University of Copenhagen

What Powers Thuti?

An interdisciplinary investigation of domestic energy decision making

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0.1 Declaration

By signing this document, we concur that all members are in agreement about the content stated in this report. Furthermore all of the research and data is our own and all exterior sources have been acknowledged to the fullest extent.

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Introduction and Formalities	ALL
Theoretical perspectives	ALL
Methodology	ALL
Findings	ALL
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0.8 Abstract

In Kenya, and many other countries around the world, the majority of the population relies on biomass for daily production of energy for cooking, lighting and heating. This biomass is for the greater part firewood, and this usage is often explained in literature to have negative social and environmental impacts. However, we show in this paper that it is not the case of Thuti sub-location in central Kenya where over half of the households we surveyed are self-sufficient in firewood. Furthermore we found that the vast majority of the households do not only use firewood for cooking, but multiple fuel types. Biogas is among the emergent alternative fuel sources in the area.

We apply a theoretical framework of structures, factors and rationales to investigate the decision-making processes related to fuel choice in the households of the area. We argue that the decision making process is complex and that there is more to the reasoning behind choosing one fuel type over another than economy. This paper also addresses the limitations and flaws of the framework and fieldwork.

1 Introduction

Around 2.6 billion people worldwide rely on biomass, namely firewood and charcoal, as the primary source of energy for cooking and heating (Lambe et al. 2015). The use of biomass fuels, especially from wood sources, also have a long tradition in Kenya. According to the Ministry of Energy, 89% of rural households use firewood as their main energy source whereas this is only the case for 7% of the urban families (Githiomi et al. 2012). Currently, about 90% of harvested wood in Kenya is used for firewood (Mugo and Gathui 2010) which comes from nearby forested areas, is purchased from neighbours, or produced on the farm in woodlots or between fields in an agroforestry system. Charcoal is the second most used fuel in Kenya, with benefits of being lightweight, assuring cleaner burning than firewood and being less expensive than liquefied petroleum gas (LPG) (Mugo and Gathui 2010; UN-DESA 2004).

Challenges related to the consumption of firewood and charcoal include the pressure on natural and forest resources due to unsustainable and often illegal wood harvesting practices which have led to vast deforestation, especially during the last three decades (MAF 2013). Firewood consumption has greatly increased with a steadily growing population in Kenya from approximately 5 million in 1950 to about 45 million in 2014 (Bussmann and Kiefer 2008; WPP 2015). Furthermore there has been an increase in consumption due to growing energy and space demand from factories, for instance for tea production, the manufacturing of soap and vegetable oils and salt mining (MAF 2013).

In addition to the potential negative environmental impacts of firewood and charcoal when sourced unsustainably, there are also important social concerns with the use of fuel biomass. Inefficient cookstoves and poor ventilation lead to harmful air pollution, which those working in the kitchen, women and children, are exposed to (Ezzati and Kammen 2002). Globally it is estimated that 4 million people die annually due to illnesses caused by pollution from cookstove smoke (Lambe et al. 2015). The task of collecting firewood typically falls on the women in the household, who additionally are responsible for many other household chores such as cooking and taking care of children.

1.1 Case area

This report focuses on the decisions that the household makes about its domestic energy and takes its point of departure in a case. Our study area, Thuti sub-location, belongs to Karima which is one of the four locations of Othaya sub-county in Nyeri county, located in the central highlands of Kenya. According to the 2009 census it is home to 3650 people who live in 1006 households, with a household size of 3.6 people. Thuti sub-location comprises an area of about 7.5 km^2, which gives a population density of 478 people per km^2 (KNBS 2009). Thuti sub-location consists of 9 villages. It is characterized by small hills, the Karima Hill Forest and its location close to Othaya Township (about 2 kilometres).

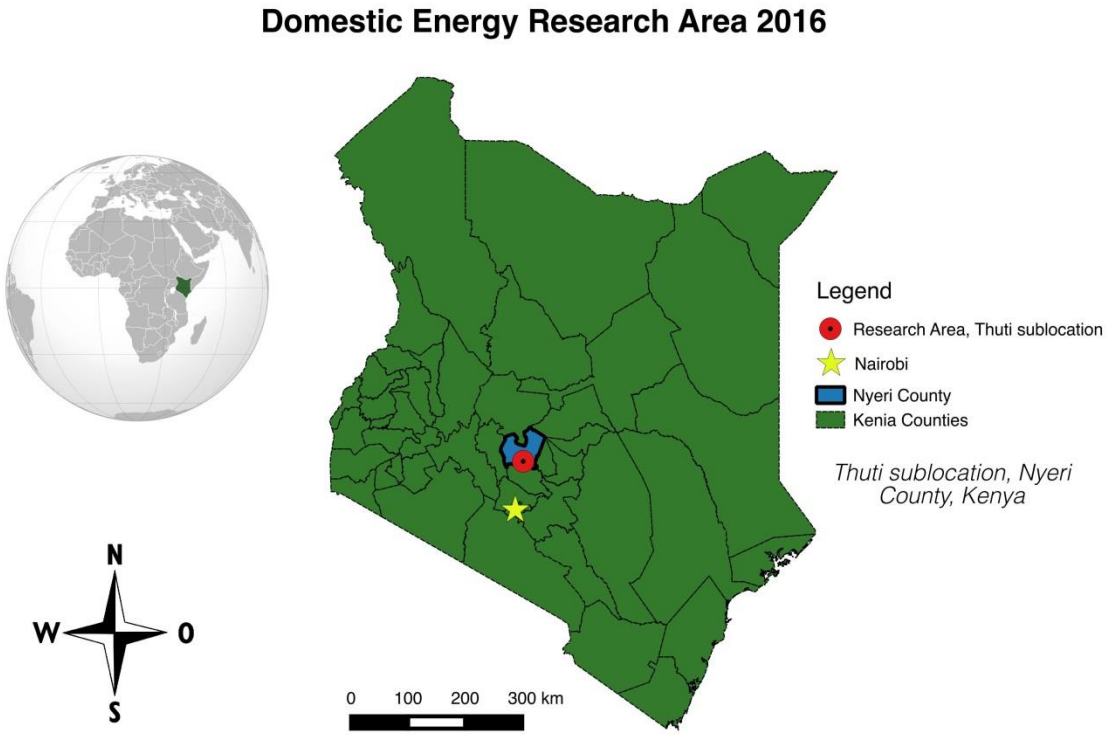

Figure 1: Map of Kenya and the location of the Research Area in Thuti sub-location, Nyeri County

Most residents are of the Kikuyu tribe and work as farmers growing cash crops like coffee, tea and macadamia nuts as well as subsistence crops including maize, potatoes, beans, bananas, and other vegetables. Dairy cows, goats and poultry are the most common livestock.

Karima Forest is seen as a sacred place; there are old fig trees that were used historically for religious ceremonies (e.g. *the Kamwangi Shrine*). After decades of logging by the local town council and residents, Karima Forest was closed to public access (Interview Lucy Waruguru -

05.03.2016). The Green Belt Movement (GBM) and the Gaia Foundation are working with the local communities in order to rehabilitate Karima Hill Forest. Before its closure, the forest had been an important source of firewood for the surrounding community; this change in access had a direct effect on many of these households' energy supply (Interview Lucy Waruguru - 05.03.2016).

Like other regions in Kenya, the vast majority of the population in Thuti use firewood as their main energy source. What is less known are the sources of this biomass. It has been estimated that there is a 71% biomass deficit in this region, higher than the national average at an already alarming 57% (Mugo and Gathui 2010).

Moreover as explained earlier, there are both health, environmental and social benefits of using more efficient cook stoves and other sources of fuel instead of firewood and charcoal. There are NGOs that have been working on the promotion of these technologies in the region, the most notable being wPower (Partnership on Women's Entrepreneurship in Renewables), which began working in the area in 2015. wPower is working with women to encourage the use of cleaner energies and to empower women.

Here it may be worth noting that, although we are working with domestic energy as a holistic topic, which includes cooking, lighting, and heating, we have decided to put the main focus of our presentation and analysis on cooking fuels. Cooking is the main consumer of fuel in our case area and we have identified cooking fuels as being the energy type with the most options for alternatives that are being promoted by local development projects.

1.2 Identification of research problem

When presented with the case of firewood use in Thuti, we learned that Karima Forest is closed for firewood collection (Atchadé et. al. 2015). As there is no other large forested area in the region, and as there is a biomass deficit in the region, we saw that there was a gap in the knowledge of where this firewood is coming from. In line with this, Githiomi et al. (2012) state that data is scarce about the source and consumption of firewood in Kenya. The only study on firewood source in this region that we know of focuses on firewood collection from forest locations off-farm, stating that women have to travel longer distances to collect firewood (Mwangi 2013). We found only two studies that mention households being self-sufficient in firewood (Githiomi et al. 2012; Pravalprukskul 2015). We therefore identified this topic of firewood self-sufficiency to be a gap in the knowledge about fuel use in the area.

Organizations in the area are working on projects to promote the use of more efficient fuels and stoves, as the "improved" firewood cookstoves, and solar lamps (Interview Professor Kiama - 05.03.2016). There are also emerging alternative fuel sources such as biogas which are on the agenda of the Ministry of Energy to promote (Mugo and Gathui 2010). In order to best promote these technologies it can be relevant to learn about the factors and rationales of households when deciding fuels and cookstoves. We have identified this as an additional research gap as we were unable to find any studies that have focused on the decision making, rationales, and the sources of firewood. This leads us to our problem statement.

1.3 Problem statement

What are the sources of domestic energy and what influences the decision making related to fuel use at the household level in Thuti sub-location?

To answer our overall problem statement we have three guiding research questions:

1. What are the sources, types, and usages of fuels for domestic energy in Thuti sub-location?
2. What factors and structures influence the rationales behind decision making of the source and types of domestic energy?
3. What is the knowledge and adoption of biogas as an alternative source of energy?

1.4 Definitions

To clarify certain phrases and words used throughout the paper we define the most central here.

Table 1: Definition of key phrases and words

Term	Our definition
Alternative fuels	Other energy sources than firewood and charcoal.
Domestic Energy	The energy used for cooking, lighting, and heating. Thereby excluding transportation.
Household	People "who eat out of the same pot daily".
Sustainability	A balance of environmental, social and economic demands (both present and future), without compromising one or the other.
Improved cookstove	A cookstove that has one entry point for the firewood (as opposed to the three entry points of the three stone stove) and that it is somewhat enclosed to insulate the fire. This insulating characteristic makes the stove use the firewood more efficiently and produces less smoke
Three-stone stove	The traditional cookstove in the region comprised of three large stones placed in a circle with three entry points for firewood.
Githeri	A traditional dish of maize and beans which requires around two hours of cooking time
Biogas	Methane gas derived from digested organic material (cow manure in the case of this report) which is produced and collected in a an air-tight container or "biodigester"

2 Theoretical perspectives: Rationales and structures that influence decision making

In this chapter we will present some theoretical perspectives and in Chapter 7 we will return to the limits of using the framework.

In order to analyze the factors that influence decision making in fuel choice we have identified and adapted a rationales framework used by various authors to describe and analyze decision making in relation to the use of natural resources (Rasmussen and Reenberg 2012; Cleveland and Soleri 2007). We most closely followed the framework used by Rasmussen and Reenberg (2012), who study land use rationales and structures behind land use changes in Burkina Faso. Since the vast majority of fuel that is used is firewood, our topic of household fuel choice is directly related to the use of natural resources and land use decisions. Therefore we have found this framework in line with our research objectives and we have divided household rationales in fuel choice decisions into the same three categories as used by Rasmussen and Reenberg: economic, sociocultural and ecological rationales. Figure 2 displays the relationships that we have observed between rationales, factors and structures.

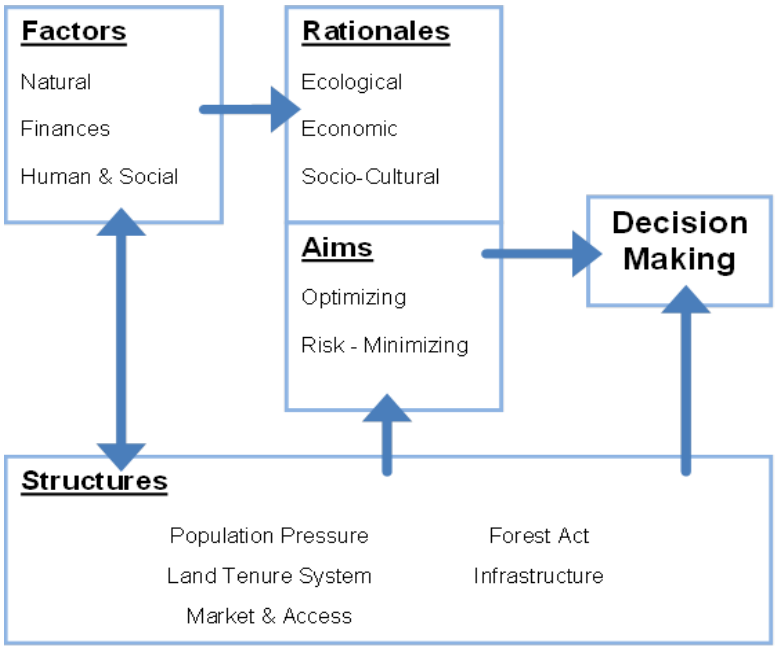

Figure 2: Framework of Decision Making (adapted from Rasmussen and Reenberg (2012)

The *economic rationale* is based on the assumptions that individuals will act to maximize personal outcome. Regarding the choice of fuel, this means that individuals will use the

cheapest and most efficient fuel at their disposal (Rasmussen and Reenberg 2012). It is implied that if farmers have access to information then they will maximize outcome accordingly (Cleveland and Soleri 2007).

The *ecological rationale* is also based on the assumption of individuals as seeking to maximize outcome, however it is assumed that individuals will include family and the community in their perspectives. Moreover it includes the multi-use strategy where it is sought to have a variety of products on the farm to ensure basic needs of the household (Rasmussen and Reenberg 2012).

On the other hand, the *socio cultural rationale* is founded on traditions. Individuals do not always act to gain money and action can be valuable due to other factors such as social relations, societal norms or traditions (Rasmussen and Reenberg 2012).

A decision often includes more than one rationale. Furthermore the behavior of individuals can be divided into risk-minimizing and optimizing. Farmers live with big uncertainties and therefore subsistence farmers aim at minimizing risks rather than maximizing gains. An important element in this is to diversify activities (Barrett et al. 2001). On the other hand, the optimizing individual is related to profit maximization. In Thuti sub-location many households use multiple fuels and we will examine if the strategy is based on risk-minimizing or optimizing arguments.

Moreover, decisions are influenced by structures. In the case of domestic energy, some of these structures are the market, government policies, population pressure and land tenure system.

Finally, factors influence rationales and interact with the structures. The three *factors*, natural, finances and human and social were identified through our field visit and have been used to categorize our findings. The *factors* are inspired by the five capitals in the livelihoods framework (DFID 1999), and it is used to provide an understanding of the livelihoods of households. The *factors* are the building blocks on which individuals base their rationales, and throughout the paper we will discuss the relation between the two.

3 Methodology

In the following chapter we will outline the methods we applied while in the field and discuss the advantages and shortcomings of these. First, we will discuss some of the biases in the report and how the time period influenced our methodological choices.

3.1 Research design and bias

Given our limited timeframe and our knowledge gap of the topic, we have focused less on participant observation and instead used interviews, surveys and natural science methods to gain an overview of our study area and investigate our research questions.

To aid us in our field work we had the assistance of a village elder named Lucy Waruguru and two local guides who also acted as interpreters. Mrs. Waruguru aided us in many organizational matters and created connections for us with local women and showed us around the area. Many of the women we have talked with are therefore chosen by Mrs. Waruguru, which of course is a bias that we acknowledge. However we felt this was acceptable, since Mrs. Waruguru is an elder in the community, which means she is a respected and well-known person, who has insight that we could not possibly establish in our allocated time. Furthermore Mrs. Waruguru showed a great understanding for our project and she provided us with a lot of our basic information in an early interview.

In line with this, our two guides, John and Caroline, also played a central role in our project. However we do recognize that both originate from the very group of people that we are studying and working with. We also gave them a certain amount of responsibility, especially with our questionnaire, which have been both a great help. All in all they were invaluable especially due to our time constraints.

In the following sections we will go into more depth with each method and how it was operationalized in the field. We will describe each method, and follow up with a reflection on the success of using these methods with an interdisciplinary approach.

3.2 Applied methods

During the development of our research problem and project objectives, we identified the different social and human, economic and natural factors that we wanted to investigate and measure throughout our fieldwork. We identified a mix of methods from social science and natural science which would allow us to triangulate our findings.

Table 2: Overview of the methods used and the key themes covered by each method.

Methodology	Key themes
Participant observation	Tradition, Strategies used by households
13 Semi-structured interviews	Strategies used by households, Biogas installations, NGOs
1 Focus group interview	Strategies used by households
28 Questionnaires	Strategies used by households
GPS measurements	Location of survey households, paths walked, markets
9 On-farm firewood availability assessment	Firewood biomass available on-farm
3 Household firewood measurements	Daily consumption of firewood

3.2.1 Semi-structured Interviews

In our initial synopsis we had an objective focused on the political work that influences the choice of fuels in the domestic sphere. This was later elaborated to identifying some of the structures that influence fuel choice. One of our primary methods of fulfilling this objective and others were through the use of interviews with key-informants. In addition, this data also helps us to elaborate on several of our research questions.

During our fieldwork we conducted 13 interviews of varied lengths and intensity. Among these were some with 'experts' who have specific knowledge on the area's consumption of fuels or aspects of fuels. These informants were able to answer questions which we could not answer through our research otherwise. We also interviewed households who use alternatives to the traditional *three-stones stove*, as well as firewood and charcoal which provided insights to the advantages and disadvantages of the different stoves and fuels.

We also experienced firsthand that with fieldwork, sometimes things take a lot longer than planned. For example, one morning two group members had the task of interviewing the Health officer in Othaya and the assistant chief in Gathugi. What seemed like a simple task involved the entire morning with the assistance of two county chiefs, two assistant chiefs, and an appearance at a *Barazza* (community meeting).

3.2.2 Focus Group Discussion

Picture 1: Focus Group Discussion

Initially we had planned to conduct two focus group discussions in order to compare responses and identify differences between respondent groups, however time only allowed us to conduct one focus group. We therefore decided to focus on women because the woman is the main decision maker in the household about the largest fuel consumer, cooking. We organized the focus group in collaboration with our local village elder, Mrs. Waruguru because she was able to help us establish contact with women who represented different age and social group affiliations in Thuti sub-location. The participants were between 27-55 years old, they were all farmers and 6 of the 9 were members of GBM and/or wPower, giving us a diverse group in terms of age and knowledge about household fuels. It is worth noting that we chose to conduct the meeting with only women present. This was to make the women feel comfortable talking in the group, and to further this only the female members of our own group were present. We used a facilitator to ask questions during the meeting, which kept the discussion flowing and on-track.

The objective of the focus group discussion was to understand the perception and thoughts of different fuel types used in the community from a female perspective. To do this we prepared several participatory rural appraisal (PRA) exercises that in themselves did not provide too much surprising information. However the exercises helped facilitate some interesting discussions which is where we obtained a lot of insights into household fuel choice. This information was then used to verify and supplement the information we gained through our questionnaire and semi-structured interviews.

Picture 2: Making Chapati with the host family

3.2.3 Participant Observation

To engage in deep hanging out requires time (Bernard 2006). Therefore we did not have the time for deep observations, but had to settle for

spontaneous participations, such as helping with cooking, chopping firewood, and other domestic chores. These allowed us to engage in conversations with our host mothers which related to our topic and to experience on our own body what women experience every day. Through talking with our host mothers we also learned they have several cookstoves and use different types of fuel in the daily work around the house. Both of our host mothers also have a dream of having biogas installed one day, and one of the husbands is planning to have it installed. This preliminary information was a great help in constructing our questionnaire and what information we could probe into while doing interviews. Finally we were able to confirm some of the tendencies we noticed with *mother* in a lot of other households.

3.2.4 Questionnaire

During our fieldwork we also constructed and distributed a questionnaire. A note of our sample size here is necessary. Our area of interest is the aforementioned Thuti sub-location which is spread in 9 villages. Given our limited timeframe, we aimed for 3 questionnaires from each village, resulting in 29 questionnaires. Dismissing one, we ended up with 28 useable questionnaires, 4 with male and the 24 others with female respondents. All respondents were asked to reply on the behalf of the household. We would have liked to sample the households randomly, and that is would have been an improvement in our study if we were to conduct it again.

All of the respondents engage in farming except the two that do not own farmland. A potential error is the fact that all of the questionnaires were conducted during the day, and not in the evening or early morning. This means that all day-labourers were not available to answer our questions.

In hindsight it is clear to us that a pilot test of our questionnaire would have been extremely useful. We had many issues with poor wording of questions that left the answers unusable, which might have been avoided if we had a pilot test. We had three interviewers, which at times asked some of the questions in slightly different ways or had different interpretations of some of the questions. However, the three groups discussed their results afterwards and tried to create a common understanding for each variable. Here pictures of stoves and kitchens could have helped a lot, and it would have been valuable to conduct more than we did.

Moreover, aspects of the questions and answers may have been “lost in translation” as the questionnaires were translated from English to Kikuyu and vice versa. This further highlights

the importance of conducting a pilot run and then talking through the entire questionnaire with all interviewers to ensure that the correct and comparable information can be obtained.

In addition to the questionnaires we also mapped the GPS waypoints for each questionnaire and took on-farm firewood availability measurements at some of questionnaire households. This was done in conjunction with the questionnaires to minimize the amount of plots that we had to go to, therefore using less of people's time.

The complete questionnaire can be found in the Appendix

3.2.5 GPS

In order to get a visual overview of the research area, GPS tracking and waypoint marking, a Garmin Etrex 10 GPS was used. Most important here are the locations of the households that participated in our questionnaire, central points like Gathenge and Gathugi market but also the tracks of the Grand Tour and the Forest Walk. The collected GPS data were used to create maps using QGIS.

Not only until after conducting the questionnaires did it become apparent to us that the administrative boundaries of Thuti sub-location are not well defined, as two groups (that were responsible for different areas) surveyed the same household twice without noticing. In addition, when connecting the GPS data with the administrative boundaries of Thuti sub-location in QGIS, it became visible that several households are actually outside of the described research area. This has also to do with recent changes of the boundaries but more current data than displayed in Figure 3 is not available.

3.2.6 Forest Resource Assessment (FRA)

To assess household self-sufficiency in firewood we conducted nine on-farm firewood availability assessments (FRA). These were done in conversation with a member of the household of the farm who pointed out their property lines and the trees that they prune for firewood as well as answered questions about their pruning management. As trees used for firewood are interspersed throughout the farm, we sampled 10-20% of the trees used for firewood throughout the farm plot. At all but two households all the trees sampled were grevillea trees (*Grevillea robusta*), the most common tree used for firewood. In order to calculate available branch biomass, we used an allometric equation by Jangra et al. (2010) meant specifically for grevillea. We chose to just calculate branch biomass because this is the predominant part of the tree used for firewood of the households sampled. This data was then compared with firewood consumption gathered in the questionnaire in order to assess

self-sufficiency in firewood. As we conducted the FRAs on the same plots as a portion of the questionnaires, we were able to compare the FRA data with the household characteristic data we obtained through the questionnaire.

During our fieldwork we learned that this method is far from perfect as it relied on both the farmers' estimation of the percentage of the trees that they prune throughout the year (a difficult estimation) as well as an estimation of how many trees they have on their property that are used for firewood. When multiple farmers stated that they have maybe 1,000 trees on their 1 acre of land we knew that this estimation was not always the best. More than half of the households also have coffee from which they use prunings for firewood, as well as other fruit trees that might be present. An estimation of this biomass was not calculated and it would have been an interesting and important addition to our estimation if time permitted. The complete FRA methodology can as well as reflections on errors be found in Appendix.

3.2.7 Firewood measurements

As a means of verifying the households' estimated daily firewood consumption stated in the survey, firewood measurements were conducted at three of the respondents' households. The chosen households consist of 4 and 5 family members, which is close to the average household size of 4 of our respondents and 3.6 of the Thuti region.

Picture 3: Firewood measurement

The women of the households were asked to set aside the amount of firewood they thought they would use during the day as well as some extra just in case more was needed than anticipated. This bundle of wood was weighed with a hand scale and the women were asked to just use that wood throughout the day. The bundle of wood was measured again at the same time the following day to find the actual amount of firewood that was consumed over

the 24 hour period. This was repeated over four days. This method was adapted from Benjaminsen (1997).

We found that by returning to the household over multiple days, we gained a better picture about the variation in daily firewood consumption than if we had just made one-time measurements. In addition we were able to have more informative conversations with these households during our repeated visits.

Grand Tour and Forest Walk

We were guided by our village elder and our guides during our first day for a Grand Tour of the Thuti area which was a great way to get our first glimps of the community. We also particiapted in a Forest Walk of Karima Forst with the two forest guards that guard the forest.

Findings and Discussion

In the next chapters we present our main findings in relation to our research objectives and use these findings to analyze and discuss the predominant rationales that are used in household decisions about fuel choice in Thuti sub-location.

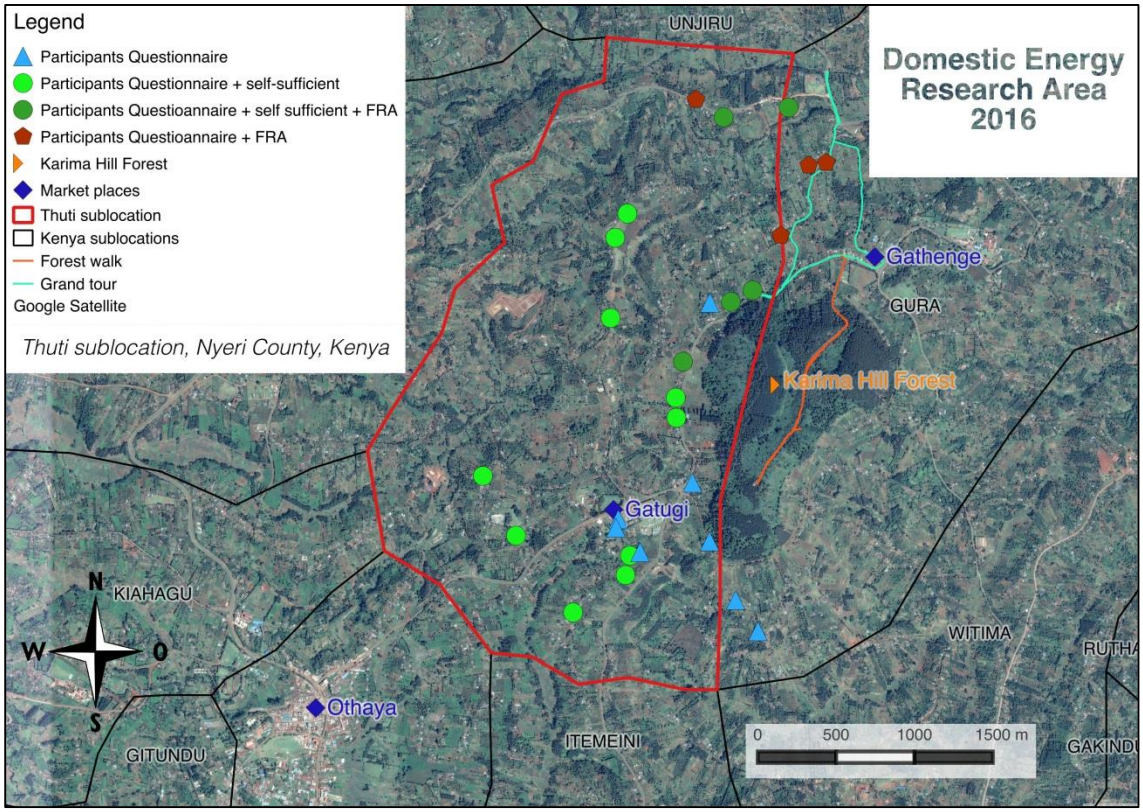

Figure 3: Map of the Research Area, Thuti sub-location, questionnaire respondents, self-sufficiency and FRA

4 Fuel use and distribution

In line with the national and regional trend of domestic energy (Mugo and Gathui 2010; Mwangi 2013), firewood is used by 89% of our respondents. Only two households do not use firewood. These households do not own land and live in the village center.

All but one respondent uses more than one cooking fuel source, charcoal being the most common secondary fuel (57%), followed by LPG (43%) (Figure6). Households use on average two fuel types for cooking fuel purposes in our sample.

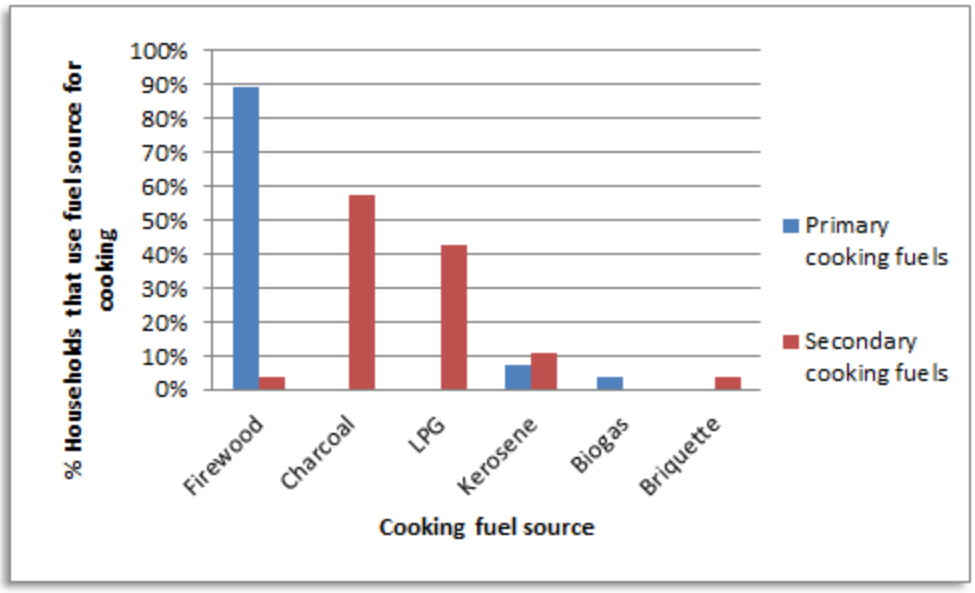

Figure 4: Primary and secondary sources of cooking fuels used by questionnaire respondent households in Thuti sub-location, Nyeri County, Kenya 2016 (n=28).

The diversification strategies can both be understood as risk-minimizing and optimizing. An example of this is charcoal which is often used for cooking as well as for heating in the coldest months, June-August. In the focus group the women said that charcoal is used when there are no other alternatives. The women explained that it is dirty which makes it hard to clean dishes, it smells bad and it emits dangerous carbon monoxide. They said that it was mainly people in cities and who rented houses who used it. However, they also use it when it is hard to find dry firewood in the rainy season. Following this description it can be seen as a risk-minimizing strategy, since it is a way to diversify to not only rely on firewood. On the other hand it became clear from interviews that some women produce charcoal when they have a surplus of wood, for instance after pruning coffee trees. In that way it is an optimizing strategy, to gain as much possible from one act.

LPG is used to heat up food and tea quickly, such as in the very early morning to make tea for children going to school or to reheat food. Some focus group participants explained that although LPG is faster and more convenient than firewood or charcoal, it is too expensive for all cooking purposes. LPG is therefore only used when it takes too much time to start the fire and in that way it is an optimizing strategy.

Kerosene is primarily used for lighting, however the two respondents that do not own land and do not use firewood use kerosene as their main cooking fuel and the third household uses kerosene as a supplementary cooking fuel. Although kerosene is no longer common in this

area as most houses have been connected to the electrical grid, it is still used as a backup during electricity shortages (Interview Assistant Chief Charles - 08.03.2016).

For lighting, electricity is the most common. For the whole Thuti sub-location, the assistant chief estimates that at least 80% of the residents in Thuti are connected to the grid. In general for lighting purposes kerosene is being pushed out by electricity, which is something we observed and which was noted by the assistant chief (Interview Assistant Chief Charles - 08.03.2016). Many of the households that we visited have a dusty kerosene lantern in their kitchen that they used before they had electricity. Two households had solar lamps which they use as a backup for lighting during blackouts.

Picture 4: Kerosene lamp (left) and solar lamp (right)

Electricity is also used for the televisions that can be found in many homes and to charge cellphones and other small appliances. Refrigerators, stoves and other large appliances were not seen at our respondents' households. At our focus group discussion the women also mentioned that in a perfect world, they would cook with electricity, because it is the easiest. However, for now it is too expensive to use for more than lighting purposes.

Although only one of our survey respondents has a biogas system and uses it as her primary cooking fuel source, we visited a total of six household with biodigesters and heard of up to possibly twenty others in the area. The knowledge and adoption of biogas in Thuti will be discussed in Chapter 8.

5 Factors

Through our data collection, we identified various factors that influence household fuel choice decisions. We have broken up these factors into the following categories: finance, human and social and natural factors which we will present in the following chapters. Throughout the chapters we will discuss how this is related to the three rationales.

5.1 Natural Factors: firewood, on-farm biomass and tree cultivation

As firewood is the predominant cooking fuel source for our respondent population, we have focused this part of our discussion on natural factors that influence the choices made about firewood use.

5.1.1 Source of firewood

Firewood is sourced through various means in Thuti. Over half (58%) of the households obtain all of their firewood from their farm, and we have considered these households "self-sufficient" in firewood (Figure 5). In similar firewood consumption studies in the region that measured firewood consumption, Githiomi et al (2012) observed a respondent self-sufficiency of 43% and Pravalipruskul (2015) observed that "over half" of respondents were self-sufficient in firewood.

Other households get some firewood from their farms and buy the rest from neighbours or buy all from their neighbours. Three out of 25 respondents stated they collect firewood from Karima Forest. One of these three respondents also sells additional firewood from the Forest to neighbours. It is possible that some of our other respondents also use firewood from the Forest and did not decide to reveal this sensitive information.

Overall, Thuti appears to be a case of a community that obtains most of its firewood from on-farm production, be it from their own farm or a neighbour's. Karima Forest used to be a much more important source of firewood before its closure to the public (Interview Lucy Wanguru - 05.03.2016). One woman recounted how she would spend a day collecting firewood at Karima Forest; she and her friends walked the kilometre up the hill to the forest with their babies strapped to their chests. They would collect and then carry a backload of branches weighing many tens of kilograms back down the hill to their homes.

In the focus group the women talked down about the people who would go to Karima and collect firewood. Moreover they mentioned deforestation as a disadvantage of firewood and this reflects the ecological rationale and how they are concerned about the common goods.

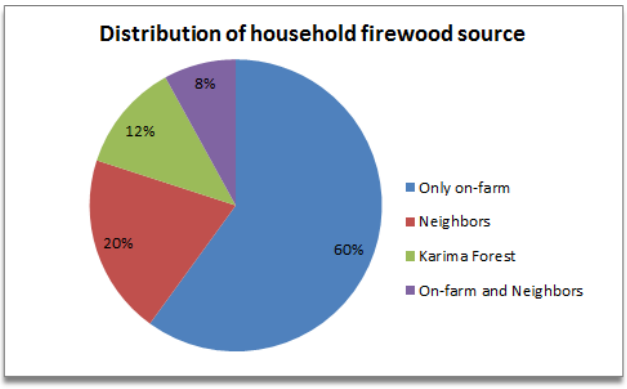

Figure 5: Distribution of firewood sources of survey respondents in Thuti sub-location, Nyeri, Kenya (n= 25)

5.1.2 Firewood consumption

The average household firewood consumption of the survey respondents is 5.5 kg daily and 38.5 kg weekly. This rate of consumption is comparable, but higher to the 32 kg of firewood consumed weekly by respondents in a similar study by Githomi et al. (2012) in the nearby Kiambu, Thika and Maragwa districts. The average consumption of the three households where the firewood measurements were taken over the course of four days, was 6.7 kg daily and 46.9 kg weekly (Table 3), a notably higher rate of consumption the average value reported from survey respondents. The difference in the firewood use stated in the survey compared to that of the actual measurements taken at the households might reflect the actual consumption of other households in the area. If the three sampled households are a good representation of the surveyed households, then it is possible that the firewood measurements have highlighted the chance of households underreporting their consumption. Household size is not accounted for in these consumption values, however as the firewood measurements highlight in Table 3, consumption depends on additional factors as well. Household 2 (5 members) consumed on average almost three times more firewood daily than Household 1 and 3 (4 and 5 members respectively). There is clearly a large variance in daily firewood consumption among survey respondents as well, which depends not only on household size, but also on the daily activities of the household; the number of meals prepared during the day and the types of foods cooked.

Table 3: Daily household firewood consumption measurement results over a four-day period (measurements listed as actual, wet weight of wood in kilograms)

Household	# Household members	Day 1 firewood (kg)	Day 2 firewood (kg)	Day 3 firewood (kg)	Day 4 firewood (kg)	4-day Average firewood (kg)
1	4	9.1	5.3	0.6	3.4	**4.6**
2	5	10	12	9	17*	**12**
3	5	3	5	4	4	**4**

**Githeri* cooked that day

5.1.3 On-farm biomass

The most predominant tree used for firewood is grevillea (*Grevillea robusta*), which is a fast growing tree, ideal for fast production of fuel biomass (Mugo and Gathui 2010). However through our conversations with farmers during the FRA, it became clear that the grevillea and other trees used for firewood have multiple purposes on the farm. Trees are interplanted with crops, which is a way to maximize the use of land space. These interplanted trees are routinely pruned in order to reduce the shading of crops, most notably coffee, as farmers say the coffee is more productive in full sun. The grevillea leaves from these prunings can be commonly seen as being used as a soil covering below the crops. Many farmers stated that these same grevillea trees would be cut and sold as timber and that pruning is a management technique to improve the quality of the timber. Finally, grevillea trees can be seen marking the boundaries of many farm plots. This is an example of the ecological rationale with the multi-use strategy since many different products are produced to meet different household needs. An additional firewood biomass source is the routine prunings of coffee branches, which applies to 61% of the survey respondents. The coffee branch biomass is just a byproduct of this management technique.

Therefore, on-farm trees are used for multiple purposes and they would likely be pruned either way, if they were used for firewood or not. So one factor that influences household fuel choice is the pure nature of trees and their management; they need to be pruned. Like many survey respondents noted, firewood is available and free.

5.1.4 Estimated on-farm available branch biomass

The forest resource assessment (FRA) gave us insight into the amount of branch biomass households have available on their farms that could be used as firewood. Of the nine FRA households, the average estimated available daily pruned branch biomass was 5.89 kg, which

is around 2150 kg annually available per household and 472 kg available annually per household member (Appendix). This is almost half of the national estimated annual per capita consumption of 741 kg of firewood (Mugo and Gathui 2010). However it is possible that the households in this region consume less than the national average. By extrapolating the values found with the firewood measurements, the average annual per capita consumption of these three households is 539 kg. Of all the survey respondents, the average stated annual consumption per capita is 502 kg. The greater level of stated consumption compared to the measured available on-farm biomass suggests that these households must additionally source firewood off-farm. Three of the five FRA households that do not produce enough firewood on-farm, buy firewood from their neighbours' compounds. The three households that do claim self-sufficiency in firewood do however exceed this average per capita consumption.

5.1.5 On-farm tree cultivation

Of the households that are self-sufficient in firewood, 79% state that they continue to plant trees on their compound, compared to 64% of the households that are not self-sufficient in firewood. Tree planting is conducted both through seed collection as well as replanting seedlings found under trees. There has been an apparent influence by NGOs in the promotion of the cultivation and planting of trees in the region. The Green Belt Movement (GBM) has been active in Thuti since 1997, organizing groups of women to cultivate and plant trees in Karima Forest as well as on their own farm compounds (Interview Lucy Wanguru - 05.03.2016). We interviewed a participant of a wPower project who has made a tree nursery with group of women. The trees will be sold to GBM, wPower and other NGOs involved in reforestation projects of Karima forest. These same women grow trees individually for their own farms.

5.2 Financial factors: lack of capital, control of household finances, self-sufficiency

Throughout data collection, money was the most commonly mentioned factor that influences fuel choice, which was also the case in other similar studies (Mwangi 2013; Githiomi et al. 2012). Over half of the survey respondents stated that a "pro" to the use of firewood and charcoal is that it is inexpensive or free. These arguments used by the farmers reflect an economic rationale.

The domestic control of finances is also a factor in relation to the decisions about the types of fuels purchased. In many households it is the husband who controls the finances, often being

the one employed. This imbalance in power is somewhat counteracted by the women's groups, where women have a money exchange and pooling systems. This allows the women to have access to money in times of investment or in times of need, which can free them of some everyday worries.

5.2.1 Self-sufficiency in firewood and farm plot size

Among the 89% of the households that use firewood as their primary fuel source, 58% obtain all of their firewood from their own farm (Figure 5). This value can be compared to a similar study in neighbouring regions to Nyeri, where 43% of households were found to obtain firewood directly from the farm (Githiomi et al 2012). This leads to the question of what might characterize households that source all of their firewood on-farm, or are self-sufficient in firewood versus households that do not source all firewood on-farm, or are non-self-sufficient in firewood.

Table 4: Household financial characteristics of firewood self-sufficiency

Household characteristic	Self-sufficient in firewood (n= 14 households)	Non-self-sufficient in firewood (n= 11 households)
Average plot size (acres)	2.15	1.33
% Income below 5,000 KSh	50%	90%
Household members	4 (range 1-6)	3.6 (range 2-6)
Average number of cows	2 (range 0-10)	1.9 (range 0-3)
% that produce coffee	93%	45%

Table 4 displays household financial characteristics between households that are self-sufficient in firewood and those that are not. There is a greater proportion of the non-self-sufficient households that listed their income as the lowest income bracket (Table 4), suggesting that there might be a relationship between household self-sufficiency and wealth. Although income was measured in the questionnaire, we found that most of our respondents are farmers; income alone is not a good representation of household wealth. In addition, numerous households were uncertain about the value they stated for their monthly income. In order to get a more holistic understanding of household finances, studies on the topic often measure indicators of wealth (Mushongah and Scoones 2012). Through interviews with our key informants, we identified some indicators for wealth for the community; farm size, the

production of coffee plants and the number of cows. We found that the households' production of coffee as being the most notable wealth indicator in relation to self-sufficiency in firewood; a greater proportion of self-sufficient households cultivate coffee than those non-self-sufficient. This supports the possible relationship between household income and self-sufficiency. However a different interpretation of this possible relationship is that the coffee trees offer additional firewood biomass, and so enabling the household to be self-sufficient in firewood.

The households' self-sufficiency in firewood might also simply be dedicating more land to tree production. A decision to dedicate more land to trees might be influenced by such natural factors as topography. At one of the households where we conducted an FRA, the woman pointed out that the majority of her trees are on the slope that is too steep to terrace and plant crops. In that way this natural factor has influenced her decision making, which includes an economic rationale as the cultivation of trees is in this situation the best way to maximize the potential of the land. Therefore this can be an example of an optimizing strategy.

5.3 Human and social factors: Traditions, social networks and health

Of the 26 survey respondents who use firewood, 7 still use the three stone stove as their primary firewood stove. The most common reason given by respondents who use the three stone stove is that it is how they have always cooked and it was what they were taught by their mothers. Some of the households that have an improved stove also showed us that they still use a three stone stove when they need to use a large pot to cook a large meal.

The improved cookstoves are widely used in the area; 18 of the questionnaire respondents currently use some form of improved firewood cook stove. Three learned about the technologies through an agricultural officer and two through a neighbour. Six of the 18 respondents made their own stoves and five of these are associated with a community organization. This shows how knowledge and social relations play an important role in the uptake of new stoves.

We interviewed multiple members of a wPower group that recently began a pilot briquette making project. wPower has also made one training in the area where they picked 2-3 women from different women's groups and taught them about different improved cookstoves. The idea behind was that the women would be able to spread the knowledge and pass it on to the women in their own women's groups.

Finally, health was listed as a concern by survey respondents, by focus group discussion participants and many of those interviewed. A common concern for firewood and charcoal is the smoke pollution. Some of the respondents who had changed to improved firewood stoves mentioned that an additional benefit to being more efficient was that they produced less smoke. According to the local nurse, women come with chest problems caused by smoke. The nurse also mentioned that younger women are dealing with these problems better than elderly because of a higher education level.

6 Structures

In this chapter we will examine some of the structures and in connection to this, some of the actors that influence domestic energy. We will first focus on the population growth and land tenure system and secondly, The Forest Act and Karima Forest. Thereafter we will look into the market and access and finally we will focus on electricity.

6.1 Population growth and land tenure systems

Population growth is a commonly mentioned driver of land use change (Rasmussen and Reenberg 2012; Boserup 1965) and it can also be related to fuel decision making. According to the assistant chief, there is little population growth in the area. In 2009, 3650 people were living in Thuti (KNBS 2009). This number did not change much since the last census in 1999, only with about 40 people (Interview Assistant Chief Charles - 08.03.2016). So even though the population in the sub-location did not grow substantially, whereas the average population of Kenya did grow by 2.7% annually for the last 8 years (World Bank 2014), it becomes clear that the population pressure in Thuti must have other reasons.

These can be found in the predominant land tenure system in the sub-location. It is a tradition that a young man should not live in the same house as his parents which eventually leads to the point where the land of the family has to be divided. In addition, a study by Scheffler and Dodoo (2009) reveals that parents rather decide to have fewer children than to divide their land into smaller and less sufficient fractions. Still, despite this tendency, which has an important impact on current fertility rates, the tradition to divide the land of the father reduces the individual plot size for future generations. Therefore, if the amount of trees that can be cultivated on a farm is influenced by plot size, then the ability to produce enough firewood in the future might become more difficult.

6.2 The Forest Act and Karima Forest

Both the assistant chief and the forest guards of Karima Forest confirm that people are still collecting firewood from the forest, even though it is now illegal. However, this phenomenon is decreasing. The assistant chief says that 3 years ago it was very bad, and people were still collecting a lot. He mentions that they have a lot of security because the forest was suffering from the massive deforestation. Karima Forest is therefore now protected by two forest guards and no one is allowed to enter unless they have a signed permission by the regional officer. Anyone caught in the forest faces a fine and a lawsuit (Interview Assistant Chief Charles - 08.03.2016).

One of the focus points of the Forest Act of 2005 is to enable participatory forest management with the adjacent communities (Parliament of Kenya 2005). This community use system has not been put in place for Karima Forest however. Due to the community's current inability to participate in the managed use of the forest, access to this historically used source of firewood is no longer legally available to households.

6.3 Market and access

Professor Kiama, the Academic Director of wPower, explained that one of the constraints for adopting cleaner energies is the access to other fuels and stoves. The shops which provide these alternatives are in Nairobi. This is a massive challenge for many households, where the mother rarely will have the time and money to go to the capital.

However Kiama also explained that he had just seen a young man in Othaya selling clean cookstoves who had started 3 months ago. We also saw places in Othaya selling improved cookstoves and this shows it might be an emerging market.

The problem of access to market is also expressed in our questionnaire, through talking with women, and our observations, alternatives to firewood must be bought on markets or in town.

Although most of the area is accessible by tarmac road, there are still very few households in the area that can afford to travel far, or who own a vehicle of their own. On top of that roads are partly winding mountain roads, which make even shorter travels an endeavor. Our questionnaire shows that people would go anywhere from between 0.5 to 35 km to get LPG (Figure 3). It is more expensive to buy LPG in the local village, Gathugi, than in Othaya; the

price difference is 200 KSh to refill 6 kg LPG, and a difference of 400 KSh to refill 12 kg LPG[1]. However, time and costs for transportation is saved by buying locally.

6.4 Infrastructure: Electricity and Kenya Power

The electricity infrastructure in the area was developed during the presidency of the former president Mwai Kibaki, who was from the area. The main barrier for the usage of electricity is therefore not the access, but more the high price. This was mentioned by the women in the focus group and it could also be seen in our questionnaire where the high price is stated as the major disadvantage of the use of electricity. For many it is hence only used as an alternative to kerosene for lighting. This is an example of how the structures influence the decision making of the households. If the structures were in place to provide cheap electricity it would probably influence their decision making, since women expressed an big interest in this as an alternative cooking fuel source.

7 Factors, structures and rationales

In the previous chapters we have separated human and social, financial and natural factors. However, it should be noted that they are related and interact. An example of this is the presence of coffee trees. We have discussed it under the financial factor since it is an indicator of wealth however it is clearly also a natural factor. Another example to illustrate how the factors are intertwined is women's groups where human and social factors can contribute to financial factors.

In line with this, the structures interact with the factors and they influence each other. The demographic development and land tenure systems affect the natural factors of the households, since the plot sizes are getting smaller. Another example is The Forest Act, a structure which has influenced the community's access to firewood, which can be considered a natural factor. The removal of access has influenced households' choice to source their firewood somewhere else.

In the previous chapters we have also discussed how the three rationales are manifested. When women were asked why they used the different fuels, the economic rationale was most often dominating the decision. However it cannot be stated that the economic rationale is

[1] To refill 6 kg LPG it costs 950 Kenyan Shillings (KSh) in Othaya, and in Gathugi it costs 1150 KSh. To refill 12 kg it costs 2000 KSh in Othaya and 2400 in Gathugi. 1 USD = 101 KSh.

more important than the other rationales. This can be demonstrated through the example of improved cookstoves. Even though it is inexpensive to build an improved cookstove and it can be done almost entirely with on-farm resources, some households do not change. According to the economic rationale, people would change because by investing a small amount of money, they could save firewood, and in the end maximize their profits. In this case, the socio-cultural rationale is dominating, since tradition is often the reason why the women do not want to change. Moreover, this example shows one of the weaknesses of the economic rationale. It is assumed that people have information about how to act in an economical rational way. However, people might have imperfect information, and might not even know that the improved cookstoves exist and their benefits for efficiency and health.

Even though all the women in the focus group stated they would use electricity in an ideal world, we cannot be sure that they would completely abolish using firewood or charcoal, because the socio-cultural rationale was also dominant for cooking in general. Survey respondents and focus group discussion participants stated that an advantage of using firewood and charcoal is that it cooks the food better and some stated it makes the food taste better. The fact that firewood and charcoal cooks food slower compared to LPG is seen as a good thing by some, as people find that it is unnatural to be able to cook *githeri* quicker than the normal two hours it takes with firewood. So even if electricity or LPG became cheap it is not certain that women would abolish firewood even though it would be economically rational to do so.

Deforestation and multi-use strategies relating to trees reflect the ecological rationale, however it was the least dominant of the three rationales.

Throughout the paper we argue that there is a difference between factors and rationales, with factors being based on our observations and fairly tangible and rationales as a mindset being influenced by these factors and the structures mentioned earlier. We find this anchoring in real world observables behind the rationales to be lacking in the paper by Rasmussen and Reenberg (2012), alongside the lack of attention to structures on micro level, ie. the household as an entity. Moreover we have found some limits to using the rationales which will be discussed in the next section.

7.1 Limits to rationales: Shared decision making

A limitation of the three rationales is the focus on individual decisions and the lack of attention to the household as a unit. The ecological and socio-cultural rationales take into

account that the individual will include perspectives of the household and community, however the overall understanding is individualistic.

In the focus group we asked who decides what fuel to use for cooking. Without hesitation the women answered that they do, and that the man just wants to be served dinner. However, the women also added that if they need finance to invest in a new stove, they would often go to the man who is in charge of the main finances in the family

Dr. Thenya, the consultant of wPower, confirmed this and said that the man does not care how his food is cooked, but he wants to be able to see his food, so it is of interest to him to have electricity installed (Personal Communication Dr. Thenya - 11.03.2016). The man is also often the main decision maker when it comes to the energy used for lighting, since it is a bigger investment (wPower 2015).

Therefore it can be questioned to what degree it is individual decision making, because as presented, it can be decisions made in common by more household members. Moreover social relations can influence decision making. As explained, many women participate in women's groups where they discuss and learn about other fuels and make common savings to help each other. Women's decisions on cooking fuels are therefore also influenced by these groups.

Through this analysis we have tried to present examples of how decision making is complex and is influenced by many different factors, structures and rationales. This might be useful to examine further for development projects promoting new fuels. Therefore we will end by describing the knowledge and potentials of biogas which is an example of an emerging alternative fuel.

8 Biogas: An alternative path to self-sufficiency

Biogas is an alternative path to household self-sufficiency and it appears to be an emergent fuel source that in recent years is gaining traction (wPower 2015; Mugo and Gathiu 2010). As many households in Thuti are self-sufficient they might not be as inclined to think about switching to another fuel source such as biogas. But as farm plot sizes are decreasing as described above, the need for a sustainable fuel source that is not very dependent on plot size will likely be more prevalent in the future.

During our fieldwork we learned of around thirty biodigesters currently being used in the region (Interview with Michael - 03.10.2016), and visited six in Thuti. As 70% of the survey respondent households have at least one cow for manure production, as well as other logistical requirements for biogas production, we identified biogas as a potential alternative fuel source for many households in Thuti. More information about biogas use and its potential for adoption in Thuti can be found in the Appendix 11.5.

In general biogas is well known in the area and it frequently came up in conversations when respondents were asked about alternative fuel sources. It appears like the general concept of biogas is understood and that this information is being spread through friends and neighbours. However there might be a gap in the knowledge of its functioning and the different biodigester options available. Many of the focus group discussion participants indicated that they would be interested in biogas if they had more money. However as the conversation about biogas continued, other reasons came up. One big concern was that biogas might run out in the middle of cooking, that it is not as reliable as other fuel choices. This is a misconception because as long as the biodigester, the vessel where the biogas is produced, is serviced properly, then continuous supply of biogas will be available. This highlights the possible lack of knowledge about this new technology.

All of the six households we interviewed that have a biodigester, said that they decided to get one installed because they knew of someone who had one and saw their success with it. This reflects the socio-cultural rationale since the women argue that a social relation was one of the main reasons for installing it. This is an important rationale to consider when promoting a new technology; social relations play an important role on the uptake of new technologies. An additional reason given for installing a biodigester was because in the long run, money is saved since the only input is free and available manure. This reflects the economic rationale.

Women in the focus group discussion stated finances as the main barrier to the installation of biogas, however additional aspect of misconceptions of the technology could be observed. We learned of two biodigester models that are being used in the area, one which costs up to ten times the amount to construct as the other. Although the inexpensive model is much more financially feasible to install, it is much less common in the region. Many of the women in the focus group discussion had not heard of the inexpensive option when asked about it, which is likely due to the fact that information about this technology is spread through word of mouth. This is an example of the imperfect knowledge which makes it hard to use the economic rationale. However, if more information was known about inexpensive ways to install biogas, perhaps other decisions would be made.

The households that we visited with the expensive model were notably above the average household in the area in regards to household finances, education level and occupation. In line with this, one of the biogas installers said that a common characteristic of a household that installs biogas is their disposable income. Due to this, they have the ability to think ahead and make economic rationales about the money that can be saved with the installation of biogas over the long-term. Both biodigester installers that we met also stated that some understanding of the engineering and functioning of the system is needed for a household to make a biodigester work properly. Therefore biogas might be perceived as a technology that is only accessible to the educated and wealthy.

Another interesting social-human factor that we identified was the increased presence of the man of the household in deciding to install a biodigester compared to other cooking fuels. The big financial investment might imply that like the case with the choice to install electricity, the hierarchical structure of the household have an influence on the decision to install a biodigester.

Although the Ministry of Energy states that biogas should be promoted as an alternative fuel source (Mugo and Gathui 2010), Michael, one of the biodigester installers, said that promotion at the governmental level is going too slowly. The structures do not encourage the use of biogas and it is therefore to a higher degree a decision based on factors and rationales.

To conclude, it is not just financial factors that are limiting the uptake of biogas for households in the area. Social factors also influence the choice of adoption, and both the woman and the man are involved in the decision to install biogas. People are learning about the technology through word of mouth, and might be more easily convinced to adopt the

technology once they have seen a neighbour's success with it. Through analyzing the household's rationales on the uptake of a technology, an organization promoting such technology might have increased success.

9 Conclusion

In this paper we have presented and analyzed our findings about the the different fuels used for domestic energy in Thuti sub-location. We have identified and discussed the factors, structures and rationales that influence household decision making about the use of these fuels.

Although we had expected to find that the majority of the women in the area use firewood for cooking, we did not expect to find that they are using other fuel types to supplement firewood use such as charcoal and LPG. Using a diverse array of fuels is a common strategy in the area, and it primarily reflects an optimising strategy.

We are surprised to find that Karima Forest is just a small source of firewood for households in the area. Instead, we found that 58 % of our respondents are self-sufficient in firewood, stating that they only use firewood from their own farm. The majority of those who do not, source firewood from their neighbours' farms. This means that women are not walking long distances to collect firewood, which is the case in many other regions in Kenya. Previously more women from the community collected firewood in Karima Forest, but have been forced to find other sources of firewood since they have been denied access. This is an example of how the fuel choice is not just made by individuals, it is also influenced by structures.

We argue that decision making is influenced by factors and structures and that it can be problematic to assume that decision making is the result of an individual. Our results show that decisions in households are done in interaction between husband and wife, with each influencing the others' sphere of activity. The husband controlling the finances have the power to discourage the wife's wishes to change, however we also found that women are organising themselves in women's groups which also works to support each other financially.

The interplay between factors and structures is the basis for our understanding of the decisions being made in our case area. Further it has been valuable to us to highlight decision making through the lens of the framework of the rationales by Rasmussen and Reenberg

(2012). We found that both economic and social-cultural rationales have a role in the decision making about fuel choice. The ecological rationale was also apparent, however less important.

With each generation household farm plot sizes are decreasing. As at least 2 acres is required for household self-sufficiency in firewood, the ability to remain self-sufficient in this fuel type will likely become unfeasible for more and more households in the future. Therefore sustainable, alternative fuel sources are important to investigate. Biogas is an emergent alternative fuel source being used in Thuti sub-location. Although the financial barrier to this technology is present, the misconception about the cost of its installation is currently further enhancing this barrier to adoption.

9.1 Perspectives

In the following section we will address some of the topics that we did not have time to go into much depth with. Most of the topics mentioned have however briefly been addressed in the paper.

Biogas is definitely an emergent fuel with potential to change the fuel scene, it is fast and efficient, good for the environment, and most importantly free once it is operational. In a further investigation it would be interesting to look into the cheaper biodigesters since the high costs are most often mentioned as the barrier for uptaking the technology. Moreover it would be interesting to examine the role the Kenyan government and NGOs have in promotion of this technology.

Another perspective that we did not delve deeply into was the issue of gender. Originally we had envisioned that we would address certain power structures in households and question the role of husband and wife in regards to fuel choice. We have discussed their respective roles in regards to decision making, however this is a topic that could be perceived from many different angles.

Another perspective, which was often mentioned during our visit, was Karima Forest. As mentioned Karima Forest is closed for access from the local communities and the political issues and reasons behind this lack of involvement of the local community could also be investigated by an interdisciplinary team.

Finally, as mentioned in the introduction, a crucial theme related to cookstoves is health. We have briefly touched on this topic with our interviews with a nurse and a health officer of the region in question. However it is still a relatively unexplored topic in the region. Our experience with the health officer led us to believe that there is much to be investigated on this topic. Improved cookstoves and the efficiencies of these different cookstoves, alternatives to firewood, or even better working positions in the kitchen could be topics to work with.

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10.2 Interviews

Lucy Wanguru 05.03.2016. Interview on *The Green Belt Movement and wPower's work in Thuti.* Interviewed by Natalie Waithera.

Professor Kiama 05.03.2016. Interview on *wPower and Wangari Maathai Institute*. Interviewed by Kirstine Jespersen.

Assistant Chief Charles 08.03.2016. Interview on *Fuels in Thuti and Karima Forest*. Interviewed by Mathias Hjorth.

Health Officer 08.03.2016. Interview on *Health issues pertaining to domestic energy specific for Thuti sub-location*. Interviewed by Mathias Hjorth

Michael K. 10.03.2016. Interview on *biodigesters in the area and the potential uptake of the technology.* Interviewed by Elizabeth Willey.

11 Appendices

11.1 Overview of methods used during the fieldwork

Methodology	Who	When
Participant observation	N/A	04.-13.03.2016
14 Semi-structured interviews	Professor Kiama	05.03.2016
	Lucy Waruguru	05.03.2016
	6 households interviewed with Lucy Waruguru	07.03.2016
	Assistant Chief	08.03.2016
	Health Officer	08.03.2016
	Nurse	10.03.2016
	Biogas Installer	10.03.2016
	Household with biogas	12.03.2016
	Forest Walk - interview with the guards	08.03.2016
12 Firewood measurements	Questionnaire households 008, 009 and 010	010 - 07.03.-11.03.2016 009 - 07.03.-11.03.2016 008 - 08.03-12.03.2016
28 Questionnaires	With a member of each of 27 households	09.03.-10.03.2016
9 FRA	With 9 participant households of the questionnaire	09.03 and 11.03.2016
1 Focus Group Discussion	With 9 women	10.03.2016
GPS	N/A	04.-13.03.2016

11.2 Questionnaire

1.1. Waypoint

1.2. Telephone number for identification

1.3. Date

1.4. Name

1.5. Gender

1.6. Position in household

1.7. What is your age?

10-20

20-30

30-40

40-50

60-70

1.8. No. of people living in your household

1.9. What is your and your spouse's occupation?

1.10. What is your and your spouse's alternative occupation?

1.11. Which of the following monthly income categories do your household belong to? (net income)

Below 5000

5000-10.000

10.000-15,000

15,000-20,000

Above 20,000

Do not wish to answer

1.12. Do you have any alternative sources of income? And how much?

1.13.What is the size of your farming plot? (Acres)

1.14.What crops do you grow on your farming plot? What percentage of these crops do they makeup?

1.15. What animals do you have? And how many of each?

1.16. Do you have trees on your compound that you use for fuel wood?

1.17. Do you plant new trees on your farm for fuel wood?

1.18. Are you a member of any woman group or other group? Which?

Notes (If you want to make a longer comment on a question, reference the question number or matrix position e.g. a reference in the fuel matrix would be J2 for Pros charcoal)

The following questions were answered for every fuel type ranked in 2.1

2.1. Rank your sources of energy from the most used to the least used (firewood, charcoal, Elect, Solar, Biogas, LPG, Kerosene)

2.2. Indicate the source of energy used in the last 1 year.

2.3. Uses of the source of energy e.g cooking heating

2.4. Quantity used. Daily Kg used for firewood and charcoal. Kilowatt for electricity

2.5. Cost per bundle of firewood, sack of charcoal, electricity bill

2.6. Place of purchase, gathering

2.7. Distance to place

2.8. No. of times travelled to obtain fuel monthly

2.9. Pros

2.10. Cons

2.11. Have you changed one of your sources of energy the last 3 years? If yes, how did they get to know the new source

2.12. Why did your household change source of energy?

The following questions were asked in connection to the use of cookstoves.

3.1. When did you start using it?

3.2. Where did you get it?

3.3. How did you get to know about it?

3.4. Pros

3.5. Cons

3.6. Cost (implementation and usage)

11.3 Focus group discussion

The focus group discussion was held with 9 women on 10th March 2016.

The discussion was designed to gather information from the women in regard to the following outcomes:

1. To understand what types of fuels are popular within the area.
2. To understand the pros and cons of various types of fuels.
3. To understand how they rank their sources in order of use.
4. To understand the role of women in relation to the fuel used in households.

Participant Demographics

Participant	AGE	OCCUPATION
1	55	Chairlady W-Power,GBM member, Farmer
2	27	Farmer
3	40	GBM Member, Farmer
4	40	Farmer,GBM Member
5	36	W-Power Secretary, Farmer, art designer.
6	30	W-power member, farmer
7	41	Farmer,GBM member
8	30	Farmer
9	40	Farmer

- All women
- All farmers
- 4- members of the green belt movement
- 3- members of the W-power initiative

Popularity of fuels

There was a list of 7 types of fuels generated and the ranking in accordance to popularity was as follows:

1. Firewood
2. Electricity
3. Charcoal
4. Paraffin
5. LPG
6. Solar
7. Biogas

- Firewood was most popular because most buy the prunings or trees from neighbours who grow them. Others have trees on their compound from which they depend on for firewood. Some in the community "steal" from Karima Forest.

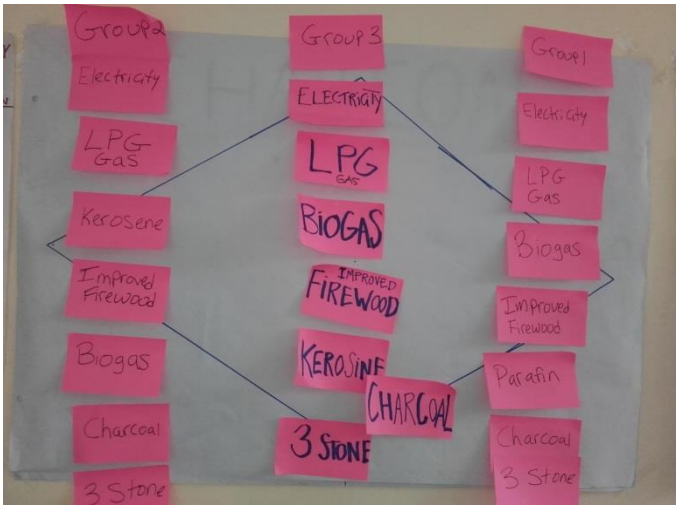
- Othaya sub-county is well lit as the Kenya Power has electrified the whole area and most households have electricity.
- The charcoal is made from the firewood thus still popular.

Overview of pros and cons for firewood, charcoal and biogas		
	Pros	**Cons**
Firewood	Cheap, Available, Fast, Efficient to make traditional food (like Githeri)	Deforestation, Smoke, Dirty, Labor demanding
Charcoal	Cheap, Rain season, You do not have to look after, More efficient than firewood	Dirty, Bad smell, Carbonmonoxide (CO) – Dangerous, When no other alternatives
Biogas	Cheap when installed, Fast, Efficient	Expensive to install, Requires labor

- An important view was that firewood is very efficient. "Very good for big meals such as githeri and arrow roots or perhaps when one is cooking for many people".
- The women said that the use of biogas is not common as it is not for their 'class' meaning that only the rich could afford it.
- Most of the women said that they have only seen the biogas from other people's homes.
- They also thought that once installed it is very cheap as there is no cost implication.
- They said if the installation process was cheaper they would go for it.
- The downside was that most traditional practices are foregone if they implement this type of energy. Such practices include roasting maize and heating during cold seasons.
- The general feeling is that even if they had this installed they will still use charcoal and firewood as alternatives.
- The sentiment was that they do not like it. They use it when they do not have an alternative. They could use it especially when the firewood has been rained on and is wet. It serves a good alternative in these instances.
- A big pro was that one could leave food to cook as the charcoal cooks slower and food does not get burnt and thus one can go about their business.i.e farming.
- They highlighted that charcoal is used mainly by people who live in rental houses and thus cannot use the firewood as per landlord's requirements.
- Reason why some still use 3 stone stove: They might need more training on the subject, Lack knowledge, Saving traditions of roasting maize and heating and Laziness.

The ideal world scenario

A scenario of an ideal world where there were no hindrances was provided in order to get their opinion. The variables were: electricity, LPG, biogas, 3 stone, paraffin, charcoal and Improved firewood stove (jiko-okoa). The women were divided into three groups within which they ranked the fuels.



1. Electricity: it was ranked first place the main hindrance is the money to get it.
2. LPG: it was also preferred when it came to cooking. They mainly use it alternatively to the firewood. In the mornings. They would use it exclusively were it not for the cost of refills.an issue of roasting maize arose as it is not possible to do it using LPG.
3. Kerosene: came third in group .group 1 and 3 say biogas came second.

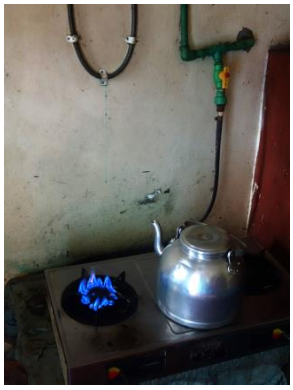
- A woman thought that the kerosene was good and criticized other women on their thoughts of it producing bad smoke. One group assumed that the status quo was maintained and thus ranked it second for the others they saw in an ideal world perspective.
- The facilitator asked why biogas is ranked third and not one yet there are no subsequent charges. They said they have money so it's not really a big deal.
- One lady said that the biogas was labour intensive compared to electricity which is just a touch of a button.
- A woman said that in the ideal world they would have taken biogas as no. 1 as they would have money to buy the cows and to hire someone to tend to them.
- Firewood was ranked as the most used fuel at no 1 but ranked fourth because of money or costs involved.

Decision-making

Generally it's the women who decide. But because of the finances involved in the switching they consult the husband who is the head of the home. In most cases women just go ahead and get stoves. There is consultation with the head of the household who is the man with regard to income. This is less common as women mostly go ahead and get the stoves

11.4 Stoves used in Thuti sub-location

Stove	Picture	Description
Three-Stone-Stove		Traditional stove, operated with firewood, sometimes iron ring to put the pot on.
Improved Energy Saving Stove		It has one entry point for the firewood (as opposed to the three entry points of the three stone stove) and that it is somewhat enclosed to insulate the fire. This insulating characteristic makes the stove use the firewood more efficiently and produces less smoke. Usually made from metal, but sometimes also from on-farm materials like dirt
Charcoal Stove - *Jiko*		Metal stove, operated with charcoal. Popular for heating in the colder month.

LPG Stove		Metal stove, usually right on top of a LPG-bottle or connected to it by a rubber/plastic pipe
Biogas Stove		Similar to the LPG stove but the Biogas comes through a pipe directly from the biodigester.
Kerosene Stove		Made from metal, operated with Kerosene

11.5 Biogas in Thuti

In our preliminary research before arriving in Thuti, we were under the impression that the use of biogas was not common and only used by a couple households that were more affluent than the representative population. During our fieldwork we discovered that biogas is much more prevalent than initially thought and that it appears to be gaining popularity in the area. We visited and heard about at least thirty biodigesters in the Thuti area that have been constructed within the past five to ten years. Micheal, an expert biodigestor installer, says that orders for new biodigester installations are on the rise, now that more people know about them through mainly word of mouth. Although it is the more affluent households that are installing the more durable, long-lasting biodigesters, Josiah, another expert, said that popularity of the much more affordable plastic tube biodigesters is also increasing.

Potential for uptake

The main requirements for a household to have a biodigester are at least 1-3 cows living in a no-grazing system in a caraal and a good water source (The Organic Farmer 2015). Of the households surveyed, 70% have at least one cow, all of which are living in a no-grazing system close to the home. There is also running water at the majority, if not all, of the households visited. Therefore, it appears as though these households have the resources for sufficient biogas production for a biogas system large enough for families of the average household size of the area (4) (Mugo and Gathui 2010). With the no-grazing system located near the home, both the source of manure and water are conveniently located next to where a biodigester would best be installed. We observed that the manure from the caraal is moved to a pile next to the caraal to cure before applying to crops and most of the households we visited have a source of water right next to the caraal for cleaning the stalls, which makes adding these inputs to the biodigester that more convenient. In addition, the households we visited all use the manure slurry byproduct of the biodigester as a soil amendment for their crops and spoke highly of its effectiveness, which is also supported by the literature.

Desire to switch

The desire to switch to a biogas system for their main cooking fuel source was discussed during the focus group discussion after the participants ordered their desired fuel types (if money was not a concern).

At first the woman said that their reservations about the system was that it required daily labor, but then they joked that if money was not concern, they would be able to pay hired help to maintain the biodigester. It was also mentioned that there was a concern that the biogas might run out in the middle of cooking, where other fuel sources are more reliable.

Both Josiah and Michael, the expert biodigester installers interviewed, and the other households interviewed with biodigesters, gave some insights into the challenges with the implementation of this relatively new technology in the area. Michael, who has been installing biodigesters for ten years, noted that the majority of his clients are households with a disposable income and know how to plan ahead and make the calculation about the cost saving of the technology. Focus group discussion participants said that cost was the main barrier to stopping them from looking into the installation of a biodigester. Aside from the cost barrier, it was noted by both Michael and Josiah that some understanding of the engineering and functioning of the system is needed for proper servicing

Biodigester systems

Of the biodigesters visited, five are of "fixed dome biogas systems" (The Organic Farmer 2016), a model that requires significant capital for the building materials (price range of 80,000- 150,000 KSh). The households with this system all appeared to have household members with well-paid occupations, high levels of education and nice looking houses; above the average households in the area.

We visited one household with a plastic tube biodigester, which requires much less capital for the installation and building materials (range of 8,000 - 10,000 KSh). This household appeared to be more representative of the average household in the area. The owner, Josiah, has made a business of making these biodigesters and has constructed six of them in the Thuti area, including that of his neighbour. Josiah installed his own seven years ago and

he and his family of four have been using it as their main cooking fuel. His neighbour used her biodigester for one year before the tube was punctured by dogs. This highlights one of the downsides of this biodigester model; it is much more fragile than the cement model and requires some form of protection. Although it is much more affordable, the plastic tube biodigester option might be less known in the community as no one talked about this model when asked about what they know about biodigesters.

Fixed Dome Biodigester System

Plastic Tube Biodigester System

11.6 Results from survey on primary fuel

Table 5: The distribution of the primary and secondary fuels used for cooking

Primary fuel	Number of resp.	% of 28 respondents	Avg. quantity
Firewood	25	89	5,5 kg / day
Kerosene	2	7	48 KSh / litre
Biogas	1	4	4 cows

11.7 FRA Methodology and additional errors:

The FRA was conducted to calculate just the biomass being produced on the farm that has the potential to be used for firewood by the household. Therefore, only the trees that the household uses for firewood were included in the FRA sample. As these trees are interspersed throughout the farm instead concentrated in woodlots, it was decided to sample 10-20% of the trees, aiming to select those that best represented the total. The equation by Jangara (2010) uses just the diameter at breast height (DBH) of the sampled trees in order to calculate branch biomass. Farmers were asked to estimate in percent how much of the tree branches pruned throughout the year. This information was then used to adjust the branch biomass calculations to reflect the amount of branches that are available for firewood. One shortcoming of the FRA is the allometric equation used is specifically for grevillea trees, although at two of the households other tree species were included in the FRA measurements, leading to even less accurate estimations. Finally, there are shortcomings to the accuracy of such an allometric equation which is discussed in the literature.

The results of the FRA can be found in the table below.

Table 6: FRA summary

Household	001	002	003	004	006	007_	008	009	010	Average	Stdv
Farm size (acres)	1	2.5	7	3	1.5	1	0.5	0.125	1	1.96	2.10
household size	6	5	5	5	5	1	5	5	4	4.56	1.42
firewood trees	50	80	100	15	40	30	12	9	100	48.44	36.62
average DBH (cm)	65.5	75.75	62.3	112.8	82.5	58	81.25	73.25	60.4	74.64	16.88
Average branch biomass of one tree (kg)	48.8	55.77	41.39	115.62	66.22	31.31	65.8	50.34	44.89	57.79	24.38
Estimated annual pruned branch BM (kg)	2440.22	4015.77	3725.09	1560.91	2383.93	845.24	789.65	453.1	3142.06	2150.66	1316.46
Estimated available daily pruned branch BM (kg)	6.69	11	10.21	4.28	6.53	2.32	2.16	1.19	8.61	5.89	3.62
Stated daily firewood consumption (kg)	8	3	3	5 -8kg	6- 9kg	3	3 logs	10	n/a	5.40	3.36
Daily firewood consumption (kg)	8	3	3	6.50	7.5	3	4	11	4	5.56	2.84
Measured daily firewood consumption (kg)	n/a	n/a	n/a	n/a	n/a	n/a	4	12	4	6.67	4.62
On-farm sufficient for daily consumption?	n	Y	y	n	y/n	n	n	n	y	N/A	N/A
Buy firewood?	y	N	n	n	n	n	y	y	y	N/A	N/A
"Self-suffcient"	n	Y	y	n	?	n	n	n	n, but could be	N/A	N/A

11.8 Synopsis

Domestic Energy 2016

An interdisciplinary field work on choice of cooking fuel in households in Gakina, Othaya County, Nyeri, Kenya

By Kirstine, Elizabeth, Frederik, Dominik, Mathias

Introduction

Around 2.6 billion people worldwide rely on biomass (namely firewood and charcoal) as the primary source of energy for cooking and heating (Lambe et al. 2015). The use of biomass fuels, especially from wood sources also has a long tradition in Kenya. According to the Ministry of Energy, 89% of rural households use firewood as their main energy source where only 7% of the urban families use it as their main source (Githiomi et al. 2012). Currently, about 90% of harvested wood in Kenya is used for woodfuel (Mugo and Gathui, 2010). Woodfuel is harvested in nearby forested areas, purchased or produced on the farm in woodlots or between fields in an agroforestry system.Charcoal is the second most used cooking fuel in Kenya, with benefits of being lightweight, cleaner burning than woodfuel and less expensive than gas. Although the sale of charcoal is legal, the legality of charcoal production appears blurred with confusing regulations and permitting processes, leading to much of the charcoal produced to be coined as illegal (Ministry, Environment and Natural Resources, 2013). Regardless, the economic importance of the charcoal industry can not be contested; charcoal production employs over 700,000 people, and its value chain supports an estimated 2.8 million people, with a market value of $427 million (Mugo and Gathui, 2010).

Challenges with the consumption of fuelwood and charcoal include the reduction of forest resources due to unsustainable and often illegal wood harvesting practices. Fuelwood consumption has greatly increased with a steadily growing population from approximately 5 million in 1950 to about 45 million in 2014 (WPP 2015). Furthermore there has been an increase in consumption due to energy demand from factories, for instance for tea and coffee production.This consumption puts pressure on local natural resources and has led to vast

deforestation as well as an alarming -57% biomass energy supply deficit in Kenya (Mugo and Gathui 2010).

Kenya's forestry sector is vulnerable to many factors including climate change, ineffective institutions and enforcement, corruption and illegal logging. This is expected to have important effects on the composition, growth rates and regenerative capacity of the forests and therefore also on woodfuel supply (Dion et al., 2012).To protect the forests and control the woodfuel demand, in 2005 the Kenyan government made the Forest Act. The Forest Act has enabled participatory forest management together with the adjacent communities. However, it also has a major impact on the access to fuel for the locals that used Karima Forest as important source. Since 2005 are GBM and Gaia Foundation working with the local communities in order to rehabilitate the Karima Hill Forest. The idea is to clear the eucalyptus planted in the colonial times and replace it with indigenous seedlings. The Karima Forest is seen as a sacred place. Due to the rehabilitation process and the Forest Act is the access to the Forest as source of woodfuel strongly limited (Gaia Foundation 2016). Therefore it can be questioned if community based forest management in Karima is an illusion of empowerment as it falls short to really incorporate all important actors (Chomba et al. 2015).

In addition to the potential negative environmental impacts of fuelwood and charcoal use when sourced unsustainably, there are also important social concerns with the use of fuel biomass, most notably fuelwood. Inefficient cookstoves and poor ventilation lead to harmful air pollution, which those working in the kitchen, women and children, are exposed to. Globally it is estimated that 4 million people die annually due to illnesses caused by pollution of cookstove smoke (Lambe et al., 2015). Additionally, the task of collecting firewood typically falls on the women in the household (Dohoo, 2013), meaning less time to allocate towards the actual cooking of meals and all of the many other daily tasks. Correlative studies have sound that household nutrition declines with a decreasing accessibility of biomass fuel

sources as women have less time to cook and/or they choose to not prepare as many meals with fire (Mugo and Gathui, 2010).

Hence, there are both health, environmental and social benefits of using more efficient cook stoves and other sources of fuel. NGOs have been working on the agenda for many decades to improve cookstoves and they have tried to introduce alternative fuels sources. Important actors in Nyeri county and the Othaya area are wPower, the Green Belt Movement and with some projects with the German aid organization GIZ. For these organisations, the promotion of ideas via radio, media and newspapers is very common. The heads of communities also often make demonstrations, called 'Barasas' in order to spread information provided by the NGO's.

Alternative cooking fuel sources to fuelwood include biogas (Dohoo, 2013) and liquefied petroleum gas (LPG) (Githiomi et al., 2012). The uptake of biogas has been slow in Kenya due to the high capital costs, and the requirements for maintenance and management support (Mugo and Gathui, 2010). However, Dohoo et al. (2013) proves systematically how for example installing biogas digesters on the farm reduces women's time used to collect firewood by several hours each week and/or less money purchasing firewood (Dohoo, 2013). The use of LPG for cooking fuel is better in that it is cleaner burning than wood and charcoal, however it is not an ideal rural cooking fuel source as it is typically more expensive than biomass fuel sources. In addition LPG is produced with non renewable sources. A barrier to the adoption of both biogas and LPG as a cooking fuel is that they require a different type of stove than what is used for fuelwood and charcoal.

Although there are alternatives to fuelwood, the number of people relying on fuelwood stays high in rural Kenya (Githiomi et al. 2012). This leads us to the following Problem Statement:

What are the (social, political, economic and environmental) <u>factors</u> that influence the choice of fuel for cooking purposes in domestic households?

Alternative problem statement: *What are the (rationales behind) the strategies and interests that influence the choice of fuel?*

(We expect to change the problem statement according to our findings and the input of our Kenyan counterparts once we are in the field).

The following research questions and sub-questions are related to the first problem statement and will help us answer our inquiry:

- Fuel sources: What are the sources, availability, accessibility and use of fuel for cooking?
- What types of fuels are available and what is the energy potential of these fuels?
    - What is the spatial and physical availability of these sources of fuel?
    - How accessible are the resources and who has the rights?
    - How much fuel is used on a weekly base in the average household?
- Social: How do the household/community structures influence the choice of cooking fuel?
    - What are the power relations in the community and in the household related to the choice of cooking fuel?
    - How are women empowered in the community?
    - Do women have access to cash or are finances controlled by male members of the household?
    - Is cooking meals part of tradition and therefore not able to be re-interpreted?
- Political: What are the political structures that influence the choice of cooking fuels?
    - How does the Kenyan government influence / protect the natural resource accessibility and availability?
    - What is stated in the Forests Act (and the Energy Act), and how is it implemented?
    - How did/do national policies affect the local community when it comes to cooking fuels?

    - What is the role of NGOs in Gakina and what have these done so far?
    - How have the NGOs tried to influence the choice of fuel?
- Economic: What are the economic factors that influence the choice of cooking fuels?
    - How is income related to choice of fuel?
    - How is education and tacit knowledge related to choice of fuel?

Methodology

To examine our problem statement we will use an interdisciplinary approach. We will use methods from social science and natural science which will allow us to triangulate our findings. We find it useful to make us of the Sustainable Livelihood Framework (DFID 1999). We do this to have a framework in which we can organize our data according to different assets and strategies. Our different methods will allow us to gauge the different assets the households may have. We combine this with our desktop research which will allow us to gain knowledge on governmental/institutional processes and structures.

We will make a case study of Gakina, a village North of Karima Forest, outside of Othaya, a town in the central highlands of Kenya. The study site has been selected by our partner the Wangari Maathai Institute for Peace and Environmental Studies, College of Agriculture and Veterinary Sciences at the University of Nairobi.

Case studies can offer an in depth understanding of an issue, but we are aware of the limited potential of generalizing our results. However *"social inquiries – as empirical and historical science – become truly interesting only when they relate to other inquiries"* (Lund 2014) and therefore we will also relate our study to general discussions about domestic fuel sources in Kenya and see how the results resonate with other studies.

As students from a Western university we are aware of our bias and prejudice. Our investigation is based on previous knowledge and a priori concepts and the choice of concepts affects the results. Through our study we will reflect on this and make our assumptions as visible as possible. It is also important to emphasise that it is an interdisciplinary fieldwork - meaning that though some of our methods are grounded in either

social or natural science they will have value for either perspective (e.g. Community Mapping, which creates data both of social and natural value). We have in the following section divided into social and natural methods, however that is only for overview. They are to be used in combination of and compliment each other.

Social science methods

We are going to conduct questionnaires, semi-structured interviews, participant observations, focus groups interviews, and community mapping.

Through observation, in collaboration with our host families, Kenyan counterparts, local key-informants and the community leaders we will identify respondents and thereafter we hope for a snowball effect - meaning that as we build up a relationship with our community, we anticipate more intimate and more interesting data will be available. Our main focus is on households and women, and we will use different criteria such as education level, age, socioeconomic status, distance to forest resources, type of stoves and fuel types used to ensure that data is as relevant as possible.

Participant observation

One of our main methods of establishing a relationship with the community at hand is through *participant observation*, which is a very established method in anthropological fieldwork. It is the anthropologist's way of dealing with the presumption that whatever people say they do, is never, what they actually do (Bernard, 2006). The data gathered is positivistic, but nonetheless still considered scientific. Data gathered will be through the use of field notes, pictures, recordings and transcripts from open interviews.

Fuel Collection Walks

We will engage with a sample of the local households in Gakina, probably some small-scale farmers near Karima forest. We will observe what fuels are used and how these are acquired through fuel collection walks. Additionally we might find some households using wood from Karima. This will allow us to plan walks with the women collecting firewood there and

inquire on how they have gained those rights, if they have them. This will allow us to create field notes, GPS-waypoints, knowledge on routes and procedures taken to collect firewood. Participant observation is also useful for us to gain the trust of the local community, whereas more intimate discussions will be possible. Possible ways of gaining trust could be cooking with women, playing/teaching with children, or work with farmers in their field. A general understanding of local everyday life is a strong asset when constructing interviews, which are explained in-depth below.

Interviews

An important and very useful method in any social work is the conducting of *interviews,* which is a very broad field discipline. We are most likely to use semi-structured interviews with key informants. These informants are local people with in-depth knowledge on areas we are interested in (Bernard, 2006). It can be difficult to know when your informants will reveal themselves. Semi-structured interviews are very useful for short fieldworks, where you will not have time to interview an informant more than once. Semi-structured interviews are conducted with an interview-guide to help control the direction and pace of the conversation. However a limit of control by the interviewer allows the informant to pour out as much information as possible. It can be valuable to let an informant steer the conversation, since new data might surface (Bernard, 2006).

Questionnaire

We will make *questionnaires* to further understand the fuel choices and strategies of households in Gakina. Questionnaires are good to gather quantitative information, ask closed questions and questions with categories as answers. The measurable information we are interested in is household characteristics, fuel use, consumption as a proxy for income, level of education and more. These variables can be used to conduct profiles of our households which then can be used to find patterns and hypothesis for our main questions.

Focus Groups

We will conduct focus group interviews and discussions to gain a more in depth understanding as well as to triangulate the data obtained through the questionnaire. We aim to conduct one focus group of male respondents and one focus group with female respondents, depending on the situation a division into rich/influential less influential/poorer or older and younger could be helpful as well. The focus group interview participants will ideally be selected by the villagers on the basis of their knowledge about the village territory and community, however given our short timeframe we will have to make some assumptions on the knowledge of our participants. Advantages of these types of interviews is that they are flexible and can be modified during the study which will allow us to adjust our question as we gain more knowledge (Babbie, 2002). Focus group interviews will also allow us to engage in an informal dialogue with respondents and this interaction can reveal power relations and norms of the community.

PRA

One other tool-set we wish to apply in the field is *Participatory Rural Appraisal (PRA) methods*. PRA is used for engaging with locals in activities, which will provide insight for farmers and researchers alike (FAO.org 1999). Such methods are for example the mapping of local resources with local households (e.g. wealth ranking, territorial and neighbourhood mapping). The goal of the exercise is not to finish with an *accurate* assessment of resources, but rather the *perceived* availability of resources. This can be useful for our project in regard to the choice of fuel - which we expect to be related to the availability of biomass fuels in the area. Here it can also be interesting to note differences among male and female respondent groups, since groups may have different perceptions and will answer differently in according to who they are doing the focus group with, i.e. we will learn about different power relations in the community.

Cultural Mapping

Moreover we will conduct cultural mapping exercises with the focus group respondents to explore the different household members' relationship to the local environments, including

the forest and the farm (Strang, 2010). This will give us the opportunity to establish wealth and property as well as fuel source rankings (Diamond Ranking Exercise) and create a map of the community showing the major fuel sources and distribution, accessibility and availability of land (Neighbourhood and Territory Mapping).

Natural science methods

We plan to address the aspect of the choice of biomass fuels in Gakina through a mix of empirical and analytical methods.

Fuelwood gathering and choice

We will first conduct fuel-wood gathering walks in both the forest and farm woodlots to find out where household members go to collect fuelwood and the characteristics of the biomass that is collected for fuel, including the biomass species and physical state (size, dry or green). Community mapping exercises will be important in identifying the overall locations of where fuelwood is gathered, as well as where fuelwood, charcoal and gas

can be purchased. The use of GPS waypoints that can then be connected to satellite imagery will further help to get a better overview of important locations and the routes of the fuelwood walks. A sample of these distances should also be calculated in "travel time" to take into account topography and road conditions. We might use GIS software in our data analysis to overlay the different maps that we create with this information.

Through the questionnaire, focus group discussions and semi-structured interviews, we will ask questions that pertain to fuelwood choice as well as the strategies households take to obtain fuelwood.

Physical accessibility of cooking fuel sources

The question of physical accessibility of cooking fuel sources can be addressed through the measurement of the distance between the household and the sources of the different cooking fuel options, including on-farm, forests and markets (for purchased fuel). We will measure

distances with the use of a GPS waypoints, the corresponding satellite images and GIS software.

Household consumption of fuelwood and charcoal

We will quantify daily fuelwood and charcoal use at the household level of at least five households. This information can be then used to extrapolate and estimate the annual household fuelwood and charcoal consumption.

On-farm availability of fuelwood

We will use forest resource assessment (FRA) methods to sample the woodlots of two households (and if time allows more) to estimate the amount of potential fuelwood that is available on-farm. Combined with an annual fuelwood consumption calculation, this information can be then used to estimate household fuelwood self-subsistence.

Potential for biogas

As biogas has been identified by the Kenyan government as a sustainable and healthy alternative to fuelwood, charcoal and gas fuel sources, (Mugo and Gathui, 2010), we will consider assessing the potential for such a technology at the households we are surveying. Possible information that could be gathered includes the amount of animal manure and crop residue currently available on the farm (as well as what that biomass is currently being used for eg. manure, animal feed, cooking fuel) and how much is needed on a daily/weekly basis for biogas production. We can also ask respondents about their thoughts and knowledge about such a system.

Farm forestry assessment

The Farm Forestry SLUSE group will be assessing farm forestry practices in Gakina. We will explore the possibility of sharing information with this group as many farm forestry trees are important fuel trees.

Collaboration with counterparts

We are in contact with our counterparts Natalie Waithera and Benson Ouma from Kenyan University. We plan to incorporate their perspectives and knowledge and on being open to new ideas during the development of our research question, synopsis and investigation.

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