickness and case of illness within the research team as well as frequent power cuts and blackouts which made the data digitalisation and analysis challenging caused further delays.

Due to the various local languages different enumerators had been needed in the three Clusters; in Transmara even two teams were required. The changing teams and in particular their preparation were very time-consuming as every training included a three-day workshop with following supervision. While training the surveys, not all enumerators were able to conduct them on their own. Even after more intensive training and guidance, the inconsistencies in the questionnaires were too great for two enumerators. In both cases, they had to be accompanied and used as translators in order to assure good data collection.

The geographical characteristics of some locations such as Gatuya which is very mountainous hampered the survey conduction. Additional to the large village sizes and hence the greater distance between the sampled households, the exhausting walking up the high hills and down the deep valleys took a long time and pushed the schedule to its limit. Regular and heavy rain in some locations made walking along the slippery paths difficult and was in general a handicap. No clear village boundaries but rather a continuous flow of compounds and households appeared to be a problem for identifying the exact study areas. The typical village borders are rivers, roads, paths, or even small trails. Although having been indicated by the sub-location chiefs, confirmation asked from village leaders and other village inhabitants resulted in some occasions in different border lines. A similar problem was experienced concerning population and household data. Unfortunately, data were not known in all places at all or only rough estimates could have been made. Especially at the village level, conflicting figures have been provided by location and sub-location chiefs as well as village leaders.

Since the survey was conducted on six days a week from early morning till evening, higher non-response rates were recorded from midday till noon when people were working or shopping in the market. Especially in one area of Kamuiru in Central Cluster closest to the highway where rents are very cheap and hence many people move outside of Murang'a but leave early in the morning for work and return late in the afternoon. In result, people were very often absent during the times the survey was held. Weddings, funerals, or family meetings tend to take almost the whole day and often include great portions of the households in a village if not all. Particularly Saturdays are used for many social gatherings of this kind since Sundays are assigned for general church service. However, in Kiogoro location of the Western Cluster many households were Seventh Day Adventists which keep the Saturday for worship similar to the Sabbath keepers in Maragua Ridge in Central Cluster. In both locations greater non-response was recorded during Saturdays. In Ngaini, a surveyed village in Maragua Ridge, the enumerators had to face some difficulties and limitations due to the country-wide known alcohol problem and regular drunkenness of the local men. Fortunately, no severe incidents occurred.

5 RESULTS

The research study is located in the three Cluster areas of Western, Central, and Transmara set by the GIZ PSDA program. The rurban-rural distribution is 157 and 163 or 49.1% and 50.9% respectively as shown in Table 5-1. In total, 320 households were assessed with an almost equal share in each Cluster. Table 5-2. displays the sample distribution for the household survey. The variations from the initially targeted number of 104 samples for each Cluster are due to the lack of time in Western Cluster or as in Central and Transmara due to more experience and supporting circumstances. The overall level of Non-response was above 30%, only for Transmara far below at around 20%. These figures are partly due to the reasons already mentioned in Chapter 4.3.5, page 39. In Transmara, the lower rate is founded on the local characteristics. As the main economic activity is farming and the household's farming areas are mostly located on the compound, most people were around and available. Out of this sample, a total of 15 interviews were conducted with suitable and willing households. Additionally, four restaurants were interviewed. For the interview distribution see Appendix VII, page 98.

Stratum	N	%
Rurban	157	49.1
Rural	163	50.9

Table 5-1. *Sample distribution regarding rurban - rural*

Cluster	Location	Rurban/rural	Sub-location	N	%
Western	Khayega	Rurban	Shidodo	51	15.9
	Shibuye	Rural	Shiasava	50	15.6
	Total			101	31.5
Central	Gatuya	Rurban	Gatuya	52	16.3
	Maragua Ridge	Rural	Kamuiru	55	17.2
	Total			107	33.5
Transmara	Kiogoro	Rurban	Boronyi	52	16.2
	Ndanai	Rural	Kipsingei	60	18.8
	Total			112	35
TOTAL				320	100

Table 5-2. *Sample distribution of the household survey in the three Clusters*

5.1 SAMPLE CHARACTERISTICS

The total sample of 320 households is presented as a whole as well as divided into rurban and rural observations. Due to their definition and the resulting differences in accessibility and households' livelihoods, a comparison is of interest. Since literature agrees on income being a main driver of energy transition, households were divided into three income groups - low, medium, and high - based on prior defined characteristics. The criteria lists were established together with the individual location and sub-location chiefs and verified by the local enumerators. Because of the differences between the regions, guidelines had to be formulated for every Cluster and in some cases with specification for individual locations. The individual criteria for each Cluster are attached in Appendix V, page 94. The general parameters, however, are as following:

- Connection to electricity and water pipe
- House and compound features (interior & exterior)
- Land quality and size
- Interviewee's clothes and education
- Type of transportation ownership

The house type and its interior are the most obvious and one of the first criteria to be assessed. In general, a permanent brick house with a properly fixed iron sheet or tiled roofing is perceived to belong to high income households, whereas a poorly made mud hut with a grass roof is associated with low income. Well-maintained mud or timber walls covered with an iron sheet are typical homesteads of the medium class. Land size and quality is also positively associated with increased income. While households with low income possess rather small land of lower quality, larger areas of good quality are owned by the rich. In the case of livestock, the relationship is different. While the medium class keeps the greatest amount of cattle and other animals, the wealthy own only a few but of high quality. However, in the enumerator's training it was emphasized that these criteria are non-static but rather

Stratum	Sub-stratum	Rurban		Rural		Total	
		N	%	N	%	N	%
Socio-economic status	Low	38	24.2	67	41.1	105	32.8
	Medium	83	52.9	76	46.6	159	49.7
	High	36	22.9	20	12.3	56	17.5
Income (in KSh)	Mean	137,842	-	106,816	-	121,633	-
	Highest	684,233	-	470,062	-	684,233	-
	Lowest	15,762	-	4,550	-	4,550	-
Household size	Mean	4.85	-	5.74	-	5.30	-
	Highest	12	-	15	-	15	-
	Lowest	1	-	1	-	1	-

Table 5-3. *General sample characteristics*

guidelines and that in conflicting cases common sense should be applied. According to this categorization, 32.8% of the total sample are of low income, 49.7% in the medium stratum, and 17.5% in the highest class. Table 5-3. gives an overview of the sample characteristics. A similar picture, slight skewed towards the lower end, is observed for the rural areas while the data in the rurban setting seems to be relatively normal distributed. Since the household classifications were dependent on the enumerator's personal judgment, these are open to a potential bias. Intensive training and particular explication of the matter, however, should have reduced such bias to an acceptable level. The classification was done on ethical grounds in order not to offend any household by asking about an actual income. Furthermore, the calculated income level gives in some cases conflicting data. The indicated amount is the midpoint of two income values which had been derived from the household's food and fuel expenditures and the associated share of the total budget. In spite of guidance, result questioning, and control, in some instances the two figures were fairly different. However, the average rurban income is with KSh137,842 over KSh30,000 higher than the mean income in rural settings per year. The typical annual earnings in the total sample is KSh121,633. The average household size in the surveyed households is 5.3 with a maximum of 15 people living together and a minimum of one person.

Besides the household size, literature tells us that age, education, as well as occupation and the social sphere at work are determinants of fuel and stove choice. Table 5-4. summarizes the collected data for the interviewee. 80% of all surveys were held with the household's Mama alone or with her in a group. The survey was focused on the main person cooking which in most Kenyan household are the women. However, in the absence of the Mama also husband and children were interviewed after assuring their knowledge about the household's cooking patterns and related choices. The age distribution was rather similar in all locations with around 50% of the interviewees being between 20 and 40 years old and less than 30% between 41 to 60. Such age categories were already created in the survey in order to receive more honest answers. The levels of education were initially split into further categories but were then grouped together due to small number of cases. In 1985 the Kenyan school system got reformed transforming the initially seven years of Primary school into eight years. However, for the analysis the education's content and quality are assumed to be comparable. Therefore, it is not differentiated whether an individual finished seven under the old regime or eight years of Primary school under the newer system. For the whole sample, it is indicated that almost 40% of the total sample finished Primary school and 12.2% the four years of Secondary school. However, there is also a great number who started but did not finish school. This might be caused by the individual family situation and the need of additional labour. Furthermore, societal patriarchal structures might affect the results as most interviewees are female. Older people stated that in earlier times, education was perceived as unimportant or even as bad. This might explain the 12.6% of individuals that did not receive any kind of formal education. The most common work in the sample was farming with 72.2%. Rurban areas experienced despite some initial assumptions higher fraction of people doing farming as main occupation than in rural areas. Here, a greater proportion than in rurban parts enjoys employment and is engaged as students. In both zones, around 14% of the sample is busy running small businesses such as shops or working as artisan.

Stratum	Sub-stratum	Rurban		Rural		Total	
		N	%	N	%	N	%
Interviewee	Mama	127	80.9	130	79.8	257	80.3
	Husband	8	5.1	12	7.4	20	6.3
	Other	22	14.0	21	12.9	43	13.5
Age	Below 20	10	6.4	10	6.1	20	6.3
	From 20 to 40	76	48.4	90	55.2	166	51.9
	From 41 to 60	44	28.0	48	29.4	92	28.8
	Above 60	26	16.6	14	8.6	40	12.5
Education	None	21	13.4	19	11.7	40	12.6
	Primary (unfinished)	21	13.4	35	21.5	56	17.5
	Primary (finished)	54	34.4	73	44.8	127	39.7
	Secondary (unfinished)	26	16.6	14	8.6	40	12.5
	Secondary (finished)	23	14.6	16	9.8	39	12.2
	Higher education	12	7.6	6	3.7	18	5.6
Occupation	Farming	117	74.5	114	69.9	231	72.2
	Self-employed	22	14.0	23	14.1	45	14.1
	Employed	9	5.7	14	8.6	23	7.2
	Student	9	5.7	12	7.4	21	6.6

Table 5-4. *Interviewee characteristics*

In rural and rurban areas, most households keep the structures of a patriarchal society. Although the women are mainly occupied with the cooking and associated tasks, all final decisions especially concerning the household's finance will be made by the male head. Nevertheless, women are said to have increasingly influence on the decision-making process. Of the 320 surveys, 27.5% were held with the head of the households. This is due to the research's focus on women and the societal structures of the households. The remaining 72.5% constitute in most cases the oldest male in the household, either the husband or father of the interviewee. Only in few cases, the mother or other household members were appointed to be the head.

In the total sample, more than half of the household's heads are between 20 and 60 with equal shares of 37.5% for either of the two categories within this age cluster. The similar values were checked and proved. Only two individuals are below the age of 20. The remaining 24.1% are above the 60 age mark. A similar age distribution is observed when splitting the sample into rurban and rural.

Stratum	Sub-stratum	Rurban		Rural		Total	
		N	%	N	%	N	%
Household's head	Interviewee	45	28.7	43	26.4	88	27.5
	Other	112	71.3	120	73.6	232	72.5
Specification of Other	Husband	86	76.8	96	80.0	182	78.4
	Father	8	7.1	17	14.2	25	10.8
	Mother	8	7.1	4	3.3	12	5.2
	Other	10	8.9	3	2.5	13	5.6
Age	Below 20	1	0.6	1	0.6	2	0.6
	From 20 to 40	55	35.0	65	39.9	120	37.5
	From 41 to 60	55	35.0	65	39.9	120	37.5
	Above 60	46	29.3	31	19.0	77	24.1
Education	None	24	15.3	18	11.0	42	13.1
	Primary (unfinished)	25	15.9	27	16.6	52	16.3
	Primary (finished)	54	34.4	71	43.6	125	39.1
	Secondary (unfinished)	14	8.9	15	9.2	29	9.1
	Secondary (finished)	20	12.7	21	12.9	41	12.8
	Higher education	20	12.7	11	6.7	31	9.7
Occupation	Farming	83	52.9	93	57.1	176	55.0
	Self-employed	25	15.9	35	21.5	60	18.8
	Employed	47	29.9	35	21.5	82	25.6
	Student	2	1.3	-	-	2	0.6

Table 5-5. *Household's head characteristics*

The education pattern for the household's head is similar to the one observed for interviewees with greatest fraction of samples having finished Primary school. The slightly lower school dropout figures as well the greater number of graduates of higher education could have been due to the significant higher number of males among the heads and their associated privileges, especially in older times. These might also have influenced the head's main occupation. While 55% of the total sample are farmers, 18% run their own business and over 25% are employed.

5.2 HOUSEHOLD ENERGY PROFILE

The household energy use patterns observed in the various locations give a relatively consistent picture. Figure 5-1. and 5-2. illustrate the use of the individual fuels by households for the total sample and the sub-categories rurban/rural respectively. The use of the basic biomass fuels - crop residues, twigs and firewood - is widespread in the sample: over 90% of the households stated to use such fuels with almost universal consumption of firewood with 97.2% of the sample. A similar picture is drawn for paraffin/kerosene which is used by

96.3% of the interviewees. This particular fuel is mainly used for lighting purposes and only rarely for cooking due to high market prices. Batteries for radio or torch and electricity mainly for charging mobile phones experience likewise a high demand with 86.6% and 89.1% respectively.

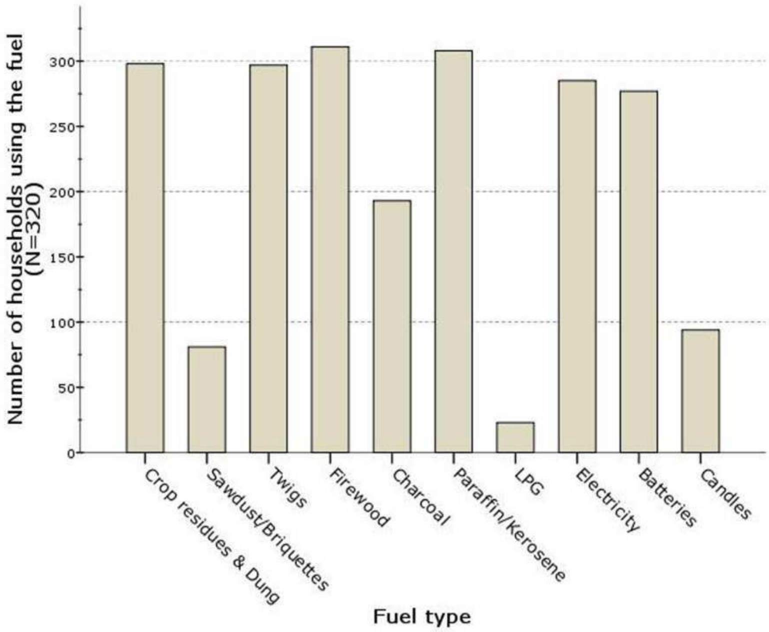

Figure 5-1. *Energy use patterns across the total sample [N =320]*

Figure 5-2. comparing rurban and rural areas shows the similarities in energy usage in particular for the mentioned fuels. However, the notion of different energy profiles can be observed. A higher charcoal and candle demand in rurban areas with 72.0% versus 49.1% and 40.1% versus 17.8% respectively gives the impression of potential availability and access implications. The differences in the use of LPG, electricity, crop residues and sawdust could be area dependent as well but are rather marginal in this sample.

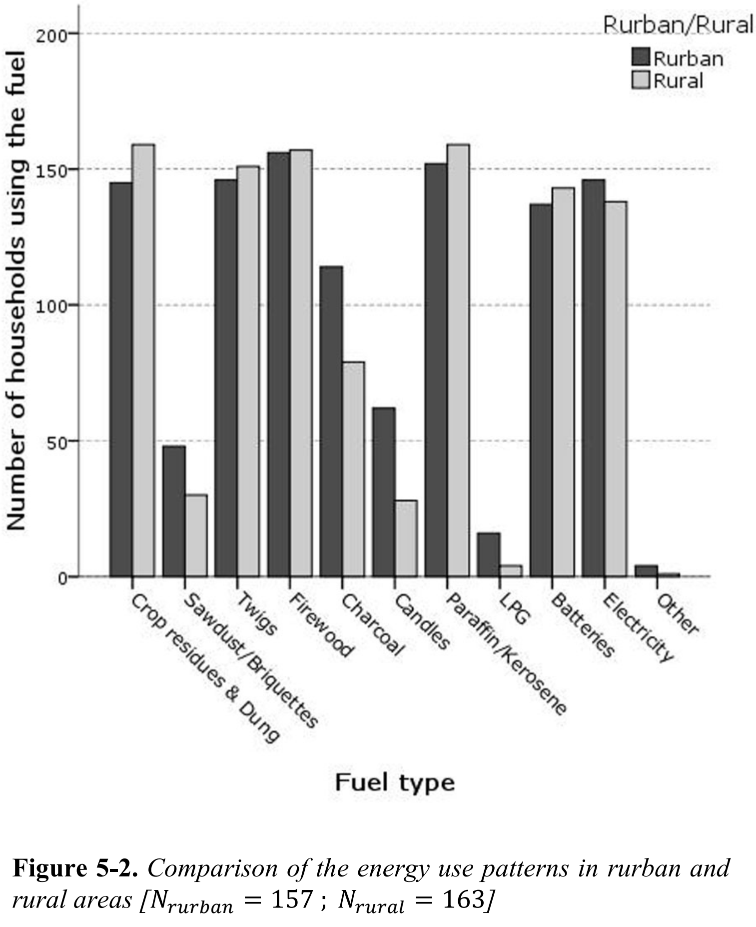

Figure 5-2. *Comparison of the energy use patterns in rurban and rural areas [$N_{rurban} = 157$; $N_{rural} = 163$]*

The difference in fuel use against income class is shown Figure 5-3. While the use of crop residues, firewood, and twigs is nearly universal and almost independent of the household's income classification, there is a slight hint of income dependency in the case of sawdust usage. Nearly 45% of the highest income class use sawdust as an energy source while its consumption in the lower and middle class is around 20% and 22% respectively. A similar trend is observed in the case of charcoal demand which rises steadily from poor of which around 38% consume charcoal to the rich sample group where over 90%

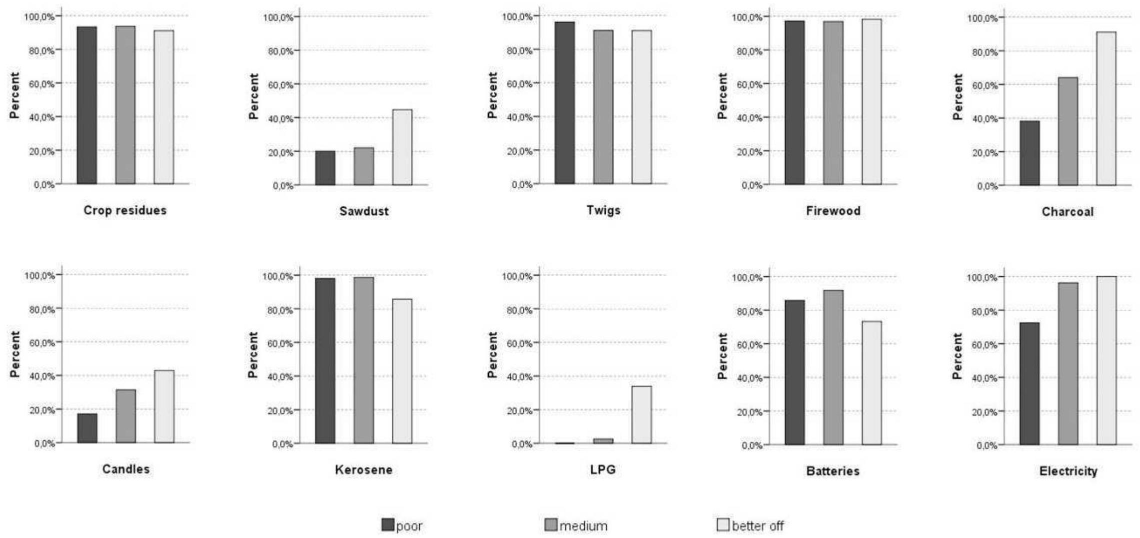

Figure 5-3. *Percentage of household using a particular fuel as energy source sorted by income category*

utilize this fuel. The use of candles and LPG is not as common as charcoal but their consumption distribution indicate comparable patterns of income related fuel choice. Again, households with a higher income tend to be more likely to use Candles or LPG as indicated in Figure 5-3. None of the poor households and only four medium class households were recorded to utilize LPG whereas almost 34% of the better off households cook with LPG. The demand for kerosene and Batteries does not follow such pattern. Here, the consumption is nearly 100% in households of both low and medium classification in the case of kerosene which is mainly used for lighting purposes and occasionally for cooking. Batteries experience a slight higher demand by the middle class households compared to the lower income group [92% and 86% respectively] which could be explained by the different financial possibilities. In both fuels, the highest income category is represented much less in comparison to the two other income groups. This might stay in relation to the universal use of electricity whereas only 72.4% of the poorest make use of electricity in their daily lives.

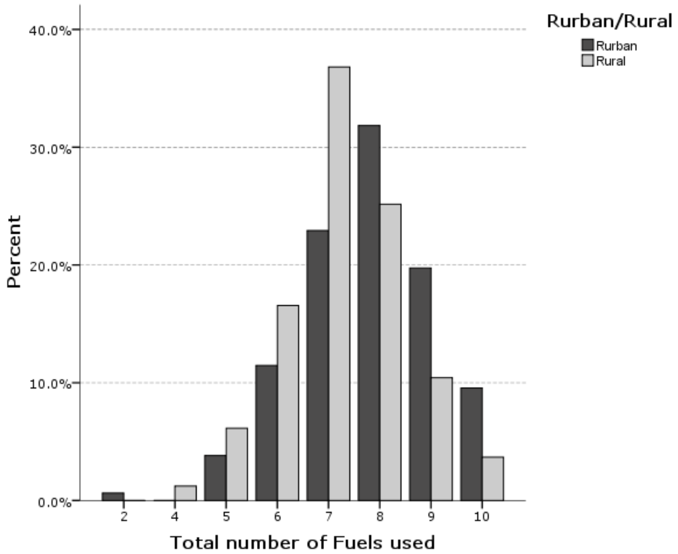

Figure 5-4. *Diversification of energy in rurban and rural areas*

As diverse the fuel use is across the total sample as diverse is the energy consumption within the individual households. Figure 5-4. illustrates the households' diversification in their individual energy consumption in the rurban and rural regions. With a minimum of two and a maximum of ten energy sources, every household in the sample applies a mix of various fuels to satisfy its needs. The minimum of two, however, was scored only once and the count of three fuels was not present at all.

Similarly, only two households with four fuels were noted within the sample. The total sample mean of 7.5 fuels represents the trend given by the mentioned figure. While the distribution for rurban areas with a mode of 8 fuels is slightly skewed to the right, the rural regions experience a peak at 7 energy sources and are skewed more to the left. Likewise, a great number of stoves was observed within the various households. While the diversity of stove types was rather small, the number of present stoves ranged from one up to a maximum of ten cooking stoves in one household. The total sample was highly skewed towards the lower end of the spectrum with a mode of one stove and an average stove possession of 2.7 per household. However, not all of the present stoves are in actual use. This is partly due to broken devices. Mainly portable stoves such as the KCJ or All-Metal stoves[22] suffered from broken parts and were hence not being used. Lack of access or availability to the right fuel which is mostly the case for the LPG or Kerosene burners is another reason often stated by the interviewees for the non-use of a particular stove. The fuels were quite popular and much more affordable in the past and many stoves are still present. However, significant price increases in recent years prohibits the households the actual utilization. This lowers the spectrum of used stoves to a maximum of nine in an individual household as it can be seen in Figure 5-5. Both rurban and rural areas exhibit a similar skewness to the left with only very few cases above five. Rurban households seem to be more likely to have more stoves in use while a great portion of rural households uses only one stove to satisfy their needs. Nevertheless, over 65% of the total sample uses more than one stove in their household.

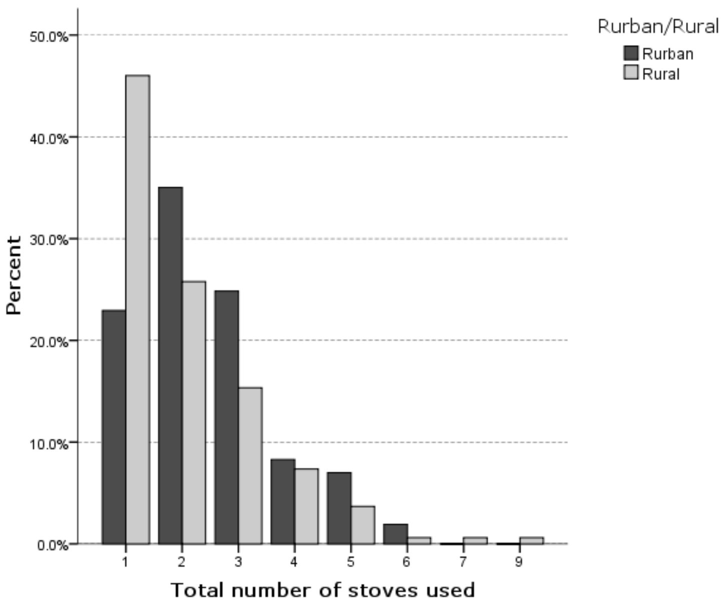

Figure 5-5. *Diversification of stoves used in households by rurban and rural areas*

Sorted by the associated income category, the number of fuels and stoves used within the households illustrate a clear trend as seen in Figure 5-6. While over 60% of rather poor households use on average only one stove, the majority of the medium class has two stoves in use and most of the relatively better off people utilize three or more stoves in their homes. Likewise, poor households tend to use on average fewer fuels than medium or high income class households. The majority of the two later groups consume a total of eight fuels in their households. However, the distribution for middle class households is rather skewed towards the left while a greater portion of better off households tends to use more fuels.

[22] For picture see Appendix VI, page 97.

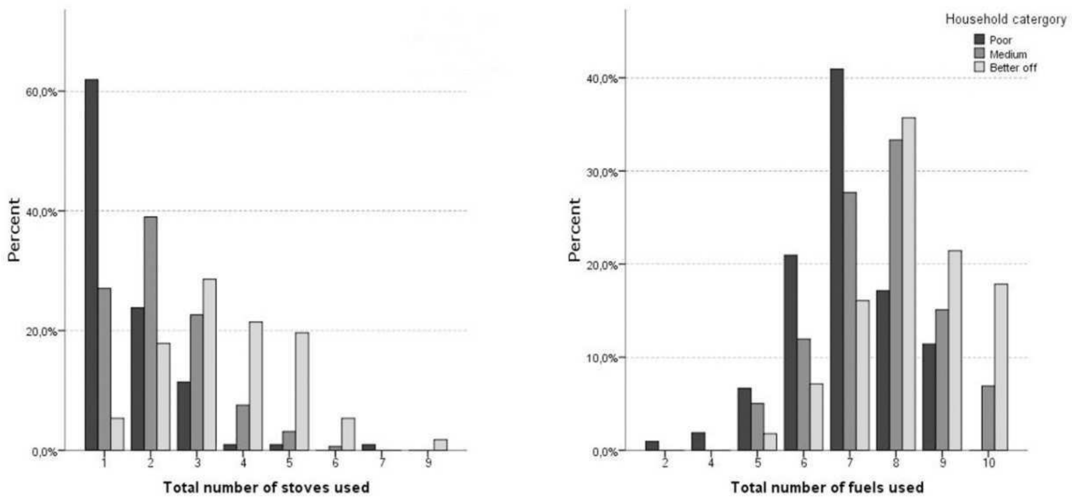

Figure 5-6. *Number of stoves and fuels used in households sorted by income category*

This multiple stoves and multiple fuel approach has often been stated to have many reasons. In order to get more focused and elaborated answers, the question about the reasons for numerous stoves was limited to cooking stoves only, this, however, was with around 64% of the total sample almost all households with multiple stoves [N=206]. In the case of several fuels, a general question about the reasons for the use of more than one fuel was asked. Here it is important to note that unlike with stove the use is not exclusive. Households were asked an open-ended question and were allowed to answer without any limitations and give multiple answers. These were noted down by word and coded afterwards. In both fields quite similar answers were given by the interviewees as summarized in Table 5-6. below. Over 50% of the households using more than one stove mentioned the advantage of being able to cook simultaneously while 57.2% made the stove choice dependent on food type or quantity. Similar statements were given for fuel diversification. 57.5% of the total sample are using more than one fuel due to the fuel´s characteristics and hence make fuel choice dependent on the food type being prepared, the stove being used or in general the intended task. Many households stated in the interviews a preference of firewood in general cooking but preferred charcoal when preparing chapattis due to its particular burning features. Likewise, households stated to prefer kerosene over other possibilities as a main lighting source.

Reason - Multiple Stove	N	%	Reason - Multiple Fuel	N	%
Simultaneous cooking	105	51.0	Food/stove /task	184	57.5
Food type & quantity	118	57.2	Fuel availability	198	61.9
Fuel availability	77	37.4	Seasonal fuel availability	47	14.7
Seasonal fuel availability	11	5.3	Backup fuels	104	32.5
Fuel affordability	25	12.1	Fuel affordability	48	15.0
Wanted new/better stove	57	27.1	Fuel is free	26	8.1
Other reason	68	33.0			

Table 5-6. *Stated reasons for the multiple stove/fuel approach*

Fuel availability is for almost 62% of the total sample a reason for having more than one fuel in the stock. Some additional 14.7% mentioned seasonal availability to be an issue while 104 households stated energy security and always having a backup fuel to be the reason for having more than one fuel. Fuel availability is also subject in terms of stove use. In total, over 42% of the relevant households declared fuel availability and its absence to be a major driver for using more than one stove. Concurrently, the price of fuel is causing the diversification as 57 households state in regard of stoves and 48 in terms of fuels. Some additional 26 households brought up that the feature of some fuels being available for free collection such as crop residues or in some instances firewood is a relative advantage.

All major fuels are relatively versatile in their application and are used for the different tasks. However, no ultimate fuel preference was observed which would limit the fuel use for a particular task to one specific energy source. Instead, for the examined tasks nearly all households were using more than one fuel as indicated in Figure 5-7. Similar observations are made in terms of stoves. In most cases, households used more than one stove per task. The histograms in Figure 5-7. illustrate a normal distribution with an average mean of 2.7 fuels used across the indicated tasks.

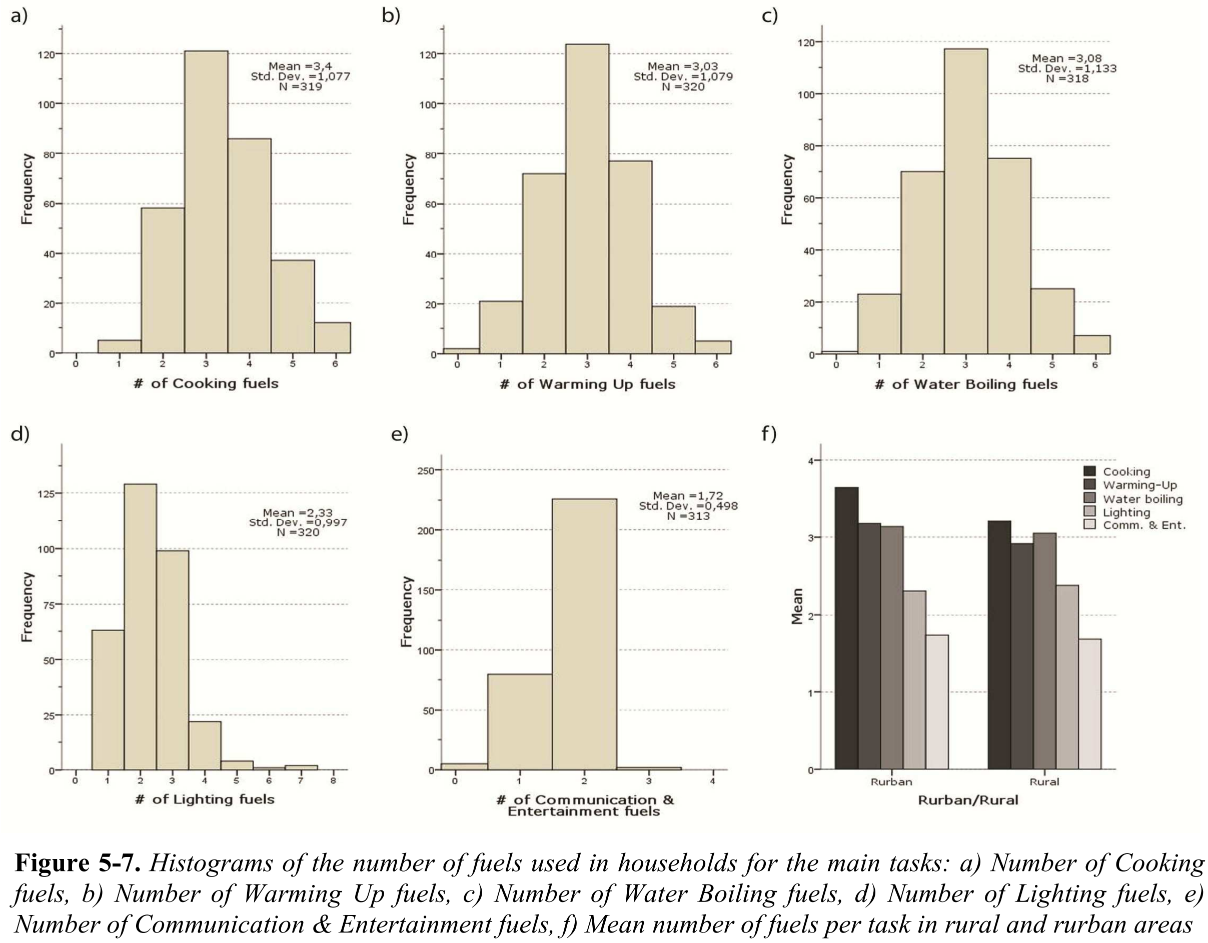

Figure 5-7. *Histograms of the number of fuels used in households for the main tasks: a) Number of Cooking fuels, b) Number of Warming Up fuels, c) Number of Water Boiling fuels, d) Number of Lighting fuels, e) Number of Communication & Entertainment fuels, f) Mean number of fuels per task in rural and rurban areas*

Only the minority of households limit their energy consumption to one fuel for a particular task or are not performing it at all like boiling water for drinking or communication and entertainment. In the case of lighting or communication and entertainment the range of potential option is rather limited which is reflected in the greater portion of households using only one energy source. The differences between rural and rurban areas are rather marginal although there is an observable trend that rurban regions use on average more fuels per task than rural households except in the case of lighting. The resemblance between histograms b) and c) and to some extend a) is based on the households' understanding of these tasks and their interlinked and similar nature. Graph f) illustrates the average number of fuels per task in rural and rurban areas.

Out of the range of potential options the households were asked to identify their main fuel for the individual task. In order to assure for meaningful answers only households with more than one fuel option per task are considered. Figure 5-7. illustrates that this includes nearly the whole sample of 320 households for the individual tasks with only few exceptions. Due to the range of potential fuels the households are assumed to make an elaborated choice which fuel to pick as main fuel. Figure 5-8. summarizes the main task fuels stated by households with more than one option. A table with particular numbers and percentages is added in Appendix VIII. It clearly indicates a general fuel preference for the specific task. While firewood is stated to be mostly used for boiling water, cooking and warming up food, kerosene is the main lighting source in most households. Unlike a), b), or c) the behaviour of rurban and rural households can be distinguished: The electricity use for lighting purposes is in rurban areas significant higher than in rural areas. In the case of communication and entertainment, there is a head to head race between the two main energy sources electricity and batteries or better between the two associated technologies: radio for entertainment using batteries and mobile phones for communication charged by electricity. Here, the households were asked to identify the technology mostly used.

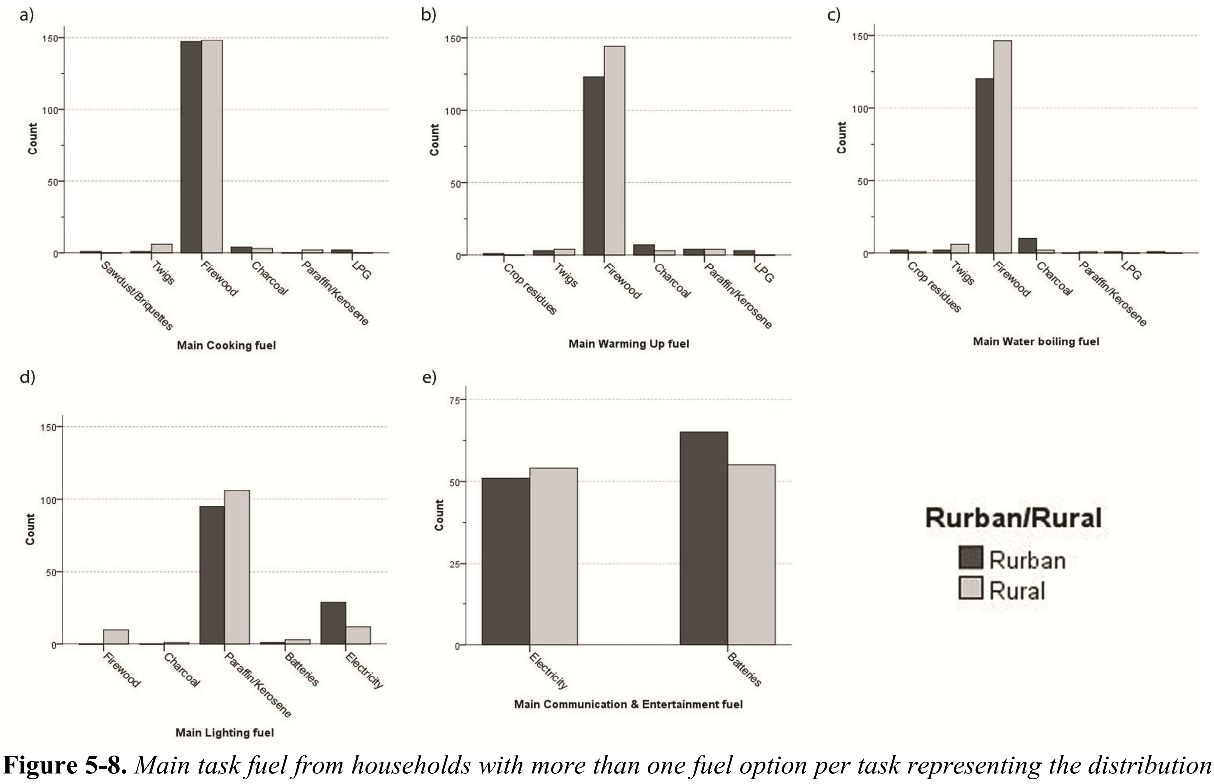

Figure 5-8. *Main task fuel from households with more than one fuel option per task representing the distribution in rurban and rural region: a) Main Cooking fuel, b) Main Warming Up fuel, c) Main Water Boiling fuel, d) Main Lighting fuel, e) Main Communication & Entertainment fuel*

Besides the in Figure 5-8. quoted tasks households utilized their fuels for a variety of other tasks as well. Roasting is besides cooking a common food preparation and includes mostly maize or meat. Although in 55% of all cases firewood was used, the preference of charcoal – statistically stated to be utilized in only around 30% - was quoted many times in the interviews with households as wells as restaurants. In 80% of the situations where space heating was performed, charcoal was consumed. Another energy-consuming task is ironing where charcoal is used in around two thirds of all cases. The red-hot charcoal or in some cases crop residues are put into the metal iron to heat it up. Only in few cases, an electric iron was found.

Based on the assumption that households made an elaborated choice concerning their main task fuel, they were asked about their reasoning which is summarized in Table 5-7. below. Since there was no great difference between rurban and rural areas, these are displayed as total sample. Fuel affordability and availability are a big issue in terms of fuel choice. For their main cooking fuel, over 37% stated that these two features are substantial for selecting the main fuel while some additional 35.6% mentioned the fuel availability significant. Availability includes the market supply of the particular fuel as well as its accessibility in the household's environment such as a nearby forest for firewood or free crop residues from the fields. For their main lighting fuel, households are more concerned about its efficiency and cost-effectiveness: almost a third of the interviewees mentioned this to be an essential factor. However, it is important to note that while only a smaller proportion pointed out the fuel' affordability and its availability to influence the fuel choice, it was observed that many households were comparing their own lighting options. These included in most cases kerosene and firewood where almost all households preferred the first as lighting source due to its better and durable light. Some households put importance into the fuel's flexibility of being portable such as a kerosene or charcoal which heats the space simultaneously. The cleanliness of the main task fuel and production of less smoke relatively to other fuels was only of marginal importance. Equally, only five households mentioned that the technological development or the fuel's inherent social status improvement was of interest.

Reason	**Main Cooking fuel**		**Main Lighting fuel**	
	N	**%**	**N**	**%**
Affordability	18	5.6	49	15.3
Availability	114	35.6	52	16.3
Affordability & availability	120	37.5	59	18.4
Efficiency & cost-effectiveness	43	13.5	102	31.9
Flexibility	9	2.8	20	6.3
Smoke reduction & cleanliness	5	1.6	11	3.4
Development	-	-	5	1.6
Other	11	3.4	22	6.9

Table 5-7. *Stated reasons for choosing a particular fuel as main lighting and main cooing fuel*

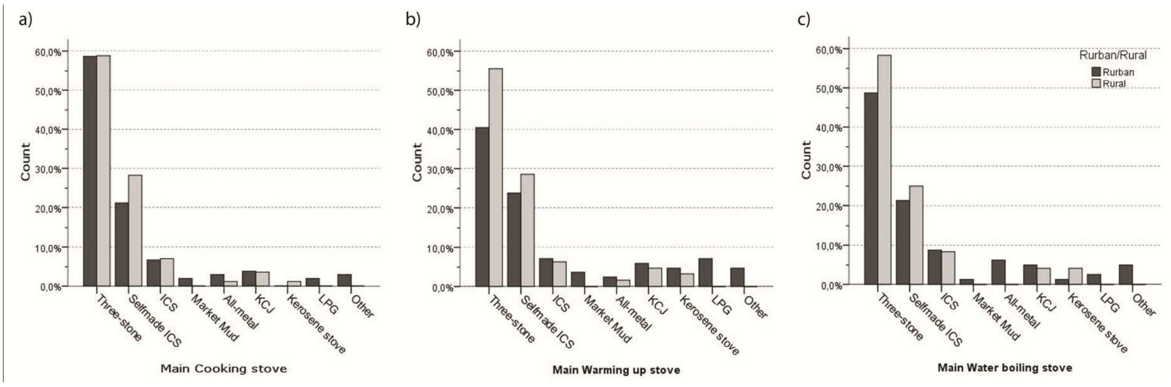

Figure 5-9. *Main task stove from households with more than one stove option per task representing the distribution in rurban and rural region: a) Main Cooking stove, b) Main Warming Up stove, c) Main Water Boiling stove*

In order to make an elaborated visualization of the main task stoves, all cases with only a single stove per task were excluded. Again, the assumption is that households with a number of options will pick their main task stove after comparison to the others and choose the best technology available. Figure 5-9. pictures the stove types used as main cooking stove. Nearly 60% of the households use a three-stone stove as their main cooking stove. Households often emphasised the stove's flexibility as its greatest advantage. The stove size can simply be adjusted to fit every pot and can accommodate every situation. Furthermore, it can be easily extended through additional stoves. Due to the different food types and quantities cooked this stove has a relative advantage over others. Another benefit often mentioned is the stove's ability to be utilized with a great variety of fuels such as dung and crop residues, twigs, firewood, and even charcoal. The great proportion of self-made ICS was mainly found in Ndanai, a region in the Transmara cluster where every household was using such a stove. All other stoves are used rather marginal; none of them reaches the 5% mark. The distribution in graph b) and c) looks to some extend alike. However, a great group of rurban households shifts away from the three-stone as main task stove to charcoal-fuelled stoves such as the All-metal stove or the KCJ. Kerosene- and LPG-fuelled stoves find in both warming up food and boiling water greater utilisation. These tasks are rather less energy-intensive compared to the everyday cooking. Households stated that in these situations LPG or kerosene is preferred due to its greater efficiency and hence speed. Besides the three main tasks, households stated to use the stoves also for other purposes. Nearly 40% of all functioning stoves were used for roasting meat or more commonly maize. Here, the traditional three-stone fire is perceived to be dominant while the KCJ and All-Metal stove account together for roughly a fifth of all the stoves used for roasting. Around 13% of the stoves are said to be used for space heating whereas 54% of households use either an All-metal stove, a KCJ, or one of the other charcoal stove such as the Market mud. The space heating figure however is assumed to be much higher in reality as households did not have enough time to reflect all their stove uses. Similar assumptions are made concerning the rate of stoves used for brewing alcohol. Since such activities are illegal and socially not accepted by the church and society, only 1.4% of the stoves were stated to be used for the distillation of alcohol but it is assumed to be done more often.

Reason	Main Cooking Stove	
	N	%
Efficiency & cost-effectiveness	123	38.4
Fuel affordability	76	23.8
Stove affordability	19	5.9
Tradition & familiarity	21	6.6
Lack of knowledge	5	1.6
Smoke reduction & cleanliness	3	0.9
Other	33	10.3

Table 5-8. *Stated reasons for choosing a particular stove as main cooking stove*

The reasons for households to choose a particular stove as their main task stove are presented in Table 5-8. with focus on the main cooking stove since cooking is the major activity. The stoves efficiency and its cost-effectiveness which are defined as the stove's characteristics to save fuel, time and money through its use compared to other models, was for 38.4% the major reason to choose a particular stove. Fuel affordability was another concern, almost 24% of the sample stated that fuel prices are a major issue. As already stated in terms of fuel choice, many households used for example kerosene and LPG in the past and still own functioning devices. However, recent fuel prices make them uneconomical for those households and prohibit their use. Around 6% declared stove prices to be a restriction in their choice simply because they could not afford another stove model. Lack of knowledge about other types was only for five households the reason for their particular stove choice. In particular old people without family did not seem to get informed about newer or in general other types of stoves. However, 6.6% of the interviewees mentioned that their stove use is based on tradition or familiarity. The cleanliness of a stove and its aspect to produce less smoke than others was only for 1% of the sample of interest.

The general relationship between fuel or stove and a particular task which is described above can be viewed in more detailed for cooking. During the questionnaires and interviews certain fuel and stove preferences for specific type of foods were made clear. Furthermore, several households mentioned the dependency between stove and fuel choice and the type of food being cooked. In the questionnaire the households were asked to identify food regularly eaten and the way it is prepared.

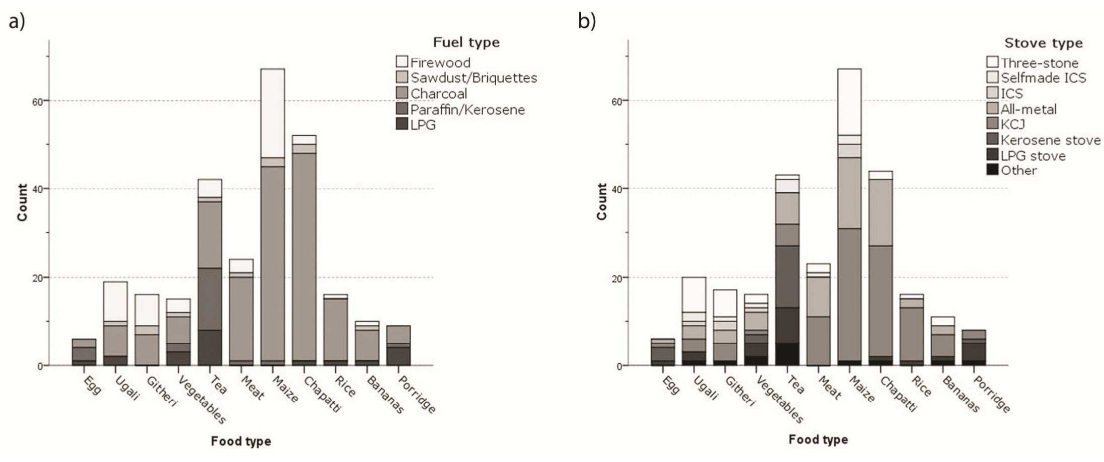

Figure 5-10. *Fuel and stove preferences for specific types of food: a) Fuel preferences, b) Stove preferences*

Figure 5-10. gives an overview of the stove and fuel preferences for the most common food types that were stated by the households. Again, those cases where the main fuel or stove was used were excluded in order to control to some extend for other limitations such as a household's economical restriction to one fuel only. Furthermore, it is assumed that devices that are not picked as main stove or fuel are selected for a particular duty after considering other options. In Graph a) there is a clear dominance of charcoal for roasting meat and maize as well as cooking rice and bananas or making Chapattis, an Indian dish that is very popular in Kenya. In the interviews and during the questionnaires households stated that these food types need a controllable constant and durable heat. Firewood was quoted to be inferior in these cases since it burns very fast at high temperatures and its flame is difficult to control for heat constancy. Especially in the case of Chapattis, nearly all households associate the preparation of chapattis with using charcoal. For the same types of food, Graph b) indicates clear preferences of the charcoal stoves KCJ and the All-metal. Although there is not a significant evidence as for charcoal, the results in Figure 5-10. a) for kerosene and LPG correspond with the notions given by the households during the conversations. Both fuels are in favour for light foods that do not need long cooking time such as tea, porridge or eggs. Here, for more than half of all cases these fuels were preferred due to their efficiency and cost-effectiveness in cooking these foods. Graph b) supports this impression. Kerosene and LPG stoves dominate the device choice when such light foods are cooked. High fuel prices however, limit their everyday use. Although not backed up by Figure 5-9. households tend to give preference to firewood when preparing Ugali or Githeri. These are often cooked in large quantities and are meant to feed the whole family for a couple of days. Households stated the three-stone fire's flexibility to adjust to various pot sizes to be beneficial. Additionally, for larger quantities of food firewood was quoted to be the most cost-effective energy source. Furthermore, households often mentioned the better taste when cooking with firewood.

Literature has indicated a potential relationship between the fuel adoption and the household's culture such as age or the head's educational level. Such connections have been tried to be identified in the current sample through correlation and regression analysis for which the stoves and fuels were ordered and ranked according to the energy ladder. Every variable was tested for a relationship with either fuel or stove adoption as main task fuel. However, no such link could be recognized between the stove or fuel choice and the educational level and age of either the head or the main person cooking. Furthermore, it is assumed in the literature that the social context such as the household size or the head's occupation and hence an important daily environment plays a role on the device and fuel choice. Again, such connection could not be identified between the variables and the final choice as main task stove or fuel.

The stove-fuel dependency was not a major part of the analysis since literature is quite consistent in this point. It is assumed that as further upwards on the energy ladder, the greater is the dependency between fuel and technology. Data collected in order to investigate the potential stove and fuel preferences for a particular type of food allows for drawing a certain picture of the possible fuel-stove applications. Together with personal observations and information gathered in interviews Figure 5-11. could be sketched illustrating the potential combinations between fuels and stoves. While the traditional three-stone fire allows for the utilization of a great variety of fuels, already the GIZ ICS which are designed for greater efficiency and effectiveness, work best with a smaller range of potential fuels. Although these stoves still can burn crop residues or sawdust, their closed design make such use much more difficult and less-effective. Similar self-made models that often might have some improved insulation but lack a liner which is essential for the stove's particular design, allow on the contrary for a great fuel variety like the three-stone fire. However, comparable to the solely charcoal stove KCJ, sawdust is used to light the fire in almost every stove regardless of its actual fuel possibilities. That means that even in the GIZ ICS sawdust is used to start the fire. Furthermore, there are some special All-metal stoves only designed for sawdust which prohibit the use of any other fuel while other All-metal stoves are rather for the use of charcoal. Kerosene wicks and stoves are already much less versatile in fuel options. Likewise LPG stoves or electric plates, these stoves reach high efficiency and effectiveness through the specialization on only one fuel.

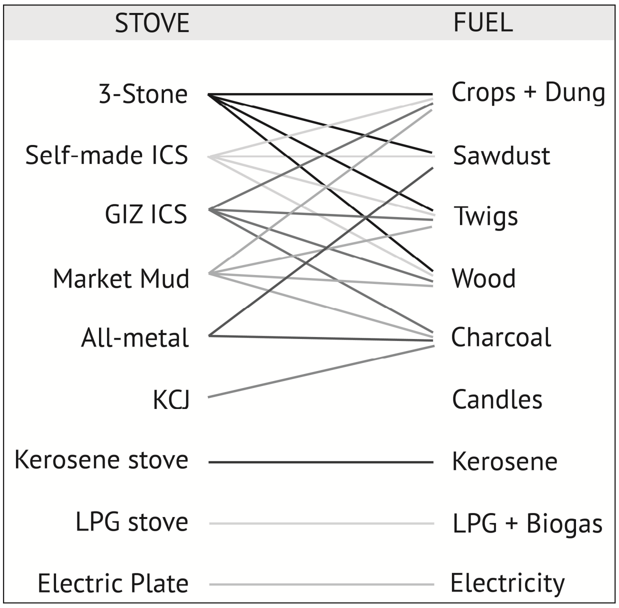

Figure 5-11. *Stove - fuel dependency*

6 DISCUSSION

Energy transition based on the assumptions of the energy ladder model is said to follow a rather linear upwards trend whereby one fuel is substituted by another, superior one in terms of cleanliness, efficiency and cost-effectiveness. This transition process is believed to be highly influenced by the socio-economic means of the particular household. Factors such as age and education of the household's head are understood to affect the final choice to some extent but are rather negligible. Likewise the number of people within the households is assumed to have a certain impact. However, various research studies have identified that households do not follow the linear and substitutional hypotheses of the energy ladder but rather a multiple fuel approach. Additionally, social and cultural factors are increasingly emphasized in the interpretation of household's energy consumption patterns as well as the effect of the individual demanded task on the actual energy choice. Nevertheless, these concepts and ideas are still embedded within the theory provided by the energy ladder and adjust to the given framework focusing on income as main driver. The fuel diversification as well as the "*different energy ladders for different types of applications*" by Fosters et al. (2000) gives the notion that it is not solely about transition towards more superior fuels. The Western world, as relatively rich and hence at the top end of the energy ladder, might stand as example. For cooking there are two major fuels, LPG and electricity – both at the top end of the ladder - which are substituted in some instances such as camping or barbecue for e.g. wood or charcoal: inferior fuels according to the ladder model. Similar, electricity is the dominant energy source in the case of lighting but often replaced by candles due to situation and individual preferences. Adoption and acceptance of energy sources is hence assumed not to be solely dependent on the household's financial means but as well on its cultural, social, and individual preferences. For these reasons, the consistent energy ladder theory is criticised as it does not acknowledge and include these factors. Furthermore, although current research disapproves the model, no alternatives were proposed so far. Since the energy ladder and its interpretation is widely used for many development initiatives, such misunderstanding of energy transition will drive funds into the wrong direction.

Martins (2005) states that as some fuels and associated technologies may be more efficient and cost-effective in providing a particular service, others will prove to be superior for another task. Evans (1987) and Tinker (1980) conclude that fuels are used in a particular task where they prove to be best. Hence it is assumed that the particular task which is intended to be accomplished which defines the actual fuel choice. Based on the assumption that with increased fuel efficiency the device dependency is enhanced, technology acceptance and adoption theory is applied to interpret household's energy consumption patterns and fuel choice. Here, much emphasize is put on the individual and its context while the technology itself and its characteristics play an important role as well. Combining recent energy

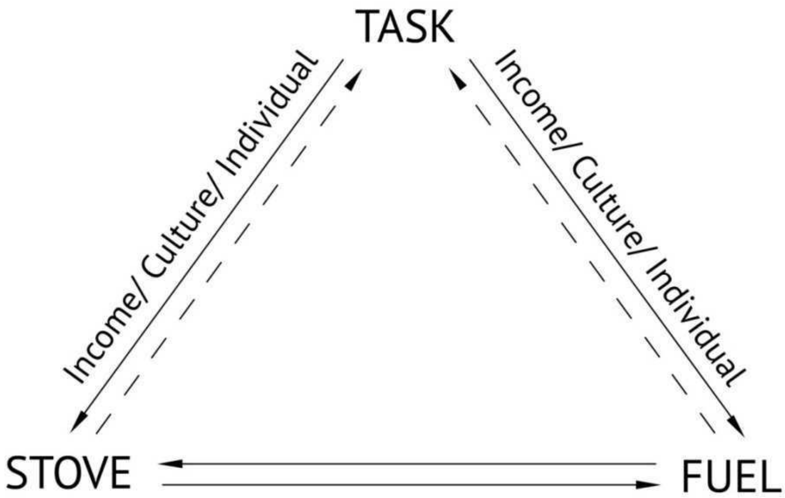

Figure 6-1. *Framework to illustrate the forces affecting fuel and stove adoption and to explain the multiple fuel and stove approach*

transition research with the existing technology adoption theory has led to an alternative framework to describe the individual forces that drive the acceptance and adoption of energy sources and their associated technologies and finally explain the multiple fuel approach. The hypothesis formulated states that fuel diversification has developed due to the multifaceted demands of the households. Figure 6-1., already introduced in Chapter 4, was developed in order to combine the different approaches and present a simple illustration of the dependencies assuming that the task's nature and its context is the main driver for adoption while income plays only a minor role. Besides picturing the stove-fuel dependency, Figure 6-1. emphasizes the influence of the particular task and its context on the stove and fuel choice. Here, the final decision is affected by the household's economic possibilities and culture as well as the individual's characteristics and personal preferences. Culture is defined as well as the social context such as an urban, rural, or rurban environment and hence access and availability, the family size, or specific cultural preferences. Individual characteristics are here understood as age, occupation, and education of the household's head or main person cooking as well as personality traits. According to Hirunyawipada and Paswan (2006:184) a personality trait is defined as *"any characteristic by which a person differs from another in a relatively permanent and consistent way"*. Furthermore, it is assumed that the presence of a stove and fuel will also have an effect on the task itself such as an arising demand of space heating triggered by a charcoal stove.

The research findings clearly indicate that within the representative sample all households follow the multiple fuel approach using a minimum of two and a maximum of ten fuels. While in the case of stoves the results are not that uniform, the majority of households possesses and utilizes more than one stove in their daily routine. Figure 5-6. indicates that the magnitude or the number of fuels or stoves is related with the household's income and the rurban or rural environment. The richer the individuals are, the greater is the average of fuels and stoves utilized. Similarly, a household living in rurban areas is more likely to use a greater variety of fuels and stoves than a rural one. These results indicate that the environment in terms of availability and access as well as income do have some influence on the household energy consumption patterns. Figure 5-3. has indicated a relationship between the increased consumption of sawdust, candles, charcoal and LPG and the income level of the particular household. This conflicts with the theory of the energy ladder since especially sawdust and candles might be viewed as rather inferior energy sources. According to the energy ladder, households switch with increasing income to more efficient energy sources along the ladder model and discontinue using their old fuels. The above results, however, indicate that rich households do not stop exhausting these resources but even increase their consumption. Such behaviour demonstrates that income does not necessarily influence the quality of the energy consumed but rather its quantity. In the case of sawdust, interviews have indicated that relatively rich households had a much better social network and hence knew earlier than other when and where sawdust would be available. Therefore, in these cases, it is not the financial but social capital that is the decisive factor. Candles, although much less efficient and much more expensive as kerosene, are bought for their cultural and ritual value and use mostly only on special occasions such as birthdays or baptism. Again, likewise sawdust, candles were increasingly used proportional with income. One further use often stated by the sample is as backup fuel in the case of kerosene shortage at the petrol station. Comparable reasons where stated for the almost universal use of crop residues, twigs or firewood as well as charcoal. Especially the latter is in some areas due to the local restrictions of charcoal burning very difficult to find. One interviewee in the Western Cluster stated that "*to get coal, it is not easy. You cannot go in the forest and burn charcoal. If you are found you are arrested and taken to court.*" Especially around Kakamega forest in the Western Cluster, laws are very strict about cutting wood in the forest and burning it to charcoal. Despite the risk of being caught and arrested, illegal cutting and burning feeds the charcoal black-market in this region. Further investigations were not possible as households were too scared to talk about their charcoal sources. Charcoal is hence often bought in larger quantities and stored in order to overcome these shortages. In other regions, charcoal is primarily used as substitute for firewood especially in the rainy seasons where dry wood is scare. Households that do not have the option to buy dry firewood either store and wait until it is dry or use instead of their usual stove the traditional three-stone fire: "*If wood is not dry, we just cook […] with the three-stone.*" During the course of the questionnaires, seasonal fuel availability due to weather and yield as well as supply shortages for kerosene at the petrol stations were very often quoted as reasons for diversifying fuel ownership and use. Households stated the importance of being energy secure and always wanting to have a backup fuel. Having more than one fuel and stove hence seems to be insurance for times of fuel shortages. This was also stated by around 40% of the sample questioned for the reasons for having multiple stoves. Figure 5-11. illustrate the great versatility of many fuel which allows using them in various kind of stoves and hence increases the independence and energy security. In the interviews, it was mentioned that it "*is nice to have that many different stoves […] I am independent with the fuels and stoves*" and further "*it could be more economical to have more than one stove for cooking instead of having only one*".

Affordability is also an issue for the relatively rich households and is stated as reason for fuel diversification. Affordable or even freely available fuels such as crop residues or twigs and firewood out of the household's compound are used as substitutes or main fuels in almost every case. "[We use sawdust] *only if we have this fuel. Like now I have five bags around, if it is empty I look for another one or I forget about it and we use wood [...]. If there is sawdust I send my kids to collect it."* This quote by a woman from Western Cluster describes well the dominant household consumption patterns. Free energy resources are more than welcome and are utilized until they are exhausted but are due to their irregular supply not necessarily the main fuel but rather a substitute. Many households summarized their multiple fuel use being due to their attitude that they would use every flammable resource in their stoves. The behaviour "*we use what we have at hand"* is maxed out by households using even plastics to start their fire. How affordability influences fuel use is demonstrated in Figure 5-3. showing that such high-end energy as electricity is used almost by the entire sample. This is achieved by a wide-spread system of charging stations where people can charge their individual devices mainly mobile phones for a negligible fee. Likewise is the use of kerosene and Batteries which also can be purchased in small units. Within the sample, most households tended to buy kerosene rather on a daily base in marginal quantities due to their lack of larger cash flow per day. Contradicting the energy ladder, these findings indicate that income seems to play a certain role in fuel choice but becomes rather minor when e.g. effective distribution strategies are provided such as good availability and the possibility to purchase the fuel in small units. In many villages local distribution systems have established where firewood or charcoal is sold directly at the household level from neighbour to neighbour. In two more rural villages even kerosene was sold in this manner. Being bought in the main district cities, the two selling individuals used this opportunity as a simple side-business along their main activities in the cities. In the case of electricity charging stations which have proven to allow electricity use despite the household' financial situation, some individuals stated during the questionnaire that their electricity consumption is rather low due to the far distances to one of the charging stations. In general, electricity grids were available in almost all regions with only few villages not having a line nearby. Nevertheless, the connection to the households as well as charging stations was rather rare. Relatively rich households stated during the interviews their wish and financial ability of being connected to the electricity net but mentioned the high up-front costs of such an investment. Further, even in cases where such barrier could be overcome, access to the existing grid was not possible due to organisational, bureaucratic or other obstacles. Similarly, the case of charcoal described above where households have difficulties to access enough quantities to secure their demand due to a low and unstable supply. The problem of access to stove models by households was obvious in a number of local markets and nearby larger trading centres. In most cases only a small variety, namely the KCJ and some All-metal stoves, were put to offer while few other alternatives were only available at the markets in the main district cities. Davis (1998) and Hosier & Kipyonda (1993) and others have come to the conclusion that fuel availability and access to it are key reasons for its adoption. The above analysis has revealed that such factors also affect the adoption of stove and fuel within the studied sample.

While access and availability influence the adoption and drive households to possess more than one fuel or stove due to energy security reasons, Figure 5-7. also allows another view on the issue of fuel diversification. The figure on page 50 indicates that almost all households use more than one fuel for a particular task demonstrating that for each particular task a variety of fuels are suitable and can be adopted. Nevertheless, the initial assumption of clear preferences for a specific fuel for each particular task is confirmed in the following Figure 5-8. While firewood dominates in all cooking related activities, kerosene is most preferred for lighting. Only the categorisation Communication & Entertainment does not present a clear indication of a particular main fuel. Here the households had to choose whether they use more their mobile phone and electricity or radio and batteries [both devices were present in almost all households]. The question is not only about the technology and hence energy source used most but rather about the intended task: making phone calls or listening to the radio. Over 57% of the sample had answered the question about the reasons for their multiple fuels that their particular fuel choice depends on the task itself and its requirements. For example even in the case of general food preparation where firewood consumption dominated the entire sample, households differ in special cases from their overall preference. In the individual interviews a significant number of households stated their preference and use of kerosene and LPG for warming up food or boiling tea due to speed and efficiency. Furthermore, for lighting the fire, various interviewees as well as questionnaires pointed to an increased use of sawdust and crop residues. These are favoured as they catch fire very quickly and burn with a sufficient heat to ignite the main fuel. But the actual fuel preference might also diverge from the general main cooking fuel and stove because of the food intended to be cooked. While some food types need a controllable constant and durable heat and hence charcoal is applied, kerosene is in favour for light foods that do not need long cooking time such as tea, porridge or eggs. In Transmara Cluster, one household declared that *"gas, you cannot use it for boiling water. [...] it takes a lot of energy [...] but maybe for boiling tea or milk"*. Such clear fuel and stove preferences associated with a special food were also observed in all four interviewed restaurants. Githeri, for instance is only cooked with an All-metal stove and charcoal; and it was emphasized by the interviewee that gas cannot be used here. Gas is only meant to be used for light foods that need only about 30min of cooking like eggs or soft meat or warming up food. Githeri however, is cooked over a long period of around 3 to 4 hours until the hard beans and maize grains become soft. Using gas was stated to be uneconomical for such foods. Charcoal and all kinds of associated stoves where dominantly used in restaurants for roasting maize or meat while sometimes also applied to heat water. Kerosene, however, was rather unpopular since it rubs off some of its smell onto the food and alters its taste negatively.

Besides the efficiency and cost-effectiveness criteria, taste plays an important role that even households using charcoal as their main cooking fuel regularly consume firewood for special dishes. The smoky flavour associated with firewood or charcoal is wanted when preparing e.g. roasted meat or maize or cooking traditional green vegetable dishes. Similar behaviour can also be observed in Western societies where barbecuing is highly associated with charcoal despite various alternatives such as gas, sun or electric grills are on the market. One of the interviewed institutional kitchens belonged to an abbey and was known to have its own borehole for clean water supply. In general, the tap water in Kenya has a high rate of contamination and is rather unsafe to drink directly. In the abbey's kitchen the clean and safe drinking water, however, had to be boiled over a fire or using charcoal to take up the unmistakable taste of smoke. This was due to the wish of guests wanting to be sure about the cleanliness of the water. This could not have been reached using another type of energy source such as boiling the water with an electric kettle. This demonstrates that taste sets the preferences and even prohibits in some cases the use of alternatives. Culture and tradition is another factor that determines adoption. The preparation of Chapattis is on one hand associated with the use of charcoal due to the fuels characteristics to provide constant and controllable heat. On the other hand, tradition and culture also influence this connection since it was stated more than once that Chapattis also can be made with firewood. In some regions such as around Nairobi and Murang'a, the relationship between Chapattis and the related use of charcoal was rather unknown. Nevertheless, in other regions of Kenya households were stating that traditionally Chapattis were a special dish only prepared for Christmas and charcoal had to be used. Due to this traditional background other fuel options such as firewood are not even considered. Although within the survey only 6.6% of the households mentioned tradition and familiarity as reason for their particular main cooking stove choice, one person in Western Cluster has summed up the ideas gained in other interviews as well as questionnaires: "*We cannot leave the three-stone, it makes us remembering the culture"*. This reminds of Bonfil-Batalla (1990) who formulated the sensation of rural communities persistently using traditional stoves as a result of the "autonomous culture" in order to keep their culture alive against the wave of adopting western values and technologies. However, over 27% of the sample stated being asked about reasons for their multiple stoves that the number of their stoves had piled up since the household wanted to have a newer and better stove. Although only five households mentioned the development or progress aspect of using their main lighting fuel, the number of individuals using a specific fuel or stove for its modernity is assumed due to the other findings to be much higher. This implies that the stove and fuel inherently also hold a social status as Masera et al. (2000) have already noted it. This is backed up by a household that uses "*firewood for everything [...] only if guests are there* [we] *cook with charcoal"*. This implies that the fuel choice comprises a certain social status where the use of charcoal indicates a richer household compared to one using firewood. In general, households tend to like "*modern stoves"* made out of bricks while "*clay is for poor people"*. Symbols indicating the social status of a household are very important within the communities. Mobile phones and other valuables were exposed during the interviews and questionnaires as well as family members changing into their best dresses after welcoming the research team. Based on the quotes and observations, particular fuel use as well stove possession is also part of the social status indication.

Within the sample fuel and device choice has also been observed to be affected by the situation and context of the task. While some households might have particular preferences for a stove and fuel in connection to a special dish, the context of its preparation might change these. The choice not only depends on "*which food we are cooking [...]* [but also] *for* *how many"* as it was answered by one restaurant in the Central Cluster. Also households were actively selecting their fuel and stove not only according to the food type but as well the quantity intended to cook. Over 57% of the surveyed sample has stated that these play a role in their stove choice. "*When you want to cook Ugali for a good number of people, for example above ten, you cannot cook with the Jiko Kisasa. I have to move to use the three-stone."* This is due to the smaller pots the Jiko Kisasa can only hold while the three-stone fire is flexible in its size and hence can hold any pot size. Furthermore, many of the more advanced stoves such as the Jiko Kisasa are affected by hot water drops causing cracks in the clay structure as well as tend to break easily under the weight of the pots. Many households mentioned in the questionnaire, that while they preferred another stove such as the Ceramic Jiko with charcoal for their general cooking, they had to use firewood and the three-stone fire for cooking Ugali due to the big portions and hence pot sizes. The sticky paste of Ugali needs to be stirred continually putting much pressure on the stove and its pot-rests. Again, the three-stone fire is of advantage due to its solidity and flexibility to adjust to any pot proving a stable surface for the pot limiting its potential movement due to stirring. Likewise, Githeri, another traditional dish often served, is cooked in great quantities and warmed up later on using eventually another stove and fuel. This illustrates that in general the stove adoption is always dependent on the local cuisine and cooking habits of the population. In addition, time is an issue when choosing fuel and stove. While firewood might be the dominant fuel in general, households use faster fuels like kerosene or gas for the same tasks "*when you are late or in a hurry"* or for cooking in the night. Similar behaviour is observed when guests are present. Since firewood needs a lot of attention due to reasons of security and constant combustion, other fuels are then preferred. *"Firewood needs too much time, you need to sit beside to blow [...]. If there are guests* [we] *also use gas. You don't need to stay at the stove"*. Here the time-savings and the possibility to move from the stove and spend the time with guest was the key reasons to deviate from the main fuel firewood. In general, as reason for their main cooking stove, the majority of households quoted among other things the time-savings as a principal motive for their adoption. Especially in the case of ICS, designed not only for saving fuel but also time, this issue was of great importance. Some households stated that also other factors such as weather and hence the location of the activity influences the choice. While there is rain, interviewees preferred to sit inside and rather use a less smoke intense charcoal stove. On the contrary, the same households would utilize firewood in their outside three-stone fire when the weather were appropriate.

Although some literature suggests a connection between the stove and fuel adoption and individual characteristics of the household's head such as age, education, occupation, or family size, no such relationship could have been identified. However, in the technology acceptance and adoption theory and in particular the 'Unified Theory of Acceptance and Use of Technology" by Venkatesh et al. (2003) much emphasise is put to the individual's characteristics such as age or education. Together with other individual's character features and personality traits these are assumed to play an important role in shaping the technology's "perceived ease of use" which in turn determines how individuals think and behave in different situations and finally whether they adopt or not. It is therefore assumed that despite the contrary analysis results, there is a certain relationship between age, education, occupation, or family size and the adoption of technology. In the context of energy-efficiency technology adoptions in existing Swedish residential buildings, Nair et al. (2009) have indicated that individuals features such as education, age and contextual factors influence household's preference for a particular type of energy-efficiency technologies. In Kenya, for instance, there were some rural elderly women cooking on their traditional three-stone stating that all the other, newer models such as the ICS were "*only for the young women*" and that they would not need such things. According to the adoption theory it is therefore suggested that these character features cause people to adopt or reject a technology. However, the different forces have to be treated with caution. While the above quote illustrates that younger women are more expected to adopt, observations in the field are rather contrary. Instead, younger families were cooking on the traditional three-stone fire or charcoal stove while more elderly households owned ICS and other modern stoves. These, however, were likely to have travelled and have seen a lot and were often well educated. Other elderly households, especially in rural households, do not have a consistent education, mostly only of few years. In their youth, education and schools were not valued high so they were kept by their parents in order to help in the household or on the field. When equalizing the level of education to some degree with the level of knowledge and information about technology, the level of education would be proportional with the adoption of new technology. The ICS technologies for example are often presented and explained in schools and colleges. That means the longer individuals would stay in formal education, the greater would be the knowledge about available technologies. Also understanding the associated health and environmental impacts of using traditional biomass fuels would strengthen the adoption rate. Although only five households mentioned lack of knowledge about other devices as reason for their main cooking stove, many other households were initially not aware about ICS for example and were highly interested to learn about them. A follow-up with the enumerators who were trained builders has shown that after gaining information about the ICS and the related benefits, the general adoption of ICS in the region was much higher. Schlag & Zuzarte (2008) confirm such notion stating that many households do not realize their options or the impacts of their biomass consumption. In the field of farming technology, Besley & Case (1993) have modelled the technology adoption in developing countries and came to the conclusion that knowledge gains in any form - either directly or through the observation and experience of others - are highly coupled with the adoption of technology. Knowledge about a technology can also be acquired through others through observation or communication from person to person. Larger households have therefore an advantage since more there is more potential to hear and learn about a technology. According to Rogers (2005) individual's willingness to adopt a technology is related to others' decisions where people observe others and infer about the usefulness of the technology. In agreement with that, occupation is expected to perform a certain function within the adoption process. While one must account for the relationship between occupation and education which has its own influence on the technology adoption, the social context and human interactions given by the work place is of importance. Corresponding to this, an individual working alone only on the field will be less likely to adopt a technology than a person working as salesman due to the social contacts. These provide on one hand further information and therefore enhance the chance of learning

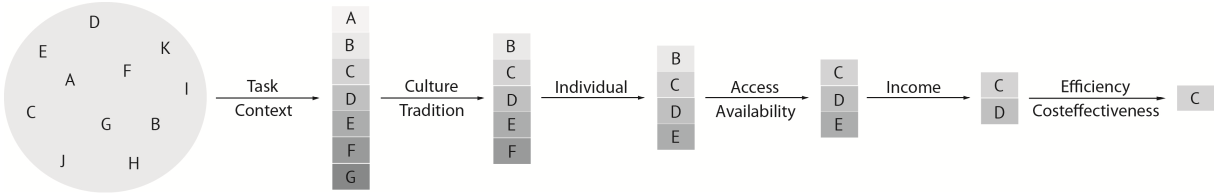

Figure 6-2. *Framework to explain and illustrate the stove and fuel adoption process by households*

about technology. On the other hand, the decision and experiences of others will influence the individual's choice.

Figure 6-1. illustrates the above described relationships very well and is a good tool for not only explaining the dependencies in stove and fuel choice but might also be adopted for other technologies. The triangle describes that it is not only income determining stove or fuel choice but rather the nature of the intended task and its context. Income then influences the final choice along other forces such as the individual's personal characteristics and the underlying culture with its associated behaviour norms. The ownership and use of numerous fuels and stoves is therefore explained by the various demands of a household. However, based on this concept and the presented results a further model is developed to explain the actual adoption process of a household. This new framework is presented in Figure 6-2. It is assumed that out of the pool of all stoves and fuels those are selected which are high in ranking based on their efficiency and cost-effectiveness and hence suitable for the particular task and its context. This, however only excludes the highly inferior fuels and stoves. Candles for instance might function to some extent as an energy source for cooking but are rather highly inefficient and not cost-effective hence not suitable for general cooking. In the case of keeping tea warm, however, candles might demonstrate to be superior relative to other energy sources. Furthermore, as expressed earlier, also the task's context has some influence on the suitability of a fuel or stove. While for example one fuel performs well when cooking for only two persons, it might be inferior to other options when the number of people increases. After the first possibilities are eliminated, cultural and traditional issues become a concern. Several fuel and stove preferences have been described that are based on the individual's culture and tradition. Specific food types for instance can only be cooked with certain fuels and stoves due to the particular taste associated with the fuel. Further, some stoves simply do not allow holding traditional pots or are not equipped to adjust to the local cuisine attitudes such as preparing great quantities at once. As Rogers (2005) has put it, a technology has to have a certain compatibility with the targeted population's culture. In this thought, the concept of 'appropriate technology' was developed in the early seventies for ensuring technology designs that satisfy rural people needs (Shumacher 1973). Under that definition, a technology is 'appropriate' when it is responds to the users' need while respecting their culture and tradition. Individual characteristics such as age, education, and other personality traits are assumed to influence the behaviour towards a technology or the energy source and hence influence adoption. In technology acceptance theory, the adoption lifecycle [Figure 3-4.] presented on page 24 illustrates the timespan when different personalities are likely to adopt a technology. Rogers (2005) and Moore (1991a) have categorised six groups of adopters and have allocated them a number of characteristics which are said to influence the behaviour towards the technology. Risk aversion for example is one of the features which in turn might also be affected by the individual's age and education as well as the family size. Brown & Venkatesh (2005) have illustrated that family size as well as its composition of members in terms of age and status, affect risk aversion and hence affinity for new technologies. Furthermore, since households also have to be informed about potential options and be aware about their benefits in order to have them as a possible choice, education put on a level with information is crucial for the adoption process. Availability and access and hence income restriction exclude further potential fuels and stoves. Although some fuels might have been ranked very high concerning their efficiency, they are either not available in the particular region or not affordable for the households. The above analysis has demonstrated these constraints and their effect on the household's choice. These limitations reduce the number of choices further. However, the households still have potential options available. Out of these, the most superior alternative in terms of efficiency and cost-effectiveness is chosen by the household to accomplish the intended task.

The framework is based on the tested and verified model illustrated in Figure 6-1. and the underlying assumption that the intended task and its context are the decisive factor determining the potential fuel and stove options. The final adoption however is attributed then on the individual's characteristics and culture or tradition, the environment and access and availability of the options, the household's financial means. Finally, efficiency and cost-effectiveness of the remaining choices are the determining aspect. Based on the result-proven hypothesis of Figure 6-1. the stove and fuel diversification is here explained by the multiple demands and needs of the households. Since every single task might lead to a different fuel and stove preference, a household has to possess many stoves and fuels to fulfil all needs. Figure 5-6. has indicated that richer households seem to possess and use more likely a greater number of stoves and fuels compared to a relatively poor household. This is understood that a rich households faces less the choice limitation caused be its income and hence has a greater variety of potential fuels. For the intended task, the household will always choose the best fuel and stove. Following that assumption, a richer household having the financial means will specialize its fuel use and use specific fuels for a particular task only. Furthermore, such household can afford a variety of fuels. In times of fuel shortage due to lack of supply at the distribution centres or due to seasonal events such as rain, a richer household can afford not only the free or cheap alternatives but also those more expensive. Such fuel stocking behaviour for energy security reasons is quite an important fragment in the multiple fuel use idea. Households want to and have to be prepared for every situation and context. Although the described model in its form fits reality very well according to literature and own research findings, the individual dynamics are acknowledged not be static but interchangeable in their order. While the first selection due to the intended task is fixed, one could argue that access and availability as well as income do play a greater role than culture and the individual's characteristics. It is therefore recognised that the general order can be switched. Access and availability of the fuels and their associated devices are certainly a crucial factor for their adoption as the research has demonstrated likewise is income and price which constraints the potential options. One could therefore also argue that these factors should be at the front of the adoption process followed by all the other elements. The proposed order, however, wants in contrast to the still dominant energy ladder model to emphasize the cultural and individual's characteristics over external decision dynamics such as access or fuel and stove prices and income. A greater research sample with a more focused analysis on quantifying the weight of the various forces in the adoption process might allow for an elaborated clarification and eventually redesign of the framework. Furthermore, it is acknowledged that not only the order is interchangeable but that households consider all factors rather simultaneously and not in a lengthy process. However, Figure 6-2. intends to illustrate that every model component has a limiting force and influence on the final choice. Additionally, this model only represents a simplification of reality and does not strive to include all potential factors that might influence the adoption of a stove or fuel. Instead, it is designed as a universal tool and meant to be applicable also in the general technology adoption theory. Most of the recent research in technology acceptance theory has been applied in the context of information technology. But also other fields can be served with the adoption process model. As example might stand music equipment and the intended task of playing music. The most dominant storage and play-back technologies are those of LP, CD, and MP3 while others such as MiniDisk might be negligible in their use and distribution. Today, MP3 system are the one mostly used, followed by CD and finally LP. Although, being already for decades on the market, the LP has shown consistency with even an increase in market shares in recent years. The context of the task - listening to music at home or on the way - will reduce some of the options. Though there are some portable LP systems, these cannot be used "on the go" or in motion but need a static surface. CD and MP3 systems do not experience such limitations and can be used with high flexibility. Since these technologies are not homogenous in themselves but differ from producer to producer further considerations have to be made about the particular product within the system field. Cultural preferences might not be that significant in this case although the social background and environment might have some influence on the final choice. The LP music system is often enjoyed in rather alternative milieus. Likewise is the digital music product by Apple who has most successfully developed a whole cultural and social identity for their products. Individual's preferences are here probably the most influencing force. Device and music medium aesthetics as well as sound predilection will shape the final technology choice ranking. Access, availability, and income will limit the potential options while the last decisive building block efficiency and cost-effectiveness might be understood as the easiness of use and price-performance ratio.

In result, households are using their multiple fuels as well as stoves in order to fulfil their individual needs. Due to the miscellaneousness of the households' demands, many fuels and stoves are needed explaining the stove and fuel diversification. According to Foley (1995) subsistence households at the ground level only demand fuel for cooking purposes, usually in form of gathered wood. But as households' economic conditions improve they will expand their demands, e.g. including lighting, space and water heating and even brewing. Foley therefore shifts away from the sole monetary value of an income increase and focuses on the side effects such an increase might bring along. Unfortunately, statistical tests did not reveal any norm whether the number of tasks is related to income, household size or any other variable or how these demands are formed. Almost all surveyed households were practicing the same main tasks with only few exceptions. Some families for instances were not boiling water for reducing its impurity while others did not own a mobile phone or radio. Especially latter is assumed to be associated with a lower income level but could not be statistically confirmed. However, rich households were observed to practice their task more often in form of cooking three instead of two times a day as other households used to do. Further, the communication & entertainment sector is much greater in households with a higher income. In general, the number of mobile phones was higher as well as was the chance of finding a TV and other electronic devices in a better-off household. Hence it can be assumed that income influences task demand. The reviewed literature on demand creation focuses mostly on marketing strategies to promote certain products or services. Information about the benefits of owning and/or using a product or services is as important as the understanding of the product or services by the individuals itself (Koerner 2008, WSP 2010). Information about a particular task, its use and benefits as well as knowledge about how to accomplish it is expected to highly influence the acceptance of the task. The actual adoption of a task and associated technology or behaviour is assumed to follow then again the process described above in Figure 6-2.

7 CONCLUSION

In the past, energy transition of households was dominantly interpreted in light of the energy ladder model which puts much emphasize on the economic background of a household. Recent research, however, has indicated that households do not substitute one fuel for another while they ascend the ladder but follow a rather multiple fuel approach. Furthermore, social and cultural factors are considered to influence fuel choice. Nevertheless, all reviewed studies still use the energy ladder as a framework for interpretation and do not offer an alternative explanatory approach.

This research aimed to fill this gap and explain this fuel diversification by introducing a new model and applying technology adoption theory in the interpretation process. The latter is possible due to the dependency between fuel and stove which increases with every step upwards on the energy ladder. The underlying assumption of the model - the multifaceted demands of the households are the major driver of the multiple fuels and hence stove approach - has proven to be the case for the particular study area. Most households own and use a variety of different fuels for a particular task but have in every case a preference for only one. Energy security in the case fuel supply shortages at the distribution centres or due doe seasonal events such as rain was often stated to be an important reason for such fuel diversification behaviour. However, context and situation of the fuel and stove use was much emphasized to shape the stratum of potential fuels and stoves and proves the assumption of task dependency. Households want to and have to be prepared for every situation and context. Not all fuels are appropriate for an intended task in terms of efficiency and cost-effectiveness. Furthermore, the number of potential fuels is then reduced through the task specific context. While some fuels and stoves serve well when e.g. cooking for only a small number of people, these might be inferior compared to others when cooking outside for a greater number of people.

The influence of income on the household’s stove and fuel choice cannot be neglected: results do indicate a relationship of the household’s financial means and its energy consumption patterns. Nevertheless, this relationship is found to be rather about the quantity and not the quality of energy consumed. Similar, higher income households tend to have more fuels and stoves in use than relatively poorer ones. Again, energy security is an issue which accounts to the multiple fuel use. Through an elaborated distribution system of small shops offering electricity charging services, almost all households were using these facilities. In other cases, inferior fuels such as charcoal are not used due to the problem of access. The notion develops that income does have some effect on the household’s choice as it limits the potential options but that availability and access do play a much greater role. Questionnaire data and interviews revealed that the household’s culture and tradition such as cooking practices highly influences the stove and fuel choice. While some fuels and stoves are appropriate for e.g. preparing Chapattis such as with firewood on the traditional three-stone fire, households prefer for this task charcoal stoves due to taste preferences and tradition. Personality traits such as age or education were not found to be statistically relevant but are assumed to have a certain weight on household's selection. Information about a technology and associated benefits has been demonstrated to be crucial for technology adoption within the context of cooking stoves as well as other settings.

The research results and the proposed model describing the individual forces and dependencies for the particular stove and fuel adoption has led to the development to a further framework illustrating the technology adoption process in this particular setting. This follows the notion of the previous model with its underlying assumption that the multiple fuel approach has developed due to the multifaceted demands of the households and that these limit the actual possible technologies. As research has demonstrated the fuel diversification is a consequence of the various household's needs and the different fuels used to fulfil these demands and being prepared for every situation. All other indicated factors further shape and limit these potential options while cost-effectiveness and efficiency means determine finally the actual adoption and use.

Although being developed within the context of stove and fuel adoption, the proposed framework is also understood to be applicable in other settings for interpreting and explaining technology adoption. To verify the model, similar studies are recommended with focus on the testing and verification of the underlying hypothesis and the framework itself. It is suggested to perform these in a comparable setting with stoves and household energy consumption patterns as well as in different contexts. Further, more emphasize could be put on the forces that drive task and need creation of the household and hence influence highly the technology adoption. Quantification of the various factors that drive adoption would allow for a better model and the interpretation of the energy transition process and finally how to influence it.

This is in particular of interest of various development initiatives that try to implement clean cooking technologies for human and environmental improvements. The traditional approach of the energy ladder focuses only on income alone as determining factor. Likewise all further findings that extend that view or even disprove were using the given framework of the energy ladder without offering an alternative. Without a simple designed model illustrating the forces as well as the process of technology adoption, development initiatives will be lead into a wrong direction. The here proposed framework intends to give these initiatives guidance and a better understanding of the various influencing factors that need to be considered when implementing a development program associated with technology. Likewise is the presented model for any government of help for successfully implementing energy or related policies. Through a better understanding people's adoption of fuel and technology these policies can be designed more effectively and efficiently without any negative effects. However, due to the versatility of the model, it can also be applied by businesses that want to implement a new technology or, in general, understand better how to improve their adoption rate.

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APPENDICES

APPENDIX I - LOCATION PROFILE

LOCATION PROFILE

Cluster ______________________ Location ______________________

Sub-Location ______________________ Village 1 ______________________

Village 2 ______________________

Location category: ☐ semi-urban ☐ rural

# of people: Location __________ Sub-Location __________ Village 1 __________ Village 2 __________

# of HH: Location __________ Sub-Location __________ Village 1 __________ Village 2 __________

# of streets: Village 1 __________ Village 2 __________

n^{th} HH: Village 1 ______ th HH Village 2 ______ th HH

Interpreter's n^{th} HH: Village 1 ______ th HH Village 2 ______ th HH

Name of nearest main city: Village 1 ______________ Village 2 ______________

Approx. distance to main city: Village 1 ______________ Village 2 ______________

Name of nearest trading centre: Village 1 ______________ Village 2 ______________

Approx. distance to trading centre: Village 1 ______________ Village 2 ______________

# of people in trading centre: Village 1 ______________ Village 2 ______________

Approx. distance to highway: Village 1 ______________ Village 2 ______________

Landscape: ____

____

Availability of free wood: ____

____

____

Rainy seasons: ____

____

____

Growing seasons: ____

____

____

Cash crops: ____

____

Food crops: ____

____

Fuel Price: Firewood______________________________ Kerosene_____________________________

Charcoal____

LPG___________________________________ Other________________________________

Fuel availability: ____

____

____

Stove Price: KCJ____

Portable Kisasa__________________________ Fireless Cooker ______________________

LPG meko______________________________ Market Mud___________________________

All metal____

Kerosene wick____

Other____

Stove availability: ____

____

# of locations in Cluster___________ # of sub-locations in location__________

# of villages in sub-location _______ # of pp./HH in sub-location___________

APPENDIX II - HOUSEHOLD QUESTIONNAIRE

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

A SURVEY ON ENERGY & STOVE TRANSITION AND POTENTIAL DESIGN ADDITIONS TO THE GIZ PSDA PROGRAM KENYA IN THE THREE CLUSTER OF WESTERN, TRANSMARA AND CENTRAL

Date ___________ Beginning Time ___________ Ending time ___________ Serial No. ___________

Interviewer's name ________________________

- Cluster ________________________ Location ________________________
  Sub-location ________________________ Village ________________________
- Household: ☐ poor ☐ medium ☐ better off

Note on interviewee____

SECTION A: Personal Information

1. How many people usually live and eat together in this household? ______
   Children (below 20 years) ______ Adults (21 – 60 years) ______ Elders (above 60) ______

2. What is your age? ***(read intervals)***
   ☐ Below 20 ☐ 20 - 30 ☐ 31 – 40 ☐ 41 - 50 ☐ 51 – 60 ☐ Above 60

3. What is the highest level of education you did receive?
   ☐ None ☐ Can write & read ☐ Primary ☐ Secondary ☐ Technical
   ☐ College ☐ University ☐ Other: ________________________

   a. ***If Primary or Secondary,*** how many years did you go there? ______

4. Do you have an occupation? ☐ Yes ☐ No

   a. ***If Yes,*** what do you do?
   ☐ Farming ☐ Self-employed ☐ Employed ☐ Part-time employed
   ☐ Student ☐ Other: ________________________

5. Who is the head of your household?
   ☐ Self ☐ Husband ☐ Other: ________________________

   a. ***If Husband or Other,***

   i. What is the Head's age?
   ☐ Below 20 ☐ 20 - 30 ☐ 31 – 40 ☐ 41 - 50 ☐ 51 – 60 ☐ Above 60

   ii. What is the Head's highest level of education?
   ☐ None ☐ Can write & read ☐ Primary ☐ Secondary ☐ Technical
   ☐ College ☐ University ☐ Other: ________________________

   1. ***If Primary or Secondary,*** how many years did she/he go to there? _______

   iii. Does the Head have an occupation? ☐ Yes ☐ No

   1. ***If Yes,*** what does she/he do?
   ☐ Farming ☐ Self-employed ☐ Employed
   ☐ Part-time employed ☐ Student ☐ Other: ____________________

SECTION B: Stove information

Please ask the Mama to show you all the stoves she has. Ask about stoves that are not in use. Pay attention to the stove's condition, that means whether something is broken or not. In the case of ICS, also observe what part is broken. Fill the answer directly into the table of ***question 7.*** *&* ***8****. respectively.*

6. What types of stoves are present in the household? *(specify amount)*

#			
1.	Jiko Kisasa		
2.	Portable Kisasa		
3.	Rocket Mud stove		
4.	Rocket Mud Lorena		
5.	Rocket Brick stove		
6.	Rocket Brick Lorena		
7.	Portable Rocket Mud		
8.	Portable Rocket Metal		
9.	Fireless cooker		
10.	Ceramic Jiko	a. Round	
		b. Square	
		c. Other	
11.	Three-stone	a. Natural	
		b. Moulded	

#			
12.	Solar cooker		
13.	All-metal stove		
14.	Kerosine wick		
15.	Kerosine pressure		
16.	LPG 6 kg (meko)		
17.	LPG 2-burner		
18.	Electric plate		
19.	Stove + Oven	a. Gas	
		b. Electricity	
		c. Wood/Charcoal	
20.	Market Mud		
21.			
22.			
23.			

7. *Indicate all the individual stoves that are present with their number in the table below. That means, if more than one stove of the same type is present, indicate every single stove in one row each.*

a. How old is the individual stove? *(Indicate number and* ***m****=months or* ***y****=years)*

b. How much did you pay for your stove? *(Indicate in KSh or specify amount and goods spent)*

c. Is something broken at the individual stove? (Indicate with **X** the Mama's answer and own observation)

i. ***If Broken,*** how long ago did the first part break? *(****ask Mama****, indicate number and* ***m****=months or* ***y****=years)*

7. Stove Number **#**	**7a.** Age		**7b.** Price	**7c.** Broken?		**7ci.** When broken?	
	No.	**m/y**		**Mama**	**Own**	**No.**	**m/y**

8. ***If an Improved Cooking Stove is broken****, what part is broken?* *(****Own observation****)*

Jiko Kisasa	☐ Cracks on the body	☐ Cracks on the liner	☐ Broken pot-rests	☐ Other:
Kisasa Portable/ Ceramic Jiko	☐ Broken pot-rests ☐ Broken stove leg	☐ Broken door ☐ Broken grid-iron	☐ Worn-out metal ☐ Broken bottom	☐ Broken liner ☐ Other:
Rocket mud/ brick + Lorena	☐ Cracks on body ☐ No fire shelve	☐ No pot-rests ☐ Cracked/broken chimney	☐ Worn-out combustion chamber ☐ Other:	
Fireless Cooker	☐ Cracks on body ☐ Other:	☐ Broken fabric	☐ Broken lid	☐ Broken holders

9. Which of your stoves do you use for ….? ***(Read task list**, multiple answers possible)*

#			Cooking	Warming-up food	Water Boiling	Other (specify in cell)	Not in use
1.	Jiko Kisasa						
2.	Portable Kisasa						
3.	Rocket Mud stove						
4.	Rocket Mud Lorena						
5.	Rocket Brick stove						
6.	Rocket Brick Lorena						
7.	Portable Rocket Mud						
8.	Portable Rocket Metal						
9.	Fireless cooker						
10.	Ceramic Jiko	a. Round					
		b. Square					
		c. Other					
11.	Three-stone	a. Natural					
		b. Moulded					
12.	Solar cooker						
13.	All-metal stove						
14.	Kerosine wick						
15.	Kerosine pressure						
16.	LPG 6 kg (meko)						
17.	LPG 2-burner						
18.	Electric plate						
19.	Stove + Oven						
20.	Market Mud						
21.	Other						
22.	Other						
23.	Other						

10. ***If more than one stove per task,*** which stove do you use as main stove for the individual tasks? *(Indicate with individual stove number # found in the table above)*

Cooking		Warming Up		Water Boiling	

a. ***If more than one stove for cooking***, which stove is your second and third most important one for cooking? 2. ____ 3. ____

i. Why do you have more than one stove for cooking? ______________________________

____

____

11. Why did you choose the particular stove as your main cooking stove? *(multiple answers possible)*

☐ Saves fuel, money, time ☐ Is flexible ☐ Good quality ☐ Is more modern

☐ Produces few smoke & is clean ☐ Is pretty (specify):______________________________

☐ Other: ____

12. ***If an ICS is present but not in use,*** why is the Improved Cooking Stove not in use?

☐ Stove is broken ☐ Needs maintenance ☐ Don't know how to use it

☐ Other: ____

SECTION C: Improved Cooking Stoves (ICS)

13. ***If no ICS is present,*** can you name any Improved Cooking Stove? Which one?

☐ None ☐ Jiko Kisasa ☐ Portable Kisasa ☐ Rocket Mud/Brick
☐ Ceramic Jiko ☐ Fireless Cooker ☐ Portable Rocket Mud/ Metal
☐ Other: ______________________________

a. ***If None*** *show pictures,* which ICS have you seen before?

☐ Jiko Kisasa ☐ Portable Kisasa ☐ Rocket Mud/Brick ☐ Ceramic Jiko
☐ Fireless Cooker ☐ Portable Rocket Mud/ Metal ☐ None

b. How have you heard about it or where have you seen it?

☐ Radio ☐ TV
☐ Brochure, leaflet, calendar, poster ☐ Friends, family, neighbours
☐ NGO & Ministry of Agriculture ☐ Village market, supermarket
☐ Producers, Installers, Marketing group ☐ Other: ______________

i. ***If Brochure, leaflet, calendar, poster***, where have you seen the Brochure, …?

☐ Producers, Installers, Marketing group ☐ NGO & Ministry of Agriculture
☐ Village market, supermarket ☐ Other: ______________

c. Why don't you have an Improved Cooking Stove?

☐ No money ☐ No interest ☐ No space ☐ Don't know where to find
☐ Don't know ☐ Other: ______________________________

If no ICS is present, *jump to page* ***6****, question* ***20.***

14. ***If an ICS is present***, how have you heard about it?

☐ Radio ☐ TV
☐ Brochure, leaflet, calendar, poster ☐ Friends, family, neighbours
☐ NGO & Ministry of Agriculture ☐ Village market, supermarket
☐ Producers, Installers, Marketing group ☐ Other: ______________

a. ***If Brochure, leaflet, calendar, poster***, where have you seen the Brochure, …?

☐ Producers, Installers, Marketing group ☐ NGO & Ministry of Agriculture
☐ Village market, supermarket ☐ Other: ______________

15. Do you maintain your Improved Cooking Stove/s? ☐ Yes ☐ No

a. ***If Yes,*** how do you maintain your Improved Cooking Stove/s?

☐ Clean the stove ☐ Smear the body with soil ☐ Cover stove if outside
☐ Clean the chimney ☐ Other: ______________________________

i. How often do you perform these tasks? _______ *(e.g.* ***3x****)* per ☐Day ☐Week ☐Month

b. ***If No***, why don't you maintain your stove/s?

☐ Stove functions well ☐ No interest ☐ No time ☐ Don't know how
☐ Other: ______________________________

16. Did you ever fix or replace any worn-out parts on your ICS? ☐ Yes ☐ No

a. ***If No,*** why not?

☐ Nothing is broken ☐ No interest ☐ No time ☐ No money ☐ Don't know how
☐ Don't know where to get new parts ☐ Other: ______________

b. ***If Yes***, please indicate who did fix or replace which worn-out part on your ICS and how often?

- *(Specify frequency as: e.g.* ***3x*** *for three times,* ***if Household & Service (Stove producer/installer/dealer) fixed/replaced same part****, fill out both columns)*

		1. Households	**2.** Service
Jiko Kisasa	Body		
	Liner		
	Pot-rest		
	Other:		
Portable Kisasa/ Ceramic Jiko	Pot-rest		
	Door		
	Metal		
	Liner		
	Legs		
	Grid-iron		
	Other:		
Rocket mud/brick + Lorena	Body		
	Pot-rest		
	Combustion chamber		
	Firewood shelve		
	Chimney		
	Other:		
Fireless cooker	Body		
	Fabric (inside)		
	Lid		
	Holders		
	Other:		

c. ***If Household fixed or replaced parts***, who showed you how to do it?

☐ Nobody ☐ Friends, family, neighbors ☐ Stove producer, installer, dealer
☐ Manual, leaflet, brochure ☐ Other: ____________________

d. ***If Service fixed or replaced parts***, did you have to pay? ☐ Yes ☐ No

i. ***If Yes***, how much do you pay on average? *(in KSh or specify amount and goods)*

____

17. Did you ever replace your Improved Cooking Stove? ☐ Yes ☐ No

a. ***If Yes***, why was it replaced?

☐ Old one got broken ☐ Wanted to have new model
☐ Other: ____________________

i. What was the lifetime of the stove? *(****m****=months or* ***y****=years)* ________

ii. Did you replace it with the same stove model? ☐ Yes ☐ No

1. ***If No***, specify new model ____________________

18. Did you get a warranty for your Improved Cooking Stove/s? ☐ Yes ☐ No

a. ***If Yes***, for how long is/was it valid after purchase? *(indicate in months)* ________

19. Do you know how to use your ICS properly in order to save energy, time and money? ☐ Yes ☐ No

a. ***If Yes***, what is the proper way of using the stove?

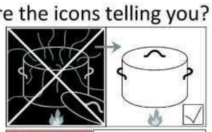
☐ Use dry firewood ☐ Use split firewood ☐ Use few sticks ☐Use a lid
☐ Pre-soak hard food ☐ Use a Fireless Cooker ☐ Lit fire only for actual cooking
☐ Other: ____________________

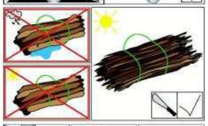
b. ***If Yes***, where do you know these techniques from?

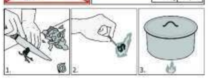
☐ Friends, family, neighbors ☐ Stove producer, installer, dealer
☐ Manual, leaflet, brochure ☐ Other: ____________________

Jump here when no ICS present

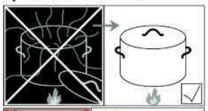
20. What are the icons telling you? *(Show bigger pictures on 'Icon Paper')*

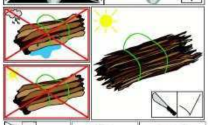
a.  ______________________________

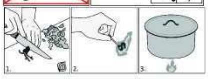
b.  ______________________________

c.  ______________________________

21. What do you think about the icons?

a.  ☐Like a lot ☐Like ☐ Neutral/Don't know ☐Dislike ☐Strongly dislike

b.  ☐Like a lot ☐Like ☐Neutral/Don't know ☐Dislike ☐Strongly dislike

c.  ☐Like a lot ☐Like ☐Neutral/Don't know ☐Dislike ☐Strongly dislike

d. Which one do you like the most? ☐ **a.** ☐ **b.** ☐ **c.**

i. Why? ______________________________

SECTION D: Energy/fuel information

22. What fuel is used in this household? *(**Read list**; multiple answers possible; **ask about other fuels**)*

1.	Firewood		**6.**	Charcoal		**11.**	Electricity	
2.	Twigs		**7.**	Paraffin/Kerosene		**12.**	Batteries	
3.	Crop residues		**8.**	LPG		**13.**	Candles	
4.	Dung		**9.**	Biogas		**14.**	Other:	
5.	Sawdust/Briquettes		**10.**	Solar heat energy		**15.**	Other:	

a. ***If Crop residues***, specify the two most important ones

1. ______________________ 2. ______________________

b. ***If Electricity***, specify the energy source.

☐ Net electricity ☐ Solar energy ☐ Wind power ☐ Generator
☐ Charging station ☐ Other: ______________________

23. Is there a fuel you don't use always, throughout year? *(Indicate **Yes**, when at least one fuel is not used always or throughout year)* ☐ Yes ☐ No

a. ***If Yes***, which fuel/s don't you use always, throughout year? *(Multiple answers possible)*

1.	Firewood		**5.**	Sawdust/ Briquettes		**9.**	Biogas		**13.**	Candles	
2.	Twigs		**6.**	Charcoal		**10.**	Solar heat energy		**14.**	Other	
3.	Crop residues		**7.**	Paraffin/Kerosene		**11.**	Electricity		**15.**	Other	
4.	Dung		**8.**	LPG		**12.**	Batteries				

b. ***If Yes***, why don't you use the fuel/s always, throughout year?

☐ Fuel is not always available ☐ Fuel sometimes too expensive
☐ Supply depends on seasons ☐ Run out of money
☐ Quality sometimes too bad ☐ Other: ______________________

24. Which of your fuels do you use for …? *(**Read task list**; multiple answers possible)*

#		Cooking	Warming up	Water Heating/ Boiling	Lighting	Communication & Entertainment	Other (specify in cell)
1.	Firewood					--------------------	
2.	Twigs					--------------------	
3.	Crop residues				---------	--------------------	
4.	Dung				---------	--------------------	
5.	Sawdust/Briquettes					--------------------	
6.	Charcoal				---------	--------------------	
7.	Paraffin/Kerosene					--------------------	
8.	LPG					--------------------	
9.	Biogas					--------------------	
10.	Solar heat energy				--------	--------------------	
11.	Electricity						
12.	Batteries	--------	----------	------------------			
13.	Candles	--------	----------	------------------		--------------------	
14.	Other						
15.	Other						

25. ***If more than one fuel per task***, which fuel do you use as main fuel for the individual tasks? *(Indicate with individual fuel number **#** found in the table above)*

Cooking		Warming Up		Water Heating		Lighting		Communication & Entertainment	

a. ***If more than one fuel for cooking***, which fuel is your second and third most important fuel for cooking?

2.		3.	

b. Why do you use more than one fuel per task? ______________________________

____

____

26. Why do you use the particular fuel as your main cooking/lighting fuel? *(multiple answers possible)*

	Main cooking fuel	Main lighting fuel
Can afford it	☐	☐
Is cleaner & produces less smoke	☐	☐
Is most efficient & cost-effective	☐	☐
Is available	☐	☐
Is flexible	☐	☐
Is more modern	☐	☐
Other:		

27. ***If communication & entertainment***, do you have any of the following devices for communication or entertainment? *(**read devices**; indicate amount of individual devices)*

___ Mobile Phone ___ Photo camera ___ Computer/Laptop ___ Radio ___ Stereo

___ TV ___ Other: ______________________________

28. Do you have any other electrical devices in your household? ___ Torch ___ Car battery

____

29. On average, is the fuel normally purchased, collected (self-made) or a combination of both?

1.	Firewood	☐ Purchased	☐ Collected	☐ Both
2.	Twigs	☐ Purchased	☐ Collected	☐ Both
3.	Crop residues	☐ Purchased	☐ Collected	☐ Both
4.	Dung		☐ Collected	
5.	Sawdust/Briquettes	☐ Purchased	☐ Collected (self-made)	☐ Both
6.	Charcoal	☐ Purchased	☐ Collected (self-made)	☐ Both
7.	Paraffin/Kerosene	☐ Purchased		
8.	LPG	☐ Purchased	☐ Collected	☐ Both
9.	Biogas	☐ Purchased	☐ Collected (self-made)	☐ Both
10.	Solar Heat energy		☐ Collected (self-made)	
11.	Electricity	☐ Purchased (grid elec.) ☐ From Charging station	☐ Collected (own device: Solar/Wind/Generator)	☐ Both
12.	Batteries	☐ Purchased		
13.	Candles	☐ Purchased	☐ Collected (self-made)	☐ Both
14.	Other	☐ Purchased	☐ Collected (self-made)	☐ Both

a. How much do you collect and/or purchase of the individual fuel? *(**If Both**, fill out table for both; indicate amount and individual unit; weight unit with scale where applicable & indicate in kg)*

- *Possible units: log; bucket; bundle; piece [for candles & batteries] **kg**=kilogram; **kWh**=kilo Watt hour; **L**=liter; **other**=specify in table)*

b. How often do you purchase and/or collect? *(e.g. **3x** per **w**=week/**m**=month/**y**=year)*

c. ***If Purchase***, how much do you pay per unit? *(Indicate in KSh or specify amount and goods spent)*

		Purchased				**Collected / Self-made**		
		a. How much do you purchase?	**b.** How often **No.**	**w/m/y**	**c.** Price per unit	**a.** How much do you collect?	**b.** How often **No.**	**w/m/y**
1.	Firewood							
2.	Twigs							
3.	Crop residues							
4.	Dung	----------------------	-------	----------	---------------			
5.	Sawdust/Briquettes							
6.	Charcoal							
7.	Paraffin/Kerosene					----------------------	-------	--------
8.	LPG					----------------------	-------	--------
9.	Biogas							
10.	Solar Heat energy	----------------------	-------	----------	---------------			
11.	Electricity							
12.	Batteries					----------------------	-------	--------
13.	Candles							
14.	Other							

d. ***If Electricity from charging station,***

i. What do you charge? *(Indicate amount and type of device in table below)*

ii. How often? *(e.g. **3x** for three times per **w**=week/**m**=month)*

iii. How much do you pay generally per device? *(In KSh or specify amount and goods spent)*

Charging station				
i. What do you charge?		**ii.** How often		**iii.** Price per Device
No.	**Device**	**No.**	**w/m**	

SECTION E: Cooking information

30. What food do you cook most often in your household? Please name the three most often food types.

1.________________________ 2.________________________ 3.________________________

31. How often do you cook these?

Food 1	☐ More than once a day ☐ Once a week	☐ Once a day ☐ Other:	☐ Three times a week	☐ Twice a week
Food 2	☐ More than once a day ☐ Once a week	☐ Once a day ☐ Other:	☐ Three times a week	☐ Twice a week
Food 3	☐ More than once a day ☐ Once a week	☐ Once a day ☐ Other:	☐ Three times a week	☐ Twice a week

32. Do you cook these three main foods with your main cooking stove and fuel? *(Tick **No** when at least for one food either stove or fuel is different; **remind** what was stated earlier => **question 9./10.** & **24./25.**)*

☐ Yes ☐ No

a. ***If No,*** which stove and/or which fuel do you use instead? *(Specify where applicable)*

	Stove	Fuel
Food 1		
Food 2		
Food 3		

b. ***If No***, why? ____

33. Do you generally buy your food? ☐ Yes ☐ No

a. ***If Yes***, how much do you usually spend on food per day, week or month? *(Indicate in KSh or specify amount and goods spent)* ____________________ per ☐ day ☐ week ☐ month

34. *Put 10 matches in front of the Mama and explain to her that these correspond to the household's total income. Ask her to divide the total of 10 matches into three categories that represent the household's expenditures: **Food, Fuel,** and **Other** expenditure.*

a. How many matches (out of 10) represent you expenditures for ...?

Food__________ Fuel__________ Other__________

35. This is the end of the questionnaire, do you like to add or ask anything? ______________________________

____

____

36. *Thank the respondent for her/his time and for answering all the questions!*

APPENDIX III – HOUSEHOLD INTERVIEW GUIDE

ICS HOUSEHOLD INTERVIEW GUIDE

Date __________ Serial No. __________ Tape No. __________

- Cluster __________ Location __________
  Sub-location __________ Village __________

Household: ☐ poor ☐ medium ☐ better off

Personal notes on interview & interviewee: __________

____

____

I. STOVE

1. What is in your opinion a perfect stove? How should this stove look like?

- What do you expect from your stove? What should your stove perform?

____

____

____

____

2. What do you like on your Improved Cooking Stove/s?

- Do you miss anything on the particular stove/s?
- Do you see any advantages/ disadvantages?

____

____

____

____

3. In which position do you normally cook? ☐ Standing ☐ Sitting ☐ Bended over ☐ Other__________

- Do like this position? ☐ Yes ☐ No
- Why are you cooking in this position?
- Does you back hurt sometimes?
- Would you like to change anything? If yes, how should that change looks like?

____

____

____

____

1

4. Where do you normally cook? ☐ inside ☐ separate kitchen house ☐ outside

- ***If inside**, is the kitchen separated from the living or sleeping area, i.e. stove is not next to bed or couch?*
  ☐ separated ☐ not separated
- What are the reasons that you are cooking there?
- Is that dependent on the stove and/or fuel? Can you explain that?

____

____

____

____

II. FUEL

5. Do you use your fuels throughout the year? What about in the rainy seasons?

- Are there fuel supply shortages regularly? Does it affect price?
- How do you cope with these changes?
- Do you switch to another fuel?
- Do you have a back-up fuel?

____

____

____

____

____

6. Do you use different fuels for cooking different foods? Which fuel do you use for what food? Why?

____

____

____

____

APPENDIX IV - INSTITUTIONAL INTERVIEW GUIDE

Date__________ Tape No.___________

INSTITUTION INTERVIEW GUIDE

- Cluster ______________________________ Location ______________________________
  Sub-location ______________________________ Town/Village ______________________________

Institution's name: ____

I. GENERAL INFORMATION

1. How often do you normally cook per day? ____

2. For how many people do you generally cook? ____

II. STOVES & FUELS

3. What kind of stoves are present? How many of the same kind?

1.	Jiko Kisasa		
2.	Portable Kisasa		
3.	Rocket Mud stove		
4.	Rocket Mud Lorena		
5.	Rocket Brick stove		
6.	Rocket Brick Lorena		
7.	Portable Rocket Mud		
8.	Portable Rocket Metal		
9.	Fireless cooker		
10.	Ceramic Jiko	a. Round	
		b. Square	
		c. Other	

11.	Three-stone fire		
12.	Solar cooker		
13.	All-metal stove		
14.	Kerosine wick		
15.	Kerosine pressure		
16.	LPG 6 kg (meko)		
17.	LPG 2-burner		
18.	Electric plate		
19.	Stove + Oven	Gas	
		Electricity	
		Wood/Charcoal	
20.	Microwave		

21.	Deep fryer		
22.	Toaster		
23.	Water boiler	Institutional	
		Household	
24.			
25.			
26.			
27.			
28.			
29.			
30.			
31.			

4. Summarize the individual stoves in table below.

a. How old is the indivudal stove?
b. How much did you pay?
c. Is something broken? How long ago did it break? What part is broken?

Stove Number #	Age	Price	Broken?		When broken? What part?
			Cook	**Own**	

5. What kind of energy do you use in your kitchen?

1.	Firewood		**5.**	Charcoal		**9.**	Solar heat energy	
2.	Twigs		**6.**	Paraffin/Kerosene		**10.**	Electricity	
3.	Crop residues		**7.**	LPG		**11.**		
4.	Sawdust/Briquettes		**8.**	Biogas		**12.**		

a. ***If 3.****(=Crop residues)*, specify the two most important ones
1.______________ 2.______________

b. ***If 11.****(=Electricity)*, specify the energy source.
☐ Net electricity ☐ Solar energy ☐ Wind power ☐ Generator
☐ Charging station ☐ Other:______________

6. Do you use a particular fuel or stove for a specific task or food?

a. Which fuel/stove do you use for which task or food? Why?
b. Why do you use or have many stoves/fuels?

7. What is your main stove and fuel? Why?

a. Do you miss anything on the particular stove/s?
b. Do you see any advantages/ disadvantages?
c. What is in your opinion a perfect stove? How should this stove look like?
d. What do you expect from your stove? What should your stove perform?

8. Do you use your fuels throughout the year? If NO, why not?

a. What about in the rainy seasons?
b. Are there fuel supply shortages regularly? Does it affect price?
c. How do you cope with these changes? Do you switch to another fuel? Do you have a back-up fuel?

APPENDIX V - CRITERIA PAPER

CRITERIA PAPER - CENTRAL

- **Place:** Location: *Maragua Ridge* Sub-Location: *Kamuiru* Villages: *Gituamba A+B & Ngaini A+B*
  Chief: Name: [redacted] Contact: [redacted]
  Name: [redacted] Contact: [redacted]
- **Place:** Location: *Gatuya* Sub-Location: *Gatuya* Villages: *Kairichi & Gathima*
  Chief: Name: [redacted] Contact: [redacted]
  Name: [redacted] Contact: [redacted]

	Poor	Medium	Better Off
Elec. / water	No electricity/water pipe	**MR**: No electricity/water pipe **G**: no electricity, but few have water	All have water, only few electricity
House	**MR**: - small, mud-brick house - simple iron sheet roof **G**: - iron/timber house - iron sheet roof	Semi-permanent houses: - Mud-bricks - Well-fixed iron sheet roof	Permanent houses: - Stone bricks - Solid-fixed iron sheet roof
Furniture	- 1 - 2 rooms - Poorly furnished	- 2 - 3 rooms - Simply Furnished	- 3 & more rooms - Well furnished
Livestock	No or few animals - Small animals (chicken, goats,...)	- Some small livestock - 1 cow	**MR**: 1 - 2 cows **G**: 3 - 5 cows
Land size	< 1 acre	**MR**: 2 - 3 acres **G**: 1 acre	**MR**: 5 - 10 acres **G**: 3 - 5 acre
Land charac.	- Subsistence Farmer - Grow food crops	- better quality of land and plants - Food & cash crops	- Mainly cash crops - well-maintained land
Fence / gate	No fence/gate	**MR**: No fence/gate **G**: wooden gates & few have hedges	Gates & hedges
Education	- Illiterate - Most kids don't go to school	- Literate - Able to send kids to school - public schools	- Literate - Can give kids higher education - private schools
Clothes	- Old clothes with holes - Dirty clothes	- Good quality clothes - Second-hand - Clean clothes	- Can afford new clothes
Vehicles	No vehicles	May have a vehicle (bicycle, bike,..)	Have vehicles (car, bike, bicylce,...)

CRITERIA PAPER - CENTRAL

- **Place:** Location: *Kiogoro* Sub-Location: *Boronyi* Villages: *Amareba & Chinche*
  Chief: Name: [redacted] Contact: [redacted]
  Name: [redacted] Contact: [redacted]
- **Place:** Location: *Ndanai* Sub-Location: *Kipsingei* Villages: *Amareba & Chinche*
  Chief: Name: [redacted] Contact: [redacted]

	Poor	Medium	Better Off
Elec. / water	- No electricity/water pipe	- No water pipe - **N**: no electricity - **K**: some have electricity	- No water pipe - **N**: no electricity - **K**: some have electricity
House	- mud house with grass roof	Semi-permanent house: - iron sheet roof - **N**: mud or timber house - **K**: mud house	Permanent house: - iron sheet roof - Brick house
Furniture	- 1 - 2 rooms - Poorly furnished	- 2 - 3 rooms - Simply Furnished	- 3 & more rooms - Well furnished
Livestock	- Small animals (poultry, goats,...) - **N**: 4 low quality cows - **K**: no cattle	- Small livestock - **N**: 4 medium quality cows - **K**: some native cows	- **N:** 4 high quality dairy cows - **K:** 1 – 2 high quality dairy cows
Land size	- **N**: < 0.5 acre - **K**: 0 - 5 acres	- **N**: 0.5 - 4 acres - **K**: 0 - 5 acres	- **N**: > 4 acres - **K**: 0 - 5 acres
Land charac.	- **N**: equal land quality - **K**: low quality & poorly developed	- **N**: equal land quality - **K**: medium quality land	- **N**: equal land quality - **K**: good quality land
Fence / gate	- **N**: No fence/gate - **K**: no gate but hedges/live fences	- **N**: live fences & some have gates - **K**: hedges & wooden gates	- **N**: good hedges & wooden gates - **K**: barbed wire & iron gates
Education	- Illiterate - Kids finish after Primary	- Literate - Kids finish Primary and sometimes Secondary	- Literate - Secondary and higher EDU
Clothes	- **N**: Old, dirty clothes, some without shoes - **K**: Decent clothes	- Second-hand, decent clothes	- decent clothing
Vehicles	- No vehicles	- May have a bicycle or bike	- Few cars, bikes, or bicylces

CRITERIA PAPER - WESTERN

- **Place:** Location: *Khayega* Sub-Location: *Shidodo* Villages: *Mathare & Ilala*
  Chief: Name: [redacted] Contact: [redacted]

- **Place:** Location: *Shibuye* Sub-Location: *Shiasava* Villages: *Mungotso & Itumbu*
  Chief: Name: [redacted] Contact: [redacted]
  Name: [redacted] Contact: [redacted]

	Poor	Medium	Better Off
1.	No electricity/water pipe	No electricity/water pipe	Few may have electricity/water pipe
2.	No permanent house: - Mud + Grass roof - Cracks and holes in wall - Few windows (with wood)	Semi-permanent houses: - Mud + iron sheet roof - No glass in windows but iron grid + wooden shutter	Permanent houses: - Bricks + iron sheet/tiled roof - Glass windows
3.	Very few animals - Small animals (chicken, pigs,...) - Very few have cows	- Small livestock - 2-6 big animals (Cattle, goats, ..) - Number of small animals	2-4 well-fed, high quality cattle and other animals
4.	0-1 acre	1-3 acre	>4 acre
5.	- Subsistence Farmer - Grow food crops (maize, beans, Vegetables, bananas)	- better quality of land and plants - Food & cash crops - Plant variety	- Mainly cash crops (tea, coffee, sugar cane, bananas, vegetables, trees,...) - well-maintained land
6.	- No/few wire fence - No gate	- Wire/wooden/life hedge - No/small fence	- full area fence (wire/brick/wooden/ well-maintained life hedge) - Big gate
7.	- Illiterate - Most kids dont go to school	- Literate - Able to send kids to school	- Literate - Can give kids higher education
8.	- Old clothes with holes - Dirty clothes	- Good quality clothes - Second-hand - Clean clothes	- Can afford new clothes
9.	No vehicles	May have a vehicle (bicycle, bike,..)	Have vehicles (car, bike, bicylce,...)
10.	- One or sometimes few rooms - Poorly furnished	- Mostly few room - Simply Furnished	- More rooms - Well furnished

APPENDIX VI - STOVE PAPER

Appendix VII - Interview Distribution

Cluster	Household	Institution
Western	6	2
Central	5	2
Transmara	4	-
TOTAL	15	4

Appendix VIII - Main Task Fuels From Households With More Than One Fuel Option Per Task

Fuel	Main Cooking fuel		Main Warming Up fuel		Main Water boiling fuel		Main Lighting fuel		Main Communication & Entertainment fuel	
	N	%	N	%	N	%	N	%	N	%
Crop residues	-	-	1	0.3	3	0.9	-	-	-	-
Sawdust	1	0.3	1	0.3	2	0.6	-	-	-	-
Twigs	9	2.8	12	3.8	10	3.1	-	-	-	-
Firewood	298	93.1	274	85.6	277	86.6	12	3.8	-	-
Charcoal	8	2.5	14	4.4	15	4.7	1	0.3	-	-
Kerosene	2	0.6	10	3.1	4	1.3	253	79.1	-	-
LPG	2	9.6	6	1.9	3	0.9	-	-	-	-
Batteries	-	-	-	-	-	-	4	1.3	153	50.5
Electricity	-	-	-	-	2	0.6	50	15.6	150	49.5