Climate change adaptation effects of a clean cooking intervention

Assessing the climate change adaptation effects of the EnDev clean cooking project in the Kitui County, Kenya.

Master Thesis | Environment & Society Studies

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Abstract

This research is commissioned by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), under the EnDev project. EnDev (Energising Development) is an energy access partnership seeking to provide sustainable access to modern energy services that meet the needs of the global poor. One facet of this energy project is the implementation of Improved Cooking Stoves (ICS). About 1.5 billion people in the world still use traditional cooking stoves, which are proven very energy-inefficient and polluting. EnDev aims to provide people with an ICS, in order to give people an opportunity to access clean cooking, and at the same time exists on the climate change adaptation effects of the ICS intervention on the affected communities, and this research will attempt to clarify the existing uncertainties. However, the main purpose of this research is not to demonstrate that there is a positive correlation between climate change adaptation and the ICS intervention, but rather to create a methodology to make this research possible. The research in Kenya will be a pilot to test the methodology created, and based on the results the methodology will be adapted to expand to multiple project locations later on. The research has the form of a case study. Data is collected through literature/desk research, an expert interview with a local climate change expert and a questionnaire in the field. The geographical location where this research is conducted is the Kitui County, Kenya. In general, it can be stated, whether conservative or not, that having an ICS for the respondents in Kitui County has had a positive effect on the degree of climate change adaptation. Looking at the purpose of this research, the creation of a methodology to measure the impact of such a project on climate change adaptation, a basis for further research has been laid in terms of cause and effect process and methodology.

An improved firewood stove (Rocket Stove) in Kitui, Kenya. Source: Own image

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Glossary of abbreviations

EnDev	Energising Development
GIS	Geographical Information Systems
GIZ	Gesellschaft für Internationale Zusammenarbeit
GTZ	Gesellschaft für Technische Zusammenarbeit
ICS	Improved Cooking Stoves
IGAD	Intergovernmental Authority on Development
IUCN	International Union for Conservation of Nature
IPCC	Intergovernmental Panel on Climate Change
KCJ	Kenya Ceramic Jiko
KEFRI	Kenya Forestry Research Institute
NCCAP	National Climate Change Action Plan
NGO	Non-governmental organisation
RVO	Rijksdienst voor Ondernemend Nederland / Netherlands Enterprise Agency
UNISDR	United Nations International Strategy for Disaster Reduction
UNFCCC	United Nations Framework Convention on Climate Change

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1. Introduction

This thesis is a study that examines the impact of a component of a development project called 'EnDev' on climate change adaptation of a particular community in Kitui County. The aim of the thesis is to develop a methodology that makes it possible to assess the impact of the project-component on climate change adaptation. It is carried out on behalf of EnDev, under the leadership of the German development organisation: the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

1.1 GIZ & EnDev

EnDev is a partnership between the Netherlands, Germany, Norway, Australia, the United Kingdom and Switzerland. The management is mostly in the hands of GIZ and supported by the Rijksdienst voor Ondernemend Nederland (RVO). GIZ is an organisation that supports the German government in achieving its objectives in the field of international cooperation for sustainable development. The task of the RVO is to stimulate entrepreneurs in sustainable, agricultural, innovative and international entrepreneurship. The Energising Development Partnership Programme (EnDev) gives households, social institutions and SMEs in developing countries continued access to modern energy technologies and energy services. The projects is carried out in 24 countries in Africa, Latin America and Asia. Worldwide, 2.9 billion people still cook with traditional methods. This has disastrous consequences for the climate, development and health, especially for women and girls, because they are usually the ones who cook. In addition, more than 1.2 billion people do not have access to any form of electricity. They rely on dirty, often expensive, sources of lighting.

EnDev supports the development of markets for modern energy supplies, especially in rural areas. It concerns renewable energy for cooking, for lighting and for mobile phones (among others). Part of EnDev is training and coaching manufacturers and retailers of, i.e., energy-efficient cooking stoves and small solar energy systems. The programme also supports the construction of electricity connections via mini-grids and grid compaction. EnDev also stimulates installations for the production of biogas at the household level. The programme focuses on supply and demand. On the demand side, an example is the development of financial products that enable poor households to buy energy products. On the supply side, it is a question of the quality and availability of these energy products. Since 2005, EnDev has reached 15 million individuals, 31,000 small businesses and 18,000 clinics and schools. EnDev works with governments, NGOs and the private sector in the partner countries in Africa, Latin America and Asia.

The chosen research location is Kitui County in Kenya, because of three factors: the development of the EnDev project in Kitui County, the feasibility of this study, which will be explained in chapter 4.4, and the fact that scientific data states that climate change effects in this region are significant.

1.1.2 EnDev and clean cooking in Kenya

In Kenya, 97 percent of the domestic energy requirement is accounted by traditional biomass, which is mainly used for cooking (GTZ, 2007). There is a firewood demand of about 3.5 million tonnes per year, while there is only a supply of an estimated 1.5 million tonnes. The result of this deficit is a high level of deforestation, which leads to all sorts of environmental issues such as land degradation, droughts and desertification. In Kenya, the majority of the population lives in poverty in rural areas, and does not have access to modern

energy services that reduce the dependence on biomass fuels. A significant amount of people still use energy inefficient three-stone-fires for cooking. Several attempts have been made by international development organisations to tackle this issue, like the EnDev project.

The ICS project, carried out by EnDev, focuses on the development of sustainable markets for ICS by developing all actors in the ICS value chain, namely the producers, the traders, the test agencies and ultimately the users. As mentioned in the introduction, in Kenya biomass meets more than 90% of the total energy needs of households. The main sources of biomass are firewood, charcoal and agricultural waste. The cooking equipment used by households are often traditional three-stone fires with very poor thermal efficiency, which can have serious consequences for the health of users (through unclean combustion). Indoor Air Pollution (IAP) is estimated to kill 14300 people each year in Kenya, the main cause being the use of biomass in basic cooking appliances in combination with unsuitable cooking space (Energypedia, 2018).The main purpose of this project is to expand access to, and use of, ICS in the (mainly) rural areas of Kenya. The EnDev project worldwide runs until mid-2019, and the main objective regarding clean cooking is to have reached 6.73 million people with the ICS-project. As EnDev (2018) states, “until December 2017, about 9.6 million people have benefited from improved stoves. EnDev has trained and capacitated more than 3,500 stove dealers. The stove business has created employment in the production, marketing and installation segments, thus increased incomes. Stove production and distribution has become a real business: the project contributed to the development of 635 full-time equivalent jobs in private enterprises within one year.”

The modern cooking intervention affects people and the environment; it affects local communities by offering an opportunity to improve their health situation, gives them an opportunity to prepare meals faster and better, and saves time and money because an ICS consumes less fuel than a traditional way of cooking. It affects the environment because the performance of an ICS is higher and more efficient than traditional cooking methods, which reduces the emission of harmful gases, and because of the lower need for fuel, it reduces the pressure on natural resources. This research will mainly be focused in the climate change adaptation effect these ICS might have on the users. Key components of climate change adaptation are the decrease of vulnerability and increase the adaptive capacity of a community. Climate change adaptation is the process of adapting to the current or future climate and its effects, to mitigate its adverse effects or to exploit favourable opportunities (IPCC, 2014). Climate change adaptation aims at taking the necessary measures to reduce the vulnerability of human and natural systems to the consequences of climate change.

1.2 Kitui County, Kenya

The main part of this research is conducted in the Kitui County (until 2010 Kitui District), which is a county in Kenya. The capital of the county is Kitui town. In 2009, 1,012,709 people lived in a surface of around 25 thousand km². The county is divided into ten divisions: Central, Chuluni, Matinyani, Mwitika, Mutitu, Ikutha, Yatta, Mutongoni, Mutomo and Mutha.

75 percent of the population lives from agriculture, and in 2005, 69 percent of the people in Kitui County lived below the poverty line. The Kenyan population lives from livestock farming; mainly cattle, sheep and goats are bred. A smaller part of the population lives from poultry farming and beekeeping. Corn, beans, sorghum, broad beans, millet and cassava are the main crops grown on the agricultural land for personal use. Cotton, tobacco, mangoes, bananas, sweet potatoes, eggplants, okra and spinach are grown for trade (Kitui County, n.d.).

Figure 1: Citizens of Kitui. Source: own image.

The climate in the county is arid or semi-arid, 40 percent of the county's area is considered arable, only 1 percent is covered with forest (Kitui County, n.d.). However, an important point is that rainfall occurs practically only during the rainy seasons (a long rainy season of about 3-4 weeks in spring, and a short rainy season of about 2 weeks in autumn). The terms Long and Short Rain are not related to the amount of rain, but rather to the duration of the rainy periods (Kitui County, n.d.). Figure 2 shows a map of Kitui County.

Figure 2: Kitui County on the map of Kenya. Source: Kitui County Government

1.3 Research problem & question

The question, and the research problem, is how and to which extent EnDev enhances the matter of climate change adaptability of the improved cooking stove users in the Kitui County, Kenya by having access to such an improved cooking stove. It is well known in the scientific literature and policy documents what the mitigation effects are, e.g. by measuring and comparing the CO2 emissions of both the traditional cooking stoves and the ICS (Ofosu et al., 2012, Jack et al., 2008). It is however unclear what the direct climate change adaptation effects are, i.e. what impact does this project have on the matter of climate change adaptability of the affected society or community? This question is the central question in the research and is relevant for EnDev, because it is of great importance to know what the effect of the project is on the adaptive and coping capacity, to determine the success factors, validity and efficiency of the project. This research will act as a set-up for further research regarding the relationship between climate change adaptation and ICS intervention. Therefore, the actual outcome of the fieldwork in Kenya is not the only important result, and creating the methodology and piloting it in Kenya is a major outcome to further develop the EnDev project in other regions and countries in a sustainable manner, and this makes it possible to give recommendations for adapting the methodology to be applied in other regions.

The research question is:

How can the impact of the EnDev ICS project and its contribution to climate change adaptability be assessed, and what is the impact of the ICS project on climate change adaptability of ICS users in Kitui County, Kenya?

This is investigated by applying a case-study research, conducting a literature review, an expert interview with a climate change expert and a field-questionnaire. As stated before, the outcomes are not of main importance, it is more important to create a working methodology which EnDev can use to prove the relationship between climate change adaptation and ICS intervention. This created methodology is piloted in Kitui County, Kenya, and these results will give a first overview of the effects on climate change adaptation of a specific project. At the end of the methodology chapter, a few sub-questions will be listed that are used to give a comprehensive view on the research subject, and to structure the overall research and this thesis.

1.4 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) at regular intervals (every 5 to 7 years), creates evaluation reports on the state of affairs regarding knowledge about climate change. The publications of IPCC are an essential scientific input for the international climate negotiations, which take place within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

As the IPCC states in their fourth report (2007), the consequences of climate change are visible worldwide. On the one hand these changes are gradual, such as temperature rise, sea level rise, an increase in greenhouse gas concentrations and acidification of the oceans. On the other hand they are more abrupt, due to changes in the frequency and intensity of weather extremes, such as precipitation, drought and heat waves. On the land and in the oceans the distribution areas of species are shifting. Globally, one-fifth of the coral has died due to climate change; glaciers are declining in size due to the melting of snow and ice, as well as changes in the amount of precipitation and their distribution over the years, that affect the available quantity and quality of fresh water in many places. The agricultural sector and

food production are experiencing both negative and positive effects of climate change. The negative consequences are manifested mainly in the southern regions, the positive effects especially in areas on the higher altitudes (i.e. an increase of precipitation). In regions where the drought is increasing, not only crop losses occur but also extensive forest fires.

According to the WHO (2014), climate change could cause 250,000 additional deaths every year from 2030, due to malnutrition, malaria, diarrhoea and heat waves. The health costs resulting directly from climate change are estimated at 2 to 4 billion dollars per year by 2030.

Yet, the effects on public health will not be the same everywhere. Since health and well-being are also closely linked to socio-economic factors (income, housing, employment, education, lifestyle, etc.), the effects of climate change are likely to exacerbate the unequal health situation in and between countries and the vulnerability of people with limited income and specific groups such as children, unemployed people, the elderly and the sick people will increase. Some positive effects are also possible, such as a slight decrease in mortality, due to the lower temperatures in specific regions, but they will largely be offset by the magnitude and severity of the adverse effects.

1.4.1 Climate change policymaking

An example of a certain framework that has been created to mitigate climate change is the UNFCCC climate treaty. The UNFCCC is a so-called framework treaty concluded and signed in 1992 under the responsibility of the United Nations during the "Earth Summit" in Rio de Janeiro (UNFCCC, n.d.). The objective of the treaty (or convention) is to reduce the emissions of greenhouse gases and thus prevent undesirable consequences of climate change. It defines an international framework within which governments can jointly take action to counter the challenges of the changing climate on the planet. The treaty recognises international responsibility for the climate and tries to prevent undesirable influence through human action. The concrete objective of the treaty is "stabilising the concentration of greenhouse gases in the atmosphere at such a level that dangerous human influence on the climate is prevented" (UNFCCC, n.d.). The Kyoto Protocol and the Paris Agreement are important in this study because they form the basis for policy processes concerning climate change, and therefore also for the EnDev project. Before the EnDev project can be properly understood and placed in the right context, it is therefore necessary to comprehend where this policy comes from.

The Kyoto Protocol, or the Kyoto Convention, is a treaty drawn up in 1997 by the UN and the UNFCCC to reduce greenhouse gas emissions (Goudie, 2013). The countries' aim was to prevent the amount of greenhouse gas in the atmosphere from reaching a critical and dangerous limit. From the very first moment, there was a lot of discussion about the treaty. According to some, it is nonsense that climate change is caused by man. Others say that the measures taken under the protocol do not go far enough. And yet others simply consider the measures to be too expensive. Under the 1997 Kyoto Protocol plans, countries are required to emit far fewer greenhouse gases than in 1990 (Goudie, 2013). The exact percentage varies from country to country, but the minimum target was 5%. On average, emissions in 2012 had to be eight percent lower. The Convention was signed by 55 countries, but some of them later withdrew from the Convention. The United States took part in the conference, but did not ratify the treaty. Canada, which did ratify the treaty, later withdrew from it.

In December 2015, no fewer than 195 countries signed the Paris Agreement, thus agreeing on an ambitious, binding and fair global climate agreement.

Even though the United States recently decided to withdraw from the Paris Agreement, it can safely be regarded as ambitious and lays a good foundation for international and national policy for the coming decades (Turkenberg et al., 2016). The objectives are to :

- To keep the temperature increase well below 2°C (compared to the pre-industrial period) and even to aim to limit this increase to 1.5°C
- Increasing the capacity of countries to adapt to climate change and generating climate resilience
- Making the transition to a low-carbon society
- Making climate financing consistent with the transition to this low-carbon and climate-resilient development (Turkenberg et al., 2016)

One of the things that made it possible to go beyond the 'old' binary system - as reflected in the Kyoto Protocol - was the shift from a regime of 'top-down' imposed reduction targets to a system where each country has to set its own 'bottom-up' targets, tailored to its own needs.

1.5 Scientific and societal relevance

1.5.1 Scientific relevance

As is stated in the introduction, there is a research gap in the linkage between climate change and ICS intervention. The aim of this research is to gain insight into the direct connection between the intervention of ICS project run by EnDev and the impact of this project on the climate change adaptation of a specific population group. Research is available regarding the relation between ICS and climate change, but this research is limited to primarily mitigation aspects; the amount of greenhouse gasses emitted by traditional stoves in relation to the clean cooking stoves (Adkins et al., 2010). The conclusions are often that ICS reduce, i.e., CO2 emissions by 30-40 percent, followed by the assumption that the implementation of ICS reduces time in gathering fuelwood and cooking, and decreases adverse health effects, which leads to a more resilient community, (see chapter 3.3). A direct link between clean cooking intervention and climate change adaptation is still unclear.

1.5.2 Societal relevance

The societal relevance of this research is that it provides insight into the actual effects ICS intervention in terms of climate change adaptation on a specific community. Effects of ICS on a user is often measured based on complex arithmetic models that determine, for example, CO2 emissions, or measure how long it takes to cook something in a traditional oven in relation to an ICS, etc. Personal aspects of a community or individual are seldom taken into consideration. It is not automatically the case that when this project is implemented, and people gain access to ICS, this automatically increases their resilience towards climate change, which is often assumed in the scientific literature (see chapter 3.3). By looking at the socio-economic impact on a livelihood, this research will provide more insight into the issues that cannot be calculated with models, and thereby contribute to the effectiveness of this project on climate change adaptation.

1.5.3 Structure

In order to get a good picture of the social impact of an ICS, it is first necessary to understand what an ICS actually is, and what forms are used in Kenya. Therefore it is first

explained which cooking technologies are used in Kenya, and what an ICS is. The chapter 'Theoretical Framework' explains various concepts and theories on climate change adaptation and related factors, and what this means in relation to ICS. This chapter also shows the sub questions used. Then the methodology of the research is discussed where it is discussed how the research questions are measured, and as a logical consequence the 'Results' chapter follows, where the outcomes of both the questionnaires as the expert interview are elaborated. The last and final chapter summarises the results using the research questions as a guideline, and makes recommendations for further research.

2. Cookstove technologies

The concept of a ‘stove’ refers to an instrument that provides heat from a given fuel (like firewood or charcoal) and uses this heat for its intended purpose in a specific application, in this case cooking. Cookstoves are therefore all devices that can both generate heat and transfer it to a suitable container (usually a cauldron) (GIZ HERA, 2014).

Households typically use a blend of different cooking fuels and thus different cooking technologies. However, most rural households use traditional three-stone cooking fires for cooking and/or various types of improved firewood stoves, running on various fuels. Although some of these improved stoves are being imported, most are produced by local producers and sold on local markets in the near villages. In addition, a new generation of institutional rocket stoves has recently become commonplace in schools and hotels. These stoves offer higher efficiency (up to 40 percent) and save up to two-thirds of the fuel used by less efficient stoves. However, its use was low due to a lack of financial mechanisms to cover the costs in advance. The most basic cooking ovens used today are three stone fires. They are constructed of three suitable stones of the same height on which a pot can be balanced over a fire. Unlike open fires, the cooking pot must be placed very close to the fire itself, thus reducing unnecessary waste of heat. With three-stone cooking fires, an overheated space is effectively formed between the cooking pot and the flame. The stones serve different purposes. In addition to making it physically possible to place a pot on the burning fuelwood, they also act as a windbreak and increase the thermal properties of the cooking fire (GIZ HERA, 2014).

2.1 Improved cooking stove

In this research, the main focus will be on improved firewood cookstoves. Cookstoves are usually called "improved" when they cook more efficient than an ordinary "traditional" cook stove. More efficient in this case means ease of use, reduced emissions of harmful gases and smoke, reduced fuel consumption and thermal heat (GIZ HERA, 2014). In Kenya, two firewood ICS are commonly used: the Rocket Stove and the Jiko Kisasa. Also, the LPG stove is also used on a small scale, and usually as a side-stove. In this research, however, the focus is on the firewood stoves.

Rocket stove
The Rocket Stove is an ICS with an L-shaped incinerator that allows (partial) combustion of gases and smoke to take place inside the stove. Thanks to the L-shape (see Figure 3), there is a good airflow in the incinerator and an efficient and very hot combustion takes place, which leads to less harmful emissions (GIZ, 2011). Figure 3 shows the functioning of a Rocket Stove.

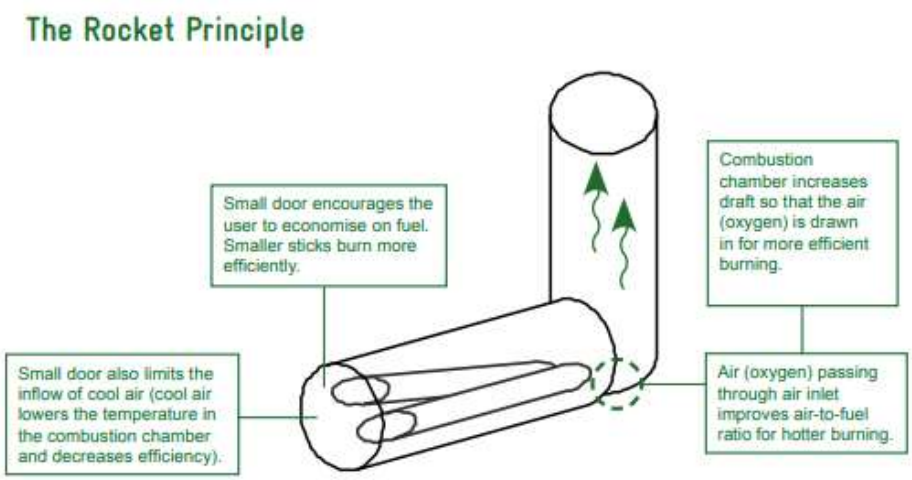

Figure 3: The Rocket Principle. Source: GIZ (2011)

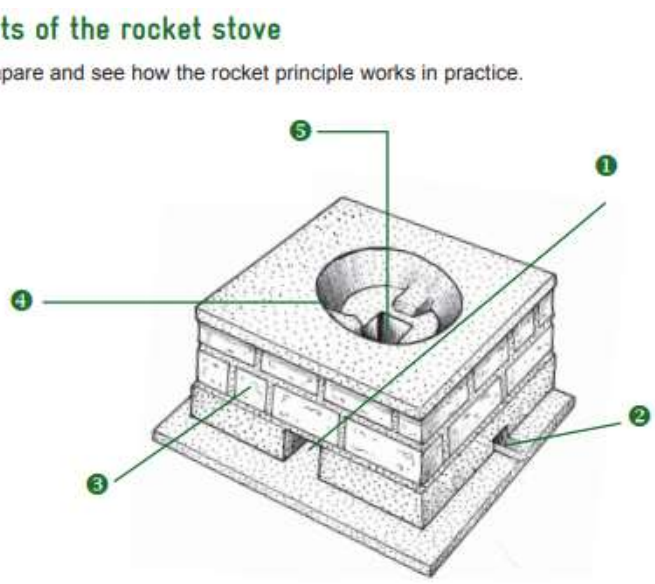

Figure 4: Parts of the Rocket Stove. Source: GIZ (2011)

Figure 4 explains the parts of a rocket stove as they exist in Kenya. These cookstoves are built by local craftsmen using mainly clay (or cement), bricks, and of course, water.
The combustion chamber of the rocket stove increases draft to enable almost complete burning, hence higher temperatures up to 600°C. This leads to faster cooking, with less firewood and less smoke (GIZ, 2011). It functions as follows:

1. The firewood entrance leads to the combustion chamber. The small entrance encourages the use of small pieces of firewood, which burn more efficiently

2. The air inlet on the side wall draws more oxygen into the combustion chamber for hotter burning
3. Insulation around the combustion chamber ensures that the wood burns at the hottest possible temperature for complete and efficient combustion.
4. Skirting allows the pot to sink at least 1/3 into the stove for better heat retention.
5. The combustion chamber ensures good draft. By insulating the combustion chamber to maintain maximum heat, the height can be limited and contained entirely within the stove

Jiko Kisasa

The second and most common ICS in Kenya is the Jiko Kisasa (GTZ, 2007). This is a fairly simple to build, and simple to operate stove, often made of mud or clay. This stove was developed in Kenya in the late 1980s and was distributed until around 1995, by GIZ (among others). In 2006, EnDev restarted the project and started promoting the Jiko Kisasa in Kenya again.

Figure 5: The base of a Jiko Kisasa. Source: own image

This stove is a bit simpler than a rocket stove, but much easier, and cheaper to manufacture. It works approximately on the same principle, but the L-shape is missing. An advantage of the Jiko Kisasa is that there often is a local availability of materials and the possibility of employment of local stove builders and installers. This makes it very low cost, making the Jiko Kisasa accessible for the very poor. The downside is that these stoves are a bit more fragile than the Rocket Stove, and that the clay that is needed is not available everywhere. It consists of a base (see Figure 5), around which a cube of clay is built for insulation (GIZ HERA, 2014). Below in Figure 6, the two stoves can be seen next to each other.

Figure 6: Rocket Stove and Jiko Kisasa. Source: Own image

3. Theoretical framework

3.1 Societal effects of climate change

3.1.1 Hazards, Vulnerability & Exposure

The central focus of this research is on climate change adaptation, which will be discussed in chapter 3.2. However, before climate change adaptation can be understood, the factors that affect or are affected by climate change adaptation have to be explained. In Figure 7 a conceptual framework is shown, provided by the IPCC (2014), it illustrates how the concept of hazards, exposure, and vulnerability leads to a risk of the effects of climate change. A hazard is the potential occurrence of a natural or human-made physical event or impact that may cause adverse effects to property, livelihoods, ecosystems and environmental resources (IPCC, 2014). These hazards are likely to become more frequent and more substantial due to climate change. In the IPCC report, the term hazard is therefore usually climate-related. In terms of exposure, the IPCC (2014) argues that the term exposure refers to the "presence of people, livelihoods, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected" by the impacts of climate change, which relates to the previously named hazards. Alternatively, as the UNISDR (2009) states: "the people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses". Vulnerability relates to exposure as being the predisposition to be adversely affected by the impacts of climate change that these people, livelihoods etc. are exposed to (IPCC, 2014). The vulnerability of a community is determined by the various aspects (such as physical, social, economic and environmental), that influence the susceptibility of a community or ecosystem (UNISDR 2009). It encompasses a variety of elements and concepts, such as the previously named susceptibility or sensitivity, to harm, and the lack of capacity to cope and adapt.

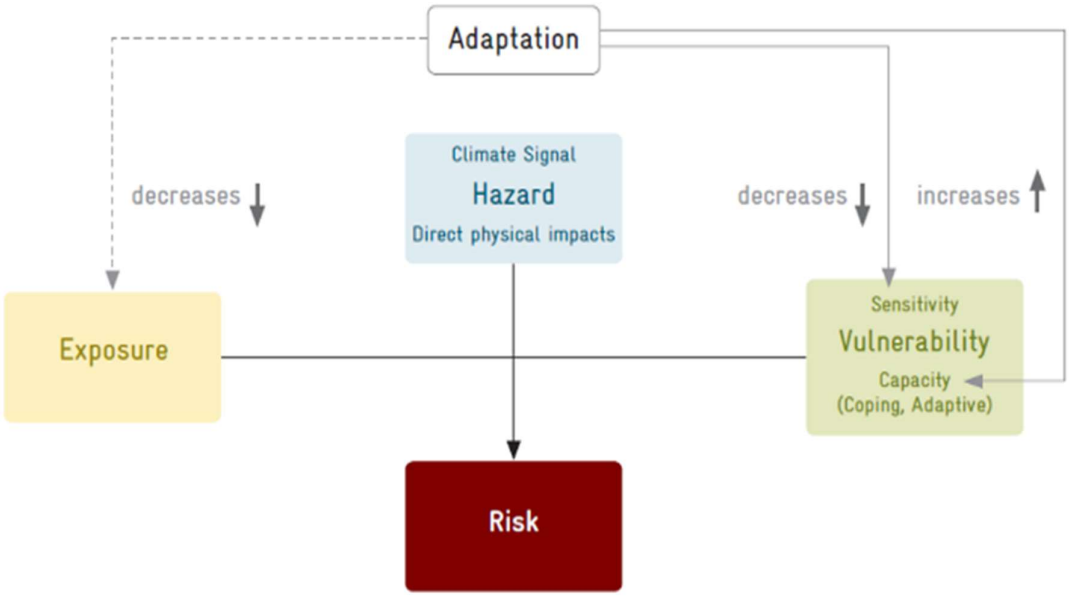

Figure 7: Vulnerability assessment. Source: IPCC

3.1.2 Risk

The interaction between these three aspects leads to a certain risk. Risk is often represented as the probability a hazardous event occurs times the impact the hazardous event has or might have (UNISDR 2009). It can be defined as the “potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values” (IPCC, 2014). Risk, therefore, is directly linked to impacts: the actual effects on human and natural systems by climate change, or extreme weather or hazards related to climate change. It refers to the effect climate change and its aspects have on these human and natural systems, occurring within a specific period of time, linked to the vulnerability of an exposed human or natural system to this effect (UNISDR 2009).

3.1.3 Resilience

According to Holling (1973) resilience is “the capacity of a system to absorb and utilize or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system structure”. In this context vulnerability refers to instances where neither its robustness nor its resilience enables a system to survive without structural changes. Robustness refers to the structural and other properties of the system that allow it to deal with disturbances without adapting, i.e. without any way durably changing either its structure or its dynamics. Vulnerability to the effects of climate change depends on the effects of the changing climate and the extent to which society is able to respond to those effects, i.e. climate resilience. Climate resilience depends, among other things, on the available financial resources, climate awareness and the present institutions (Ireland, 2012).

Resilience is defined by the IPCC (2014) as “the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation”. In this approach, resilience should be seen as one specific factor that affects adaptive capacity; adaptive capacity includes the characteristic that is often reserved for resilience: 'the ability to learn and have the capacity to adapt (i.e. of the system)'.

The vulnerability of a human or ecological system on a geographical location not only depends on the direct climate change effects but also on the socio-economic, technological, administrative and on (geo) political developments (Makoka & Kaplan, 2005). The ability of that human or ecological system to cope with adverse effects of climate change and the ability to implement adaptation measures also affect risks and vulnerability. Often a combination of developments will be the driving force that changes the vulnerability of a society. This adapting ability is something the EnDev ICS project is trying to enhance by giving people access to ICS, and will be elaborated in the next chapter.

3.2 Climate change adaptation

In the introduction one can read what is the initiator of this research is: climate change. There are two ways to deal with climate change, namely mitigation and adaptation. Climate change mitigation is the prevention or limitation of climate change by reducing greenhouse gas emissions (Goudie, 2013). However, this research focuses on climate change adaptation. Climate change adaptation is the adaptation of natural and human systems to the current and foreseeable impacts of climate change (IPCC, 2014). Climate change adaptation and its components are further explained in the following chapters.

3.2.1 Definitions

As stated by the IPCC (2014), climate change adaptation is the process of adapting to the current or expected climate and its effects, so that the (chances of) harmful consequences can be limited or prevented, and the benefits of the changing climate can be utilised. Climate change adaptation can help to increase the resilience of communities and ecosystems. The risks of climate change effects are determined by the combination of the chance of the intensity of these effects, the exposure of humans, animals and plants and the vulnerability of a society to the harmful effects of climate change.

According to the IUCN (n.d.), “Climate change will magnify existing risks and vulnerabilities to disasters due to changing patterns of some hazards and due to increased population exposure and land-use changes”. IUCN states that the influence on human systems by climate variability negatively affects mostly the communities in developing countries. Climate change is linked to climate variability, which will increasingly intensify in the future. Climate change adaptation is defined by IUCN as “…taking place through reducing vulnerability or enhancing resilience in response to climate change”. Furthermore, IUCN argues that it not only occurs in human systems but also in physical and ecological systems.

3.2.2 Adaptive Capacity

A related term to climate change adaptation is the adaptive capacity (IPCC, 2014). This term is similar to resilience, but there is a difference. Resilience is a system property that states the magnitude of shock or change that can be tolerated while maintaining the system's structure, basic functions and organisation, while adaptive capacity is the skills and strategies (social and technological) of individuals and groups aimed at responding to environmental change. In other words, resilience is a broader system property that may be related to the interaction of human and natural systems (Holling, 1973). Adaptive capacity is the possibility of systems, organizations, people and other organisms to adapt to the warming of the earth. This adaptation capacity can be increased, amongst others, by better socio-economic circumstances. Not only climate change effects, but also socio-economic processes and the policy pursued thus influence the nature and extent of the risks. Climate change leads to a gradual change in climate variables, such as the annual average temperature, and to a change in the probability and intensity of extremes, such as heat waves and heavy showers. These changes, in their turn, lead to changes in the likelihood and intensity of weather-dependent changes, due to socio-economic developments within that community. For example, if the number of people increases in an area, or if prosperity increases, or if the composition of the population changes, the seriousness of the effects of weather extremes also changes, regardless the climate changing. Often both developments occur together, so both climate change and socio-economic processes, will be the driving forces behind the increase (or decrease) in climate risks over time.

3.3 Energy access and climate change adaptation

When looking at the available scientific articles and policy documents (Abrar-ul-Hag, 2017, Adkin et al., 2010, Sapkota et al., 2012, UNDP, 2017) that try to explain the relationship between climate change adaptation and ICS, reference is often made to four certain aspects on how ICS improves socio-economic status and therefore increases climate change adaptability. In these above named articles, it is claimed that because the ICS saves time and money, the ICS users can invest this available time and money in certain things that can ensure a higher socioeconomic status. In the field of health, the sources (Abrar-ul-Hag, 2017, Adkin et al., 2010, Sapkota et al., 2012, UNDP, 2017) claim that an ICS has a positive effect on health, i.e. by improving food-borne diseases (higher food quality) and respiratory health

(lower emission of harmful substances, such as smoke). This, in turn, has a positive impact on climate change adaptation.

According to the researcher, however, this is too indirect a relationship. Yes, a higher socioeconomic status has a reducing effect on vulnerability, but it is not directly a measure of climate change adaptation. Indirect climate change adaptation effects entail the increase of socioeconomic status and therefore enhancing ones' adaptive capacity, making them less vulnerable to the negative effects of climate change. In terms of the improved cookstove project, this means that an individual who has an improved cookstove might have more time, money, a better health status and higher chances of economic development then someone cooking on traditional stoves, like the three-stone fire.

3.4 Direct effects of ICS and climate change adaptation: forest cover

As stated in the main research question, this research consists of two components: the development of a methodology to assess the effects on climate change adaptability of users of an ICS, and the actual implementation of this created methodology in Kitui County, Kenya. The first direct link that will be assessed is the link between decreasing forest cover, and being able to adapt to this by having an ICS.

The emphasis in this study is not on whether forest cover is increasing or decreasing. It only looks at the influence of climate change on a possible increase or decrease, and then at how people deal with a possible increase or decrease. However, it must first be established that climate change is having a significant impact on forest cover before it is possible to assess the extent to which adaptation can be achieved. As mentioned previously, this link is not mentioned in the literature, but arose during the process of this research. Based on the existing literature, only socio-economic status is mentioned, but during the process it became clear that this link is too ambiguous. For this reason, linkages were sought that make it possible to demonstrate that an ICS directly increases the adaptive capacity of users of an ICS. The first direct link, and in the view of the researcher the most significant one, is the link between decreasing forest cover due to a changing climate, and the fact that someone with an ICS may be better able to adapt because an ICS consumes less wood.

This research is an attempt to prove or disprove that by having access to an ICS, climate-change vulnerable communities in the Kitui County are better able to adapt themselves to the adverse effects of climate change. One way this could be the case, is when it can be proved that forest cover in Kenya is reducing due to climate change (by i.e., longer droughts, floods or differences in temperature), and that due to the fact that these people have access to an ICS that uses less firewood, they are better capable of dealing with the fact that there is less fuelwood available to enable their cooking practices.

3.4.1 Forest cover in Kenya

The first thing that has to be clearly understood, is what the situation is regarding increasing or decreasing forest cover in Kitui County. First, there must me looked at a national level; is forest cover in Kenya actually affected by climate change, and if yes, how? Is climate change the only reason for changes in forest cover, or do other factors also play a role? There is some data available stating several facts; some

saying that forest cover is increasing, some saying that there is a decrease (see below). For example, when looking at this figure (Figure 8) from the World Bank (2018), it can be seen that from 2000 until 2015, forest cover in Kenya has increased from around 6.2 percent until almost 7.8 percent.

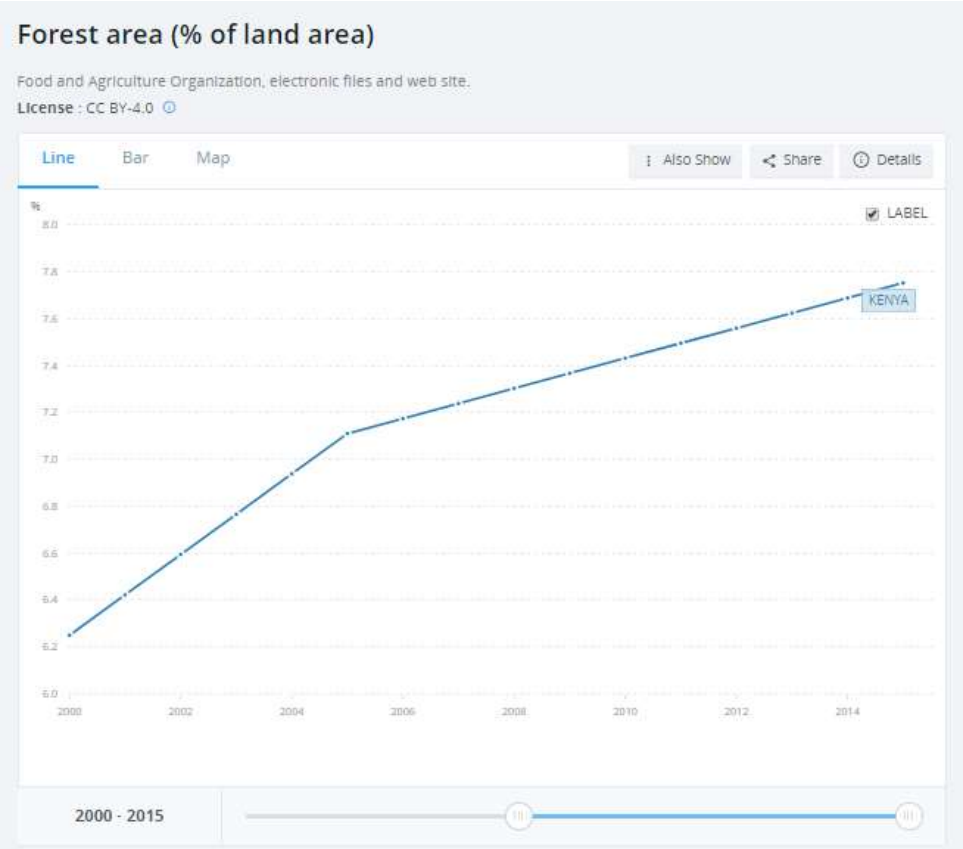

Figure 8: Forest Area in Kenya. Source: World Bank (n.d.)

In the contrary, and looking at a larger timespan, Masinda & Karanja (2011), state in their article 'The plunder of Kenya's forests' that forest coverage was 10 percent of land in Kenya in 1963, which by 2011 dropped to 6.3 percent. Some clarification can be found in the Economic Survey 2018 from the Kenya National Bureau of Statistics. It seems that from 1950 (when measurements started) forest cover was around 13 percent, and in 2000-2005, forest cover seriously declined to about 6 percent. This is said to be mainly due to deforestation resulting from industrialisation of the country. From 2000-2005, however, policies were adjusted and an active campaign against deforestation was initiated, and initiatives for reforestation and afforestation started. There is reason to believe that the contradictory statements made by the sources is a matter of perspective. When looking at the period 1950-2015, forest cover has indeed decreased. However, the last fifteen years, the decrease has not been so rapid as before. Therefore, looking at a period of 65 years there has been a major decrease of around 5 percent, but looking at the last fifteen years, there has been an increase of around 1.5 percent.

These data are, however, based on a national scale, and in order to get a better understanding it is also necessary to look at data on a local scale. In order to understand and explain changes in forest cover, it is necessary to look more specifically at regions in order to identify the underlying causes of any increase or decrease in forest cover in a particular region, as claimed by Masinda & Karanja (2011). However, in the case of forest cover in Kitui

County, relatively little is known, but climate change data are available which could have a direct or indirect impact on forest cover in Kenya. According to Lasage et al. (2008), droughts in Kitui County have a major impact on biodiversity. According to them, this has major consequences for the local population, and they mention that trees retain water, and because of the persistent droughts, 1) no water falls, so no water can be retained, and 2) as soon as water falls, it flows away, instead of remaining in the ground.

3.4.2 Relationship between forest cover and climate change adaptation

The Kenyan Ministry of Environment and Forestry (KEFRI, 2018) describes the relationship between forest management and climate change adaptation in their Second National Climate Change Action Plan (2018-2022) (NCCAP II). The reason that the NCCAP is used as an important source in this study is that this action plan is central to policy-making around the EnDev project in Kenya. It is also the only policy document on which EnDev bases its policy where climate change adaptation combined with clean cooking is concerned. They do not particularly state that forest cover is indeed decreasing or increasing; they do however state that improving forest cover is in fact an adaptation measure. At this point, maybe it is wiser to think that it is not even that important whether the forest cover is indeed increasing or decreasing, more important is that improving forest cover as an adaptation measure is very high on the agenda of NCCAP II. In short, a link is made between the use of ICS and climate change adaptation, but this link made by NCCAPII does not yet provide any measurable criteria.

Regarding the relationship between forest cover and cooking energy, in the paragraph 'Strategic Action 8: Transition to Clean Cooking' of the NCCAP II (KEFRI, 2018: 46), the only adaptation measure (among many mitigation measures) named is 'reduced stress on forests'. In this section, however, it is not described in detail how reduced stress on forests is an adaptation measure.

Further in the policy document the link between climate change adaptation and forest cover is elaborated, albeit still very limited. The relationship is described as that the ecosystem services forests provide, reduce the vulnerability of people, especially women and children. As an example, the role of forests in water supply and the related destructive impacts of floodwaters is given. More related to cooking energy is the relationship between trees and their role in agricultural systems and food security, providing security and safety nets to vulnerable communities when crop failures occur due to climate change related changes in for example precipitation patterns (KEFRI, 2018: 32). In addition, one of the Strategic Objectives (Strategic Objective 2: Increase forest cover to 10 percent of total land area) in the NCCAP II (KEFRI, 2018:33) describes a similar adaptation measure related to cooking: "Developing alternative technologies to reduce demand for biomass (i.e. clean cooking and efficient charcoal production)".

The substantiations of the arguments used to describe these relations, however, are still rather meagre, and leave room for further elaboration. It is well stated in NCCAP II what the mitigation measures of the ICS are (e.g. by measuring and comparing the CO2 emissions of both the traditional cooking stoves and the ICS). It is, however, relatively unclear what the direct climate change adaptation effects are (i.e. what impact does this project have on the adaptive capacity of the affected society or community)? The link made in the NCCAP II is rational, but not comprehensive enough.

In terms of forest cover, an increased matter of climate change adaptation could be the case when it can be proved that forest cover in Kenya is decreasing due to climate change (by for example, longer droughts, floods or differences in temperature), and that due to the fact that the people have access to an ICS that uses less firewood, they are better capable of dealing

with the fact that there is less fuelwood available to enable their cooking practices. This is visualised in Figure 9.

Climate change has an external effect on forest ecosystems. Forest ecosystems provide ecosystem services (in this case the provision of firewood) to communities. People initiate climate change adaptation, of which the ICS project is part of in terms of reduction of pressure on forest resources. Climate change adaptation therefore has an effect on the forest ecosystems.

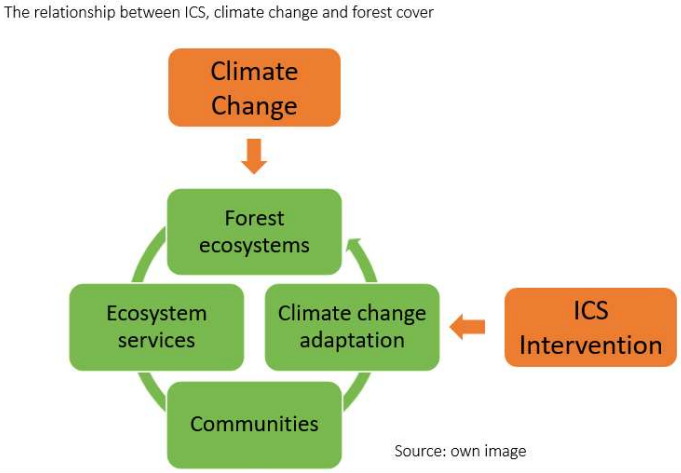

Figure 9: The relationship between ICS, climate change and forest cover. Source: own image

The relationship between forest cover and ICS is measured in two different ways in this study. Firstly, a climate expert is being consulted, who, using existing data, can create a better picture of the current climate situation in Kitui County. Secondly, the personal experiences of residents of Kitui County are asked for on the basis of the questionnaire. Measurable criteria have been developed for this, such as the extent to which people think that forest cover has changed, what is the reason for this, and how to deal with this. From this it can be analysed whether having an ICS plays an active role in being able to adapt to a lesser degree of forest cover. In short, it measures whether forest cover is actually decreasing due to climate change (e.g. increasing droughts), and if so, how this is dealt with at a local level, and whether having an ICS causes an increasing degree of adaptation to decreasing forest cover.

3.5 Direct effects of ICS and climate change adaptation: agriculture

The second direct link that reflects the linkage between ICS and climate change adaptation in the research question is the effect that climate change has on agriculture, and how an ICS can help to decrease dependence on agriculture. This part of the research examines if and to what extent climate change has an effect on agriculture, and what these effects entail. Subsequently, it is asked about personal experience regarding changing drought patterns, and what effect this has on the farmers' crops (if the respondent is a farmer). Then the focus is on how and to what extent having an ICS reduces their dependence on agriculture, and in what form they reduce their dependence on agriculture. In other words, does being involved in the ICS production process or using an ICS for productive use lead to a decrease in dependency on agriculture, or can an ICS ensure that despite the changing or failed crops, more or the same number of food products are produced?

The two direct effects are both related to agriculture, as seen in Figure 10. Climate change causes changes in drought and precipitation patterns, which has a (presumably negative) effect on agriculture. Two of these negative effects can be tackled (or the effect can be decreased) by owning an ICS or access to the ICS production chain. First of all, farmers could decrease their dependency on agriculture by getting involved in the ICS production chain, or using the ICS for productive use. Therefore, they relocate their income source from a very climate-sensitive practice (agriculture) to a less climate-sensitive income source, making them less vulnerable to the negative effects of climate change. The second agriculture-related direct measure is nutrition. The ICS is proven to enable the capacity to cook longer and better without increasing fuel-usage (Adkins et al., 2010). Therefore, dealing with changing or decreasing food availability and food types can be tackled by having an ICS, enabling to prepare, the same, better or more food than with their previous cooking method.

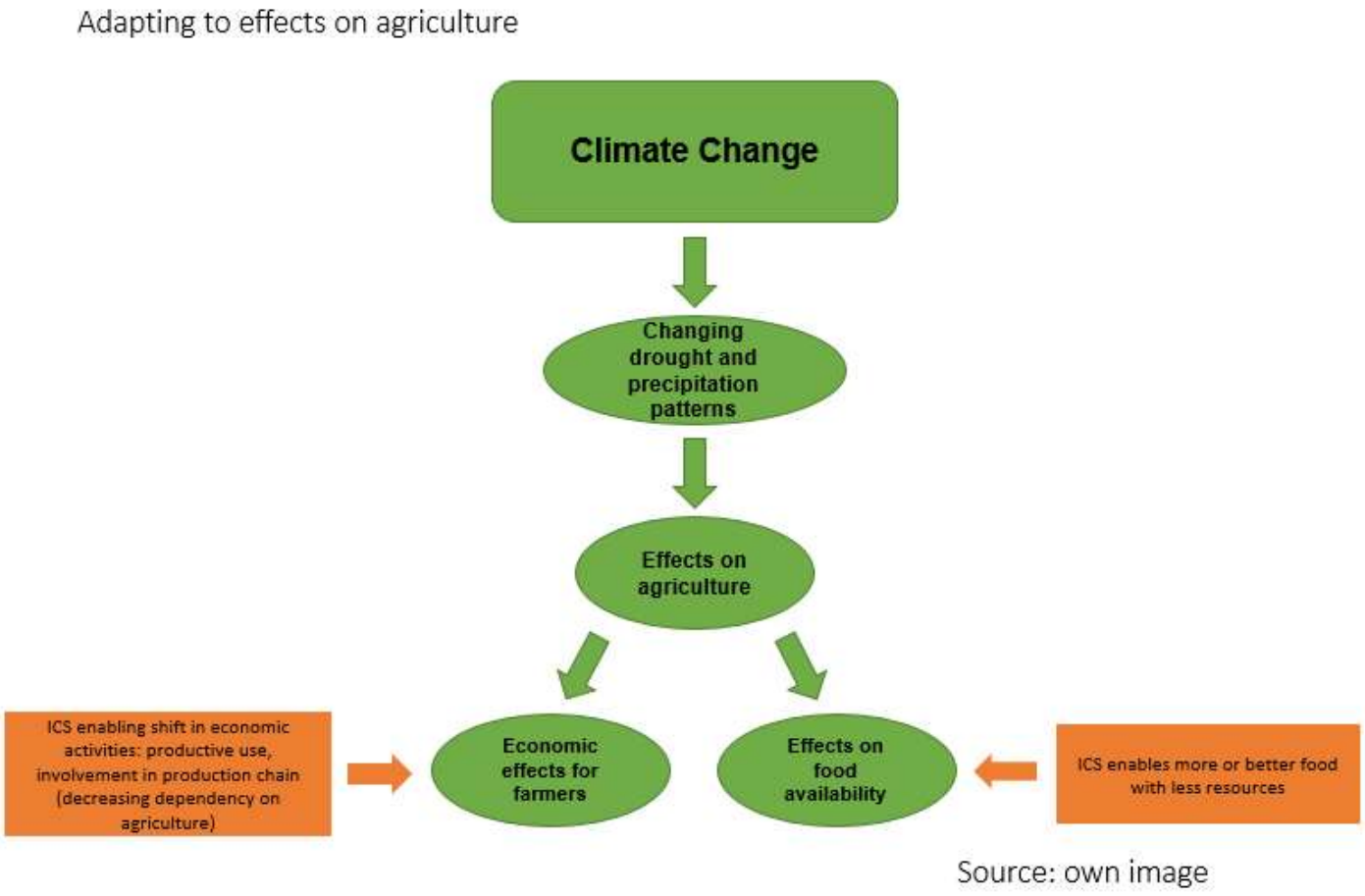

Figure 10: Climate change and the effects on agriculture and ICS. Source: own image

This direct link between ICS and climate change adaptation is measured with the help of the questionnaire, which deals with if and to what extent people use their ICS to sell food, if they are involved in the production process of an ICS, and if there is a difference in the way they cook and/or the quantity of food compared to their previous cooking method. This is explored in depth with the help of open questions in order to obtain detailed information that can help to clarify these possible links. The aim is to find out whether one is selling meals made with an ICS (which was not possible with their previous cooking method), whether one is involved in the production process and what is done with the money they earn, and whether this

reduces the dependency on farming and, finally, whether an ICS ensures that, even if there may be less food or firewood available, one still has the possibility to cook the same or perhaps even more, because one uses an ICS.

3.6 Indirect effects of ICS and climate change adaptation: socio-economic factors

The final connection that is made between having an ICS and adapting to a changing climate is increasing ones' socio-economic status by having an ICS. What I want to know is if the assumptions made in scientific literature are correct. When looking at the available scientific articles and policy documents (Abrar-ul-Hag, 2017, Adkin et al., 2010, Sapkota et al., 2012, UNDP, 2017) that try to explain the relationship between climate change adaptation and ICS, reference is often made to three certain aspects on how ICS improves socioeconomic status and therefore increases climate change adaptability; time saving, money saving and improved health. It is claimed that because the ICS saves time and money, the ICS users can invest this available time and money in certain things that can ensure a higher socioeconomic status and economic development. In terms of health, these sources claim that an ICS has a positive effect on health, i.e. by decreasing food-borne diseases (higher food quality) and respiratory health (lower emission of harmful substances, such as smoke). This, in turn, has a positive impact on climate change adaptation according to the scientific literature, because healthier people are better able to adapt to the effects of climate change. What is important is that this causal effect is claimed by science and policymakers (Abrar-ul-Hag, 2017, Adkin et al., 2010, Sapkota et al., 2012, UNDP, 2017), but that it is actually not proven by empirical data anywhere in their articles or policy documents. As far as the author of this document is concerned, these assumptions are still based on non-proved hypotheses rather than on the provision of empirical data to confirm these assumptions.

The link with climate change adaptation is more indirect than the forest cover and agriculture described above. There is a link between socio-economic status and climate change adaptation (IPCC, 2007), because people with a higher level of socio-economic status also have a higher level of adaptive capacity, but the direct link with climate change adaptation is too vague. In the case of the ICS intervention, it is more about improving overall socio-economic status than having a direct impact on climate change adaptation.

These aspects are operationalised by measuring to what extent time and money are saved by having an ICS, and what is done with the newly available time and money. In short: having more time and money (which can be a direct consequence of having an ICS) and increasing impact on someone's socioeconomic status, and thus an increasing effect on someone's resilience and adaptive capacity.

3.7 Sub-questions

As indicated in the introduction, this research is further structured through defining a number of sub questions that support the components of the main research question. These sub questions cover aspects that are thought to be related to ICS and climate change adaptation. As the Theoretical Framework has shown and will show in the Results chapter (chapter 5), three aspects are central: the link between ICS and forest cover, agriculture and socio-economic factors. These are also the three aspects that recur in the sub questions, and these aspects were examined on the basis of these sub questions.

1. Is there a change in forest cover in Kitui County, Kenya, due to the effects of climate change, and if yes, does having an ICS help people deal with a changing forest cover?
2. Does climate change have a negative impact on the agricultural sector in Kitui County, Kenya, and if yes, how do people deal with the negative effects and the impact on agriculture?
3. Does having an ICS have an impact on the users' socioeconomic status?

4. Methodology

The main aim of this research is to create a methodology to clarify the (possible) correlation between the intervention of ICS and climate change adaptation. To create a methodology, however, is it also necessary to pilot the methodology that has been created, which has been done in this research. The methodology that is explained in this chapter is tested and reviewed, and is both a qualitative research as it is a quantitative research, which makes the overall methodological approach for investigating the research problem a mixed method one. On the quantitative side, recent climate change data and other Geographical Information System (GIS)-data on Kenya on a national level, and Kitui County on a regional level are utilised and analysed. These are linked to qualitative data that is already available in the form of a literature review, and qualitative data that has been collected in the field. The self-collected empirical data consists of an expert interview and a questionnaire on household level.

4.1 Research Design

This research has the form of a case study. Case study research can be defined as a form of qualitative research, in which different methods such as in-depth or expert interview, participatory observations, questionnaires and document analysis (literature study) are used to study a social phenomenon (Bryman, 2012: 66).

A case study is a study of a social phenomenon in one or a few of its manifestations. A case study takes place in its natural environment, during a certain period of time. The focus of this research is on obtaining detailed interpretations, descriptions and statements from participants involved in the social phenomenon (Bryman, 2012: 67). A case study is characterised by a broad research question (like the research question in this thesis), which means that the research remains open to possible innovative insights and iterations. This is an iterative research process in which the research repeats several steps in the research process or in which steps run parallel to each other and thus do not form a linear process (Bryman, 2012: 67).

A case study or qualitative research in general within theoretical research is often meant as inductive research to form new theory that can later be tested by means of deductive research (usually quantitative) within a larger population (Bryman, 2012: 67). This is due to the fact that the results of qualitative research are often difficult to generalise and first needs to be tested on a wider scale. Inductive reasoning is a bottom-up method of research. This involves looking at whether a generalisation can be established on the basis of a specific observation. This research is inductive because a new methodology to measure climate change adaptation is created with the aid of research (such as literature research and expert interviews), and this methodology is tested with the use of fieldwork research, thus revealing results about the degree of climate change adaptation for a particular community using ICS. As regards the quality criteria, it can be said that a case study scores high on validity, but low on reliability.

4.2 Questionnaire

The questionnaire is the same for both ICS users and non-ICS users, apart from the fact that ICS users have an additional category added in which questions are asked that relate to having an ICS. The questionnaire is structured as follows:

1. Descriptive Statistics
2. Experience with climate change
3. Cookstove section
4. Cooking section
5. Cooking fuel collection/bought section
6. ICS section

The descriptive statistics, in which personal characteristics of the respondent are recorded, such as age, GPS location, household size and marital status, are therefore used as a starting point. Then the personal experiences with climate change are asked. For example, it is asked whether, and to what extent, a changing climate has been experienced, and what is being done to deal with these impacts. This section also contains a number of open questions, asking for detailed information that can be very valuable. Next come the sections that relate to the cookstoves and how, when and how often fuel is collected/purchased. The answers of the ICS users and non-ICS users can then be compared (i.e., the difference in collection time or cooking time). Finally, and only for the people with an ICS, there is a section in which one can explain what a difference an ICS makes for them. For example, it asks whether one is involved in the production process, whether meals are sometimes sold and what the main advantages and disadvantages of an ICS are. The questionnaire consists of around 120 questions asked to the respondent, taking about 30-45 minutes per questionnaire to complete. The preference was to conduct the research with the adult who is responsible for cooking and collecting the fuel for the cooking device. There is a division made between ICS users and non-ICS users. In total, 68 questionnaires have been conducted, of which 37 had an ICS, and 31 used traditional ways of cooking (i.e. three-stone fire).

4.3 Expert interview

The expert interview consists of a conversation between the researcher (the author of this document) and a climate change expert, who is highly involved in (components of) the research phenomenon. In this case the expert is Mr. Mwangi, researcher at the Intergovernmental Authority on Development (IGAD, an intergovernmental organisation of East African countries) and responsible for all GIS-data in terms of climate change for Kenya. The aim of this is to find out about detailed information, experiences and interpretations in relation to the phenomenon. This provides in-depth insights into the phenomenon under study, in this case the current climate change and forest cover patterns in Kenya, or more specific, in the Kitui County.

4.4 Geographical location

As mentioned before, the EnDev project is active in 24 countries, and in a large part of these countries the clean cooking component is also being implemented. In Kenya, the project is well developed and its effects are clearly visible. Climate change effects are also clearly visible in Kenya, particularly in terms of rising temperatures and increasing droughts. This has the greatest impact particularly in the arid and semi-arid areas in Kenya. In addition, the majority of the Kenyan population is active in agriculture, a sector that is very sensitive to the (negative) effects of climate change. These three factors: project advancement, the effects of climate change, and the fact that people are often active in agriculture, have led to Kenya being chosen as the research-country. Kitui County was chosen because it was logistically suitable, because it is about 300 km away from Nairobi, the limited research time, because the project is already at an advanced stage here, and because there is a good network of stove builders available to approach the users of a clean cooking stove.

4.5 Ontology and constructivism

This research is of an ontological nature. As Mills et al. state (2006), ontology or his doctrine gives a vision on reality and its building blocks (constituents). The ontology or his doctrine indicates how one looks at the world and it indicates the views that are held with regard to reality. The ontology makes clear which elements are seen as fundamental building blocks of reality. As such, it underpins any model of scientific knowledge acquisition. An example of ontology is thinking about the existence of things and how they exist. Within ontology, this research would fall under constructivism. Constructivism assumes that social phenomena and their meanings are continuously realised by social actors. It implies that social phenomena and social categories are not all produced by social interaction, but are also constantly being reviewed (Bryman, 2012). It therefore means that without social actors and social phenomena, there would be no social phenomena. In research, this vision fits better with qualitative research, such as this research (Bryman, 2012). This research investigates certain factors that influence social phenomena. It aims to find out to what extent climate change has an impact on a social environment, and how certain factors (ICS intervention) alter these social phenomena.

4.6 Sampling method

The sampling method is a targeted sample. In a targeted sample, people with certain characteristics are searched for. Typical cases are searched for, which are necessary for the sample. In this case, the network of stove-builders who were involved in the EnDev-trainings was used to get in touch with the ICS-owners. The researcher is aware that sampling via the network of stove builders can result in a bias in the sampling. However, there is no other way to contact the ICS and non-ICS users, because the sampling location is inhospitable, and distances between farms and houses are long. It is therefore necessary to use the network of a local, who has knowledge of who does and who does not have an ICS. The time span also has to do with this; there have only been two weeks in which to carry out the study in the field, which therefore requires an efficient approach. That efficiency has been found by using an existing network to sample, accepting the fact that a possible bias is created. This form of a non-probability selection can be disadvantageous for representativeness (Bryman, 2012: 203). However, in this research, representativeness is not of main importance. This research will especially be used to test the methodology to measure climate change adaptability, rather than to generalise the results that come out of it. It is therefore more important in this research, and for EnDev to give an overall image of the matter of climate change adaptability in these villages in relation to having an ICS or not, than to generalise the results. In other words, this research is used to create a methodology, which gives a basis for other researchers to further develop the methodology, using this research as a basis. In Figure 11 the geographical sampling-locations are presented. The selection of respondents is not random, because everyone in the sample has something in common: they have either an ICS or not. The following chapter discusses the descriptive statistics of the respondents to the questionnaire. Efforts have been made to find as many similarities as possible so that comparisons between ICS users and non-ICS users can be made more effective.

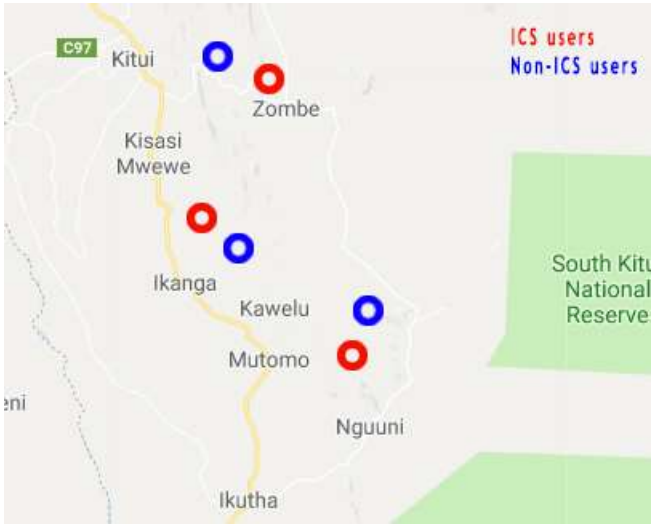

Figure 11: Sampling areas in Kitui County. Source: Own image/Google Maps

5. Results

In this research, a distinction is made between the direct climate change adaptation effects and the indirect climate change adaptation effects. Adaptation to climate change is the process by which societies reduce vulnerability to climate change or take advantage of the opportunities offered by a changing climate.

In this chapter, the results of the questionnaire are presented, with the aim to answer these ambiguities of the relationship between improved cooking stoves and the direct and indirect effects of these improved cooking stoves on the matter of climate change adaptability of their users. As stated in the Methodology section, 68 questionnaires have been conducted, of which 37 with people who have an improved cookstove, and 31 with people who cook on a traditional stove. The difference between these two groups can clarify the difference in climate change adaptability between them, in the various direct and indirect ways. First of all, the descriptive statistics are explained, after which the results that can be derived from the questionnaires are assessed.

5.1 General section: Descriptive statistics

It is very important that both the demographic and geographical characteristics of the two categories of respondents are similar, in order to be able to compare the two data as accurately as possible. The geographical characteristics are very similar, as can be seen on Figure 11, but demographic characteristics also have to be corresponding. As seen in chapter 4.6, there is a chance that a bias is created because the network of stove builders is used for sampling. However, several aspects made that there was no other way of getting in contact with the ICS users, so this bias has to be accepted.

During the course of the study, it gradually became clearer that the demographic data of the two groups would be reasonably similar. This also proved to be the case when the results were analysed: both groups had an average age of around 45 and an overwhelming majority of the respondents are women. Among the ICS users, the number of women was 73 percent, and among the non-ICS users, it was 90 percent. This is probably due to the fact that the ICS users were approached by the network of stove builders, who were often men.

Looking at the head of household, the data is almost the same. Eighty percent of respondents indicate that the man is the head of household, and around 20 percent indicate that the woman is taking on this role. Both groups indicated that the average number of household members was six, of which two were adults and four children. In 95 percent of households, all these people ate at home every day.

As seen in Figure 12, there are also similarities in terms of occupation. The majority of both ICS users and non-ICS users are active in agriculture. In a second place, both groups show 'self-employed', or in other words, people have a side business. However, it became clear that most people earn their income from agriculture and that their own business is often a secondary task (multiple options were allowed). People that were self-employed often had a business in either the tobacco industry (producing and selling tobacco, which can also be placed under agriculture) or in brick production. Among ICS users, the stove builders category can be added. These three activities are the main sectors in which a company of a self-employed respondent is active and (often) a second source of income alongside agriculture. It also happened that the man had a business of his own, and the woman was only involved in agriculture.

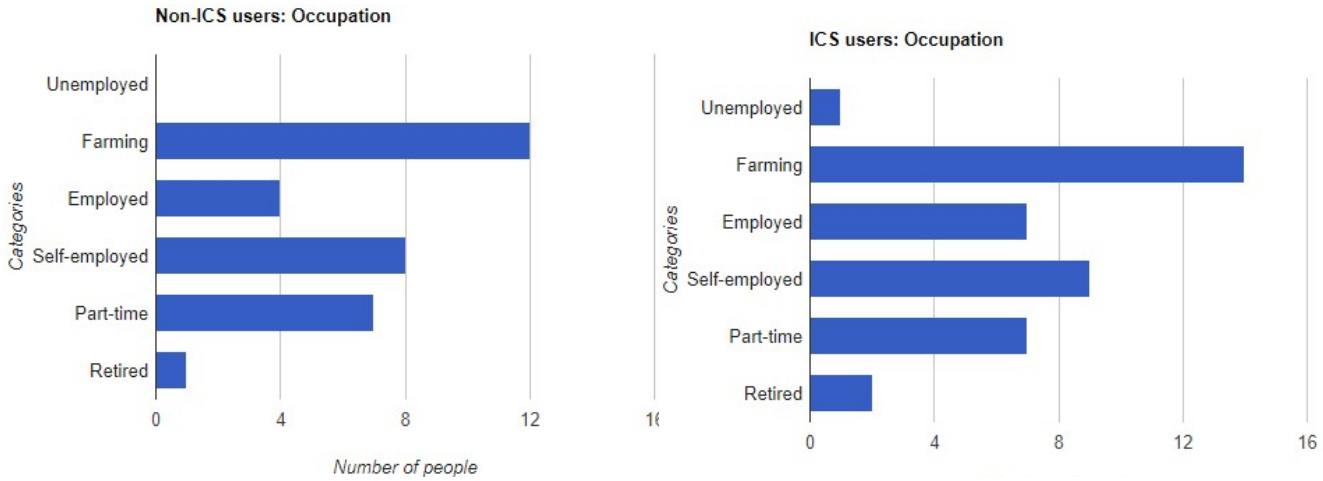

Figure 12: Occupation of respondents. Source: own image.

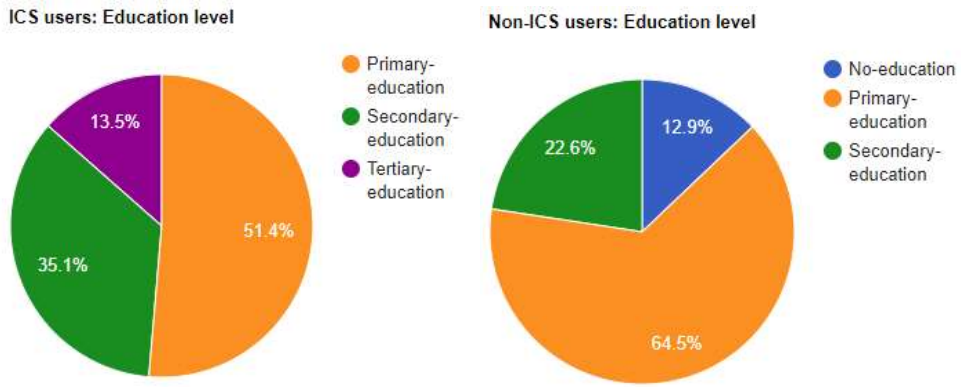

Figure 13: Education level of respondents. Source: own image

With regard to the level of education, there are some differences found between the two groups of respondents (see Figure 13). First of all, among the group of ICS users, there are no respondents who have never had any form of education. In the case of non-ICS users, there are uneducated respondents, almost thirteen percent. The share of Primary-education among non-ICS users is almost fifteen percent higher than among ICS users, namely almost 65 percent compared to about 50 percent. After that, the difference shrinks again, because the proportion of respondents with completed secondary education is higher among ICS users (35 percent) than among non-ICS users (23 percent). The respondents with tertiary education are even completely lacking among non-ICS users, and among the ICS users, this is still 13.5 percent. The group of uneducated people is missing among the ICS users, while the group with a tertiary education is missing among the non-ICS users. Whereas the group of ICS users with a secondary or tertiary education represents almost half of the respondents, among non-ICS users only 23 percent has a secondary education. The remaining 77 percent all have primary education or lower. It can therefore be concluded that the level of education of the respondents among ICS users is higher than among non-ICS users.

Figure 14: Typical household in Kitui County. Source: own image

5.2 Dissertation of cookstoves: ICS users and non-ICS users

As stated, a distinction is made between ICS users and non-ICS users. In order to make this distinction, it must of course be determined which stove someone uses, and whether this is the only stove or whether several stoves are used at the same time (stacking). It is also distinguished which stove is the primary stove, and which stove is the secondary stove. Furthermore, if someone has even one ICS and uses it as their main stove, this respondent is one of the ICS users. It that does not matter that they also use, for example, a traditional stove on the side. Fortunately, everyone who has an ICS also uses this ICS as their main stove, which will be discussed below.

Respondents had the possibility of choosing several types of cookstoves/methods, and multiple options where possible:

- Three-stone fire
- Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)
- Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)
- Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)
- Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)
- Industrial Gasifier stove (Wisdom)
- LPG
- Electrical

Regarding the amount of cookstoves owned by the respondent, it became clear that the ICS users generally have more cookstoves than non-ICS users. This appears to be the case; ICS users own an average of 2.27 stoves, and non-ICS own on average 1.25 stoves. Figure 15 and Figure 16 show which cookstoves the ICS users and non-ICS users own. This was not only requested by a simple question in the questionnaire, but the researcher also actually checked in the kitchen area (for verification) which stoves the respondent had in his or her possession. It is quite conceivable that an ICS user, knowing that a researcher will be asking questions about his/her ICS on behalf of GIZ, will scale himself/herself to the fact that he/she still uses the three-stone cooking fire from time to time.

All 37 respondents have an Artisanal Firewood Stove (either a Rocket Stove or a Jiko Kisasa). The Artisanal Charcoal Stove comes second, but many respondents indicate that it is hardly used due to the current charcoal ban. In addition, some still have a three-stone fire. Those who have this indicate that they primarily use it this to boil water to make tea in the morning.

Looking at the non-ICS users, it can be seen that all 31 respondents have a three-stone fire. In the previous section it appeared that non-ICS users have on average far fewer stoves than

ICS users, and this is also evident from these figures. The vast majority has only a three-stone fire, and a few also have an Artisanal Charcoal Stove and an LPG stove.

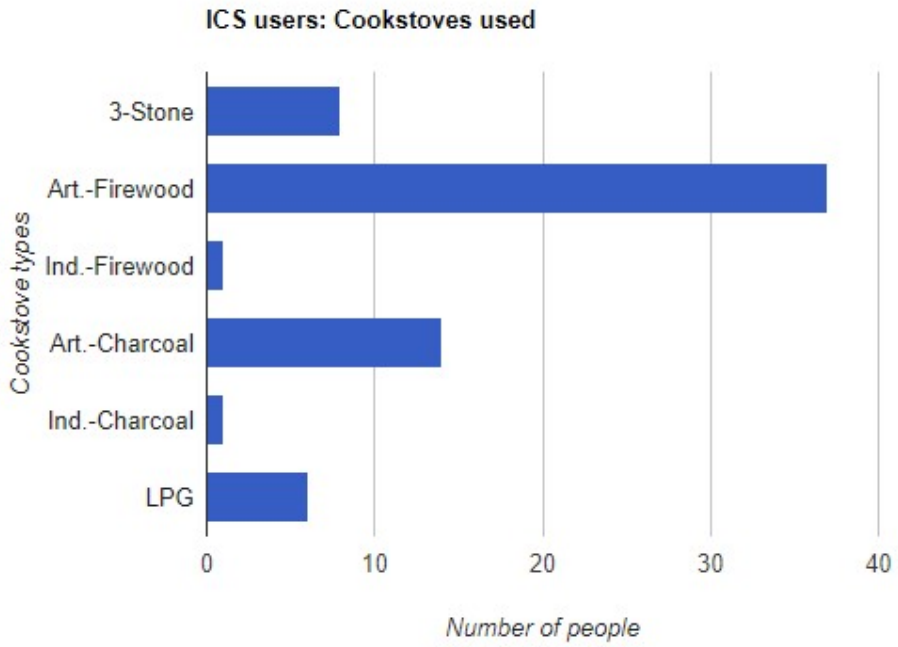

Figure 15: Types of stoves used by ICS users

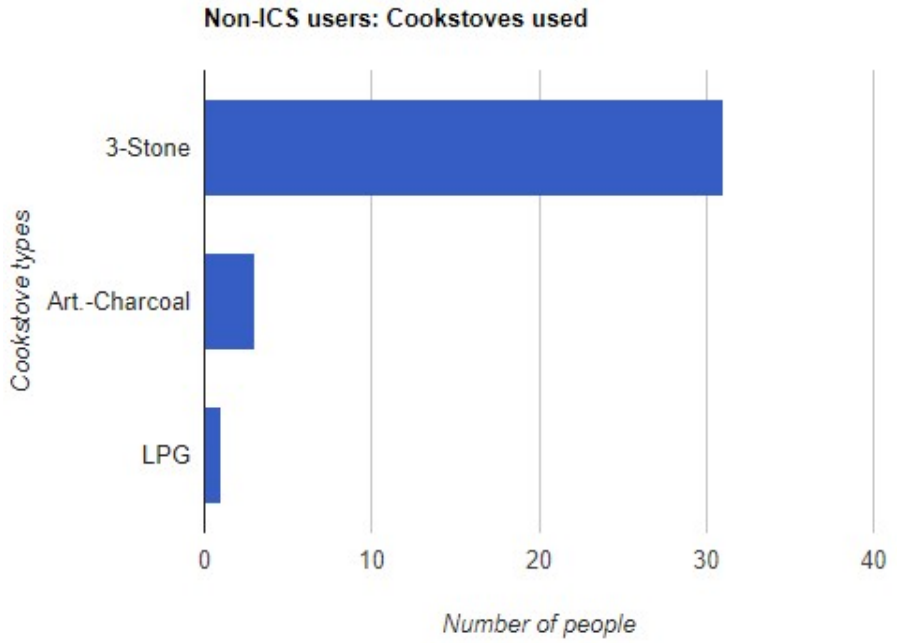

Figure 16: Types of stoves used by non-ICS users

These graphs show how many stoves the users have, but not which ones they actually use regularly, and which ones are used as a primary stove, and which as secondary stove. It is possible that you have an ICS, but you don't actually use it at all. Then, of course, the effect of an ICS is less measurable.

In this case, all the respondents that have an ICS, actually use it as their primary stove. In addition, all non-ICS users indicate that they use the three-stone cooking fire as their primary stove, which means that they use it for at least two of the three meals. Looking at the secondary stoves (if they use more than one stove regularly), the most used secondary stove among ICS users appeared to be the Artisanal Charcoal Stove, even though a charcoal ban was active. However, the majority of the people noted that the amount of times they use the charcoal stove is heavily decreasing, mainly because of the increasing limitations of obtaining charcoal.

The next question was whether they collect the fuel for their primary stove, buy it, or do both. In both cases (for ICS users and non-ICS users), the fuel required for their primary stove is firewood. Figure 17 and Figure 18 show how the ICS users and non-ICS users get their firewood. Of the ICS users the vast majority collect, namely slightly more than 75 percent (collect + both) collect their firewood for their ICS. For non-ICS users this number is lower, just over 50 percent, and almost half buy their firewood. This is rather strange at first, because non-ICS users need more firewood for their three-stone fire, so it would be more logical for them to collect it rather than buy it (financially speaking). However, an extra enquiry on the spot shows that they are forced to buy because they need a significant amount of wood, and there is not enough wood available (anymore). This is an interesting finding: ICS users consume less wood, and therefore only collect firewood around their home, unlike non-ICS users, who need more wood, which is not available, and are therefore forced to buy. This costs 1) more time, because they have to go down to the nearest village, and 2) more money.

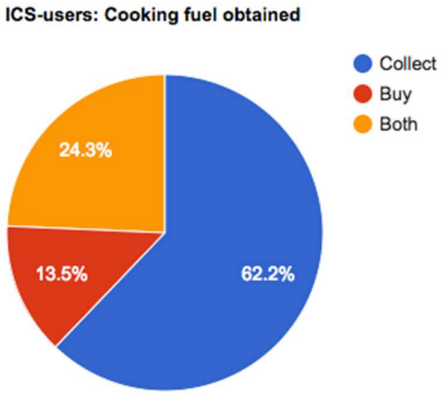

Figure 17: ICS-users: Cooking fuel obtained. Source: own image

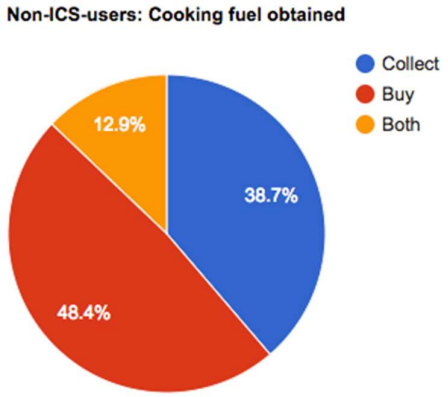

Figure 18: Non-ICS users: Cooking fuel obtained. Source: own image

What is also important is where the collected firewood comes from (purchased firewood is not included, because firewood is always purchased in the nearest village). For both the group of ICS users and non-ICS users, the collected firewood is mostly collected in the vicinity of their home. This can be seen in Figure 19 and Figure 20. Some respondents also have their own tree plantation with trees that are only intended as firewood. The number of ICS users is 10 (27 percent) and the number of non-ICS users is 6 (20 percent). The reasons for having their own plantation were similar; all respondents indicated that it became more difficult to collect firewood, so they set up their own plantation. Often this is done in cooperation with one or more neighbours, and together they take on the responsibility.

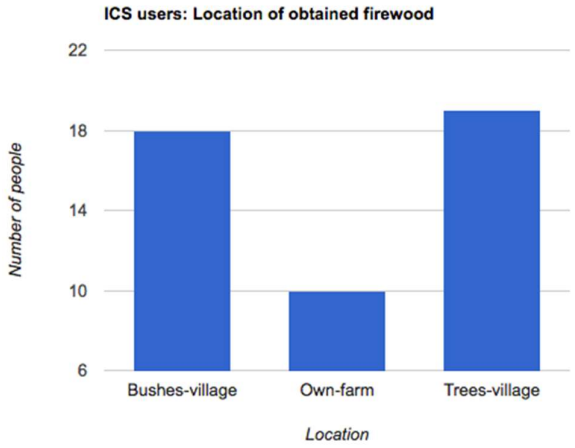

Figure 19: ICS users: Location of obtained firewood. Source: own image

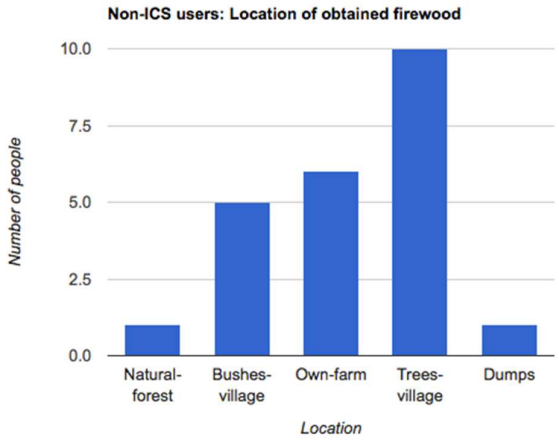

Figure 20: Non-ICS users: Location of obtained firewood. Source: own image

5.3 Direct climate change adaptation effects

As described in the theoretical framework, in case of having an improved cookstove the effect on climate change adaptation can be direct, in the form of adapting to changing forest cover (if related to climate change), reducing the dependency on climate change sensitive income sources like agriculture, and enabling better, more or the same food to be cooked with less resources (firewood), enhancing ones' nutritional values.

5.3.1 Changing forest cover: Effects of climate change on forest cover

This chapter is related to the first sub question: "Is there a change in forest cover in Kitui County, Kenya, due to the effects of climate change, and if yes, does having an ICS help people deal with a changing forest cover?" Before climate change adaptation can be stated, it is first necessary that there is clear evidence that climate change is actually changing forest cover, and a changing forest cover is not, or not primarily, caused by other (external) factors, the most important one being deforestation initiated by humans. To get a clear view of the effects of climate change on forest cover in the Kitui County, a climate change expert in Kenya was consulted (Mr. Mwangi, see methodology).

The effects of climate change on the Kitui County include higher temperatures, longer droughts and shorter rains, according to Mr. Mwangi. However, whenever it rains, it rains with a very high intensity but short duration. This has a negative effect on agriculture, water availability and forest cover. The effects on trees are significant, because the types of vegetation become different, and only drought-resistant vegetation remains. In addition, growing and regeneration of trees takes longer because of the declining resources trees have access to due to climate change. Actually, the relationship between climate change, agriculture and forest cover is a vicious circle, as can be seen in Figure 21.

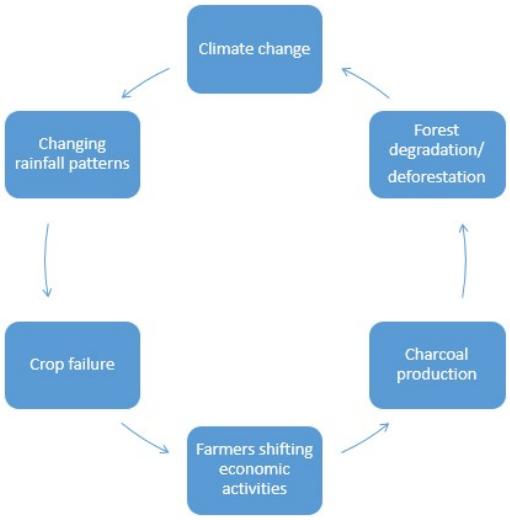

Figure 21: The vicious agricultural climate change circle. Source: own image

Climate change causes longer droughts and irregular rainfall. This has a negative effect on agriculture, because less rain is available for harvest, and therefore there is an increased risk of crop failure. This means that farmers are losing their source of income and are looking for other ways and sources to generate income. Many farmers are relocating their economic activities from agriculture to, i.e., charcoal production. Charcoal production, in turn, has an impact on deforestation, which is something that increases the matter of climate change. In short, farmers seek refuge in other economic activities because of the negative effects of climate change on their crops (and therefore their source of income), but these other economic activities have a reinforcing effect on climate change, which will eventually have an increased negative impact.

As stated, one way people are dealing with the negative effects of climate change is shifting their economic activities from agriculture to charcoal production. There is, however, a difference in perspective between the younger population and the older population of the Kitui County. The older population tends to think more on the long term solutions, like growing drought-resistant crops and investing in more long-term solutions to battle the changing climate. The younger generation, however, just thinks about the quick money and invests their money and time in charcoal production. The fuel for charcoal comes from acacia trees in the Kitui County, and once the charcoal is produced, it is not consumed for own use, but exported to other counties, and even other countries. This ensures that they have a fast income, but this is not resilient at all. Their activities reinforce the negative climate change effect, which will only affect them more in the long term.

There is an interesting development going on, being that the Kenyan government has recently introduced a ban on charcoal production, which makes it illegal to produce and sell and therefore more difficult for producers to harvest acacia trees, produce and export charcoal. In this way, they are almost forced to relocate their economic activities once again, and this may give them the idea that they need to look for their source of income in more sustainable activities. What these activities are, is however still unclear, and is something the future will hold

In Figure 22 it can be seen how forest cover has changed from 2001 till 2017. The image is provided by Mwangi, and derived from the GIS-data of the Global Forest Watch. As can be

seen, the amount of forest cover in 2001 was much higher than in 2017. According to the Mwangi, there are two reasons for this in Kenya: first, increasing deforestation, and second, changes in rainfall and drought patterns that cause trees to grow less quickly and, when felled, to grow less fast and to a lesser extent (regeneration). The following section discusses the effect of changing precipitation and drought patterns, in relation to forest cover and the personal perception and experiences of the inhabitants of Kitui County.

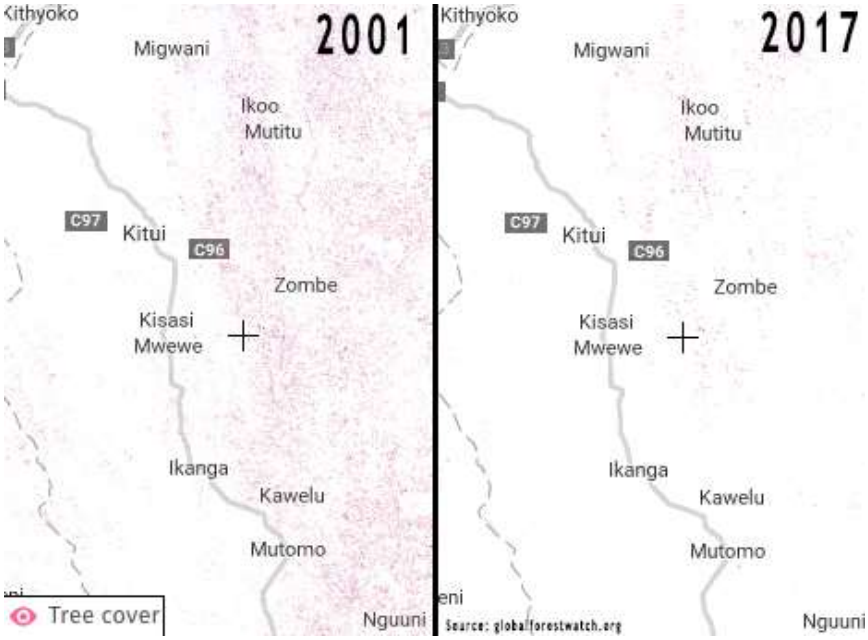

Figure 22: Changes in forest cover in the research area. Source: GlobalForestWatch

Even though forest cover in the whole of Kenya is increasing (see chapter 3.4.1), it decreases in Kitui County. In summary, it is not clear that a decrease in forest cover is mainly due to climate change, or in particular to human activity (i.e. felling of branches and trees). What is certain is that they both have an effect on the degree of forest cover in Kitui County. However, climate change does not only have a direct impact on forest cover, through the effect of droughts on tree growth and regeneration. It also has a social impact which reduces forest cover: due to longer droughts, harvests fail, forcing farmers to look for another source of income: logging to produce charcoal. In this case, climate change has a dual function in terms of decreasing forest cover.

5.3.2 Changing forest cover: Kitui County residents' perception on climate change and forest cover

The questionnaire asked about people's perception and experience of the effect of a changing climate on the presence of trees and thus firewood. First, they were asked whether there has been any experience in changes over the years in the presence and quality of trees, and then (if they had replied that there had been a change) what they thought was the cause. In the section 'Climate change', there are questions about the experiences and perceptions of the respondents about climate, and changes in climate over the years. Among other things, it was asked whether, and if so to what extent, precipitation patterns and drought patterns had changed, and what the respondent thought the cause of the changing patterns was. It then asks about the effects of these changing patterns on biodiversity, particularly trees and shrubs. As the questionnaire goes into this in greater depth, the aspect

of availability of firewood emerges. Most of the questions in this section do not distinguish between ICS users and non-ICS users, which means that the same questions are asked to both ICS users and Non-ICS users. In this way, the differences in insight and experience can be compared with each other. Finally, after this section, the questionnaire contains an open question. This allows people to express their opinions in greater detail, and gives the researcher the opportunity to gain an insight into the underlying reasons of their answers.

Of the ICS users, 100 percent indicated that changing precipitation and drought patterns have been observed over the years, and concerning the non-ICS users, the number is 97 percent. It can therefore be said that almost everyone who took part in this study indicates that there have been changes in the amount of rain and length of rain periods, and the length and intensity of the droughts. In the open question where respondents were asked what the reason behind the changes could be (according to the respondent), most of them indicated that the rain periods were getting shorter and the droughts longer. According to the respondents, this has a negative effect on biodiversity in their immediate vicinity, which in turn has a negative effect on the availability of firewood, as can been seen on Figure 23.

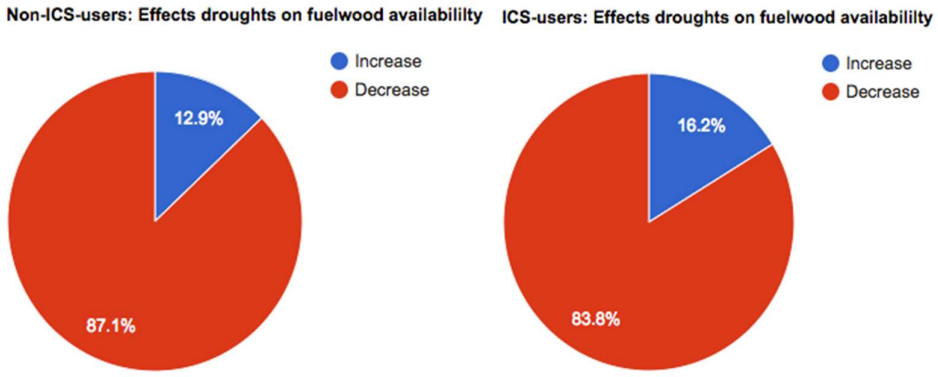

Figure 23: Personal experience: effects droughts on fuelwood availability

In the open question where was asked to what extent their physical environment has changed as a result of the increasing droughts (when this was indicated to be the case), the answers were quite similar, and also between the ICS users and non-ICS users the answers were not very different. In the most part, it is said that because of the shortage of water, cattle are dying, trees are drying up and there is less food available. In the open question on how to deal with the changing climate, the ICS users proved to be much more enterprising and inventive than the non-ICS users. Of all ICS users, more than a quarter indicated that they were investing time and money in storing water (by buying larger tanks), or installing irrigation systems for their farms. None of the non-ICS users did this, and the answers given by the non-ICS users often had to do with being more economical; in other words, consuming less water and eating less. In terms of adaptation measures, the ICS users appeared to show more initiative than non-ICS users.

5.4 ICS and agriculture dependency

This chapter is based on the second sub question: “Does climate change have a negative impact on the agricultural sector in Kitui County, Kenya, and if yes, how do people deal with the negative effects and the impact on agriculture?” The section ‘Agriculture dependency’ focuses on people that use an ICS and that have been able to reduce their dependence on agriculture through having such a cook stove. In other words, the extent to which having an

ICS can change their dependence on agriculture as the main source of income is being researched. Agriculture is a sector with a very high sensitivity to a changing climate. Sufficient precipitation is needed to allow crops to grow and harvest successfully and ideally with similar characteristics in duration and quantity. For many people, agriculture is the primary activity and source of income in Kitui County. Almost 80 percent of the respondents indicate that they are active in agriculture, and the main production is corn and fruits.

Having an ICS may allow for a different source of income, i.e. by being involved in the production process, or by using their ICS for productive purposes. If people are involved in the production process (e.g. as stove builders), they may earn more money from it than if they had agriculture as their main source of income. In this way, they reduce their sensitivity to climate change, because their income is no longer entirely dependent on a climate-sensitive practice. Another way of creating additional income is using the ICS for productive use, e.g. cooking meals and selling these meals. Due to the advantages of an ICS compared to a traditional cooking method, it might be that efficiency increases and therefore a surplus of food can be created, which can be sold to create additional income.

Of the 37 ICS users interviewed, 32 percent indicated that they play a role in the production or distribution of the ICS. This number is quite high, and probably not representative of the average Kenyan ICS user, and not even of the average ICS user in Kitui County. In all probability, this figure is so high because the sampling method used has led to the ICS users being found through the network of stove-builders and so ended up with several stove-builders who also use an ICS themselves.

Nevertheless, it remains interesting to see to what extent the involvement in the production process has influenced their livelihoods. It might be that their financial situation has improved, even if they spend less time in the field practicing agriculture. The outcome of this question appeared quite clear in the questionnaire. Of the respondents which indicated that they were involved in the production process, 97 percent stated that their financial situation had improved as a result of being active in the production chain of ICS. In the open question that follows, asking to what extent and how this reflected on their everyday life, most indicated that their activity in this sector has made their income more stable, while they have to do less physical work. This has a positive effect on their livelihoods because, firstly, they earn more and, secondly, this income is higher and more stable than the income they had before they were involved in the process.

At the end of this section there is another in-depth question, asking what is done with the extra money that is earned by being involved in the production process. Because this section is mainly concerned with the increasing independence of agriculture, it is important to focus here on investments that strengthen this independence. Looking at the answers, it can be seen that either education, extra investments in agriculture, extra investments in their company or the storage of food and drink (basic needs) are answered. All these factors could directly or indirectly reduce the dependency on farming. Education makes it possible to specialise in an economic activity in a sector other than agriculture (this also applies to children). Additional investments in agriculture can mean, for example, investing in an irrigation system, which makes people less dependent on changing rainfall and drought patterns. Investing in their business can help the company, which they or their family run, and generate additional revenue. Most of the activity is in the production of bricks, for which the clay soil in this area is very well suited. The last category is basic needs, which means that with the extra money that is earned, one stores food, water and other basic needs, which they can consume when their financial status is low, for example because of crop failures. In this way, they can overcome an economically challenging period of time because they have

stored these basic needs. Figure 24 below shows that education and basic needs accounts for most of the answers, after which investments in agriculture and their businesses follow.

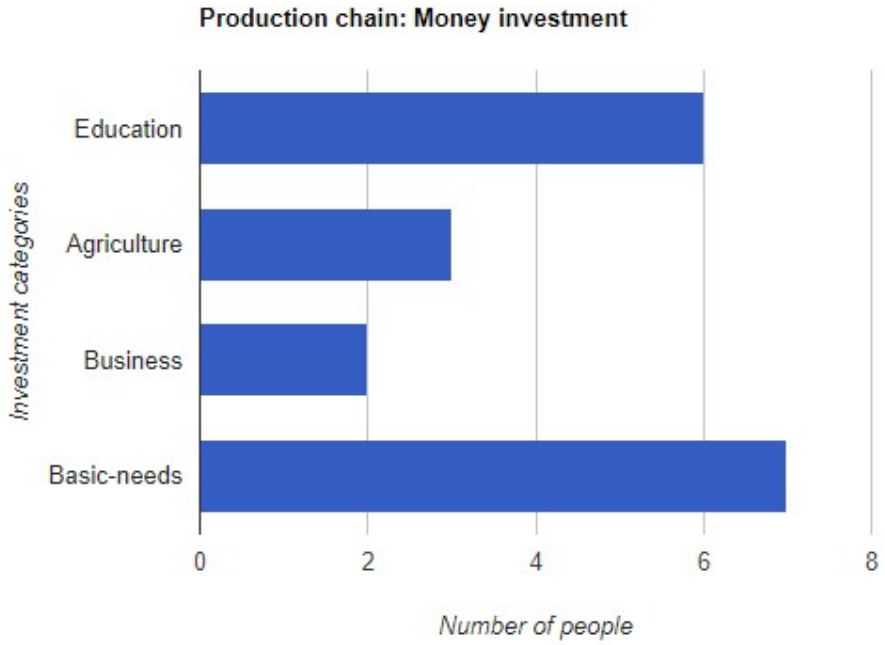

Figure 24: Production chain money investments. Source: own image

5.5 ICS and nutrition

Nutrition, climate change adaptation and an ICS are linked in the way that climate change can have a negative effect on agriculture and firewood. Agriculture and firewood are jointly responsible for the nutritional basis of the inhabitants of Kitui County. Because droughts become longer and more intensive and rainy periods become shorter and less intensive, certain crops cannot grow any more or less well (Easterling, 2007), and as can be seen in the previous paragraphs, the amount of forest cover and therefore firewood has also decreased.

People with an ICS consume less wood, their food is prepared at a higher temperature, and because they cook faster and use less fuel wood, it may also be possible to prepare other types of food than when cooking in a traditional way.

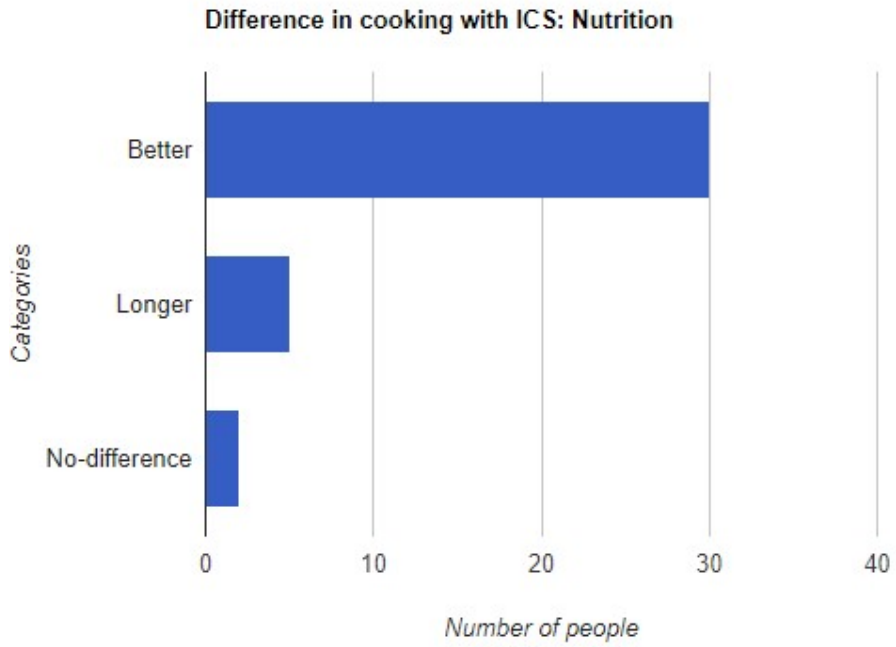

Figure 25: Difference in cooking with ICS: Nutrition. Source: own image

Nutrition is a subject that is difficult to investigate, especially because many people do not understand the questions properly, or indicate that there is little difference, except in cooking time. At the end of the cooking section, a question was asked whether anything had changed over the years in terms of food, and most respondents indicated that there was generally less food available due to persistent droughts and related crop failures. Among the ICS users 76 percent indicate that the only thing that has changed is the way of cooking (i.e. cooking with an ICS), and the rest indicates that there is less food available. Having an ICS does not affect the amount of food one consumes.

5.6 Indirect climate change adaptation effects

This chapter is based on the third sub question: “Does having an ICS have an impact on the users’ socioeconomic status?” In this section, comparative data (between ICS users and non-ICS users) is used, as well as data arising from questions that were only asked to the ICS users. Comparative data include the question of how much time is spent on average on cooking a meal, or collecting firewood, or how much money is spent on average on food. By comparing the data of the two groups, it can be determined whether there is a difference between ICS users and non-ICS users. The questions for ICS users are, for example, their experiences with a (possible) difference cooking time or collection time compared to their previous cooking method. This last section deals in more detail with the use of possible increasing time and money, in order to be able to give a clear picture of what is being done to improve their (possibly increased) time and money, and whether their health has actually improved.

5.6.1 Time saving

First of all, the time the respondents told that that they cook per day on average is looked at. The question was which meal was cooked for breakfast, lunch and dinner, and how long the total cooking time per meal was (without preparation time). For non-ICS users the average is

about 6.5 hours, while for ICS users it is about 2 hours and 45 minutes. This is a time of 3 hours and 45 minutes that ICS users on average have more to spend per day in comparison to non-ICS users. This is mainly due to the fact that an ICS simply consumes less wood and insulates better, and therefore requires less attention to function. Respondents indicate that they can light the ICS and put the cooking pot on it, and then continue to carry out their other tasks in or around the house or on the field. The non-ICS users indicate that they must constantly keep an eye on the fire, because they have to constantly put new wood in or keep an eye on the fact that the wind does not blow out the fire.

So, first of all there is cooking time. Secondly, there may be a difference in the time they spend to collect firewood. Respondents were asked how often they collect firewood per week, and how long they take to collect it on average. Converted (number of times per week in combination with the number of hours spent collecting firewood), non-ICS users spend on average about 4 hours per day collecting firewood. For ICS users this number is approximately 3 hours and 15 minutes. The quantities collected are almost the same, namely a 30-40 litre bag.

At the end of the questionnaire, in the section purely for ICS-users, ICS-users are asked in their perception how much cooking time they save on average per meal, in comparison with their previous cooking method. On average, the answer to the question how much time it saved per meal was 35 minutes, which comes down to 1 hour and 45 minutes per day (breakfast, lunch and dinner).

As can be seen in Figures 26 and 27, almost 93 percent indicate that having an ICS saves them time. Subsequently, the question is asked where this extra time is invested in (several answers were possible). Most respondents indicated that they invested their time in their agricultural business, or that they spent more time on their own business in a sector other than agriculture. Often this other company had something to do with producing bricks, or having a shop in the village. After this, people indicated that they spent their time doing chores in and around their house The fourth category showed that 3 people used that time to find work, some people choose to spend time with family (raising their children) only one person chooses to invest their time in getting educated.

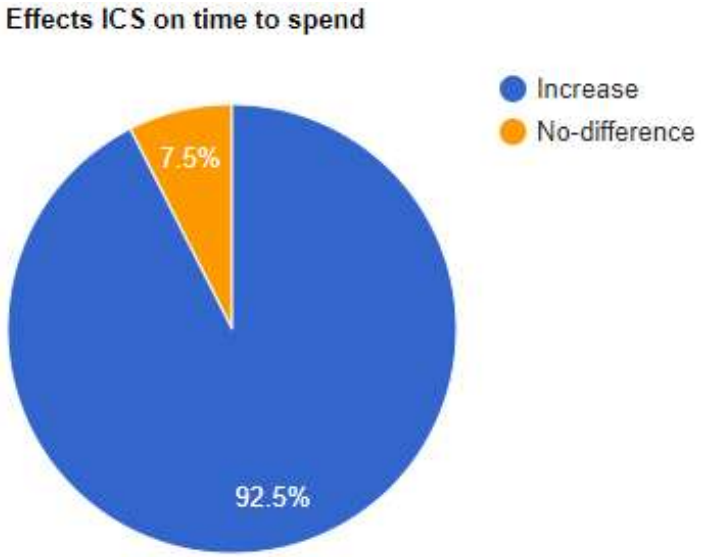

Figure 26: Effects ICS on time to spend. Source: own image

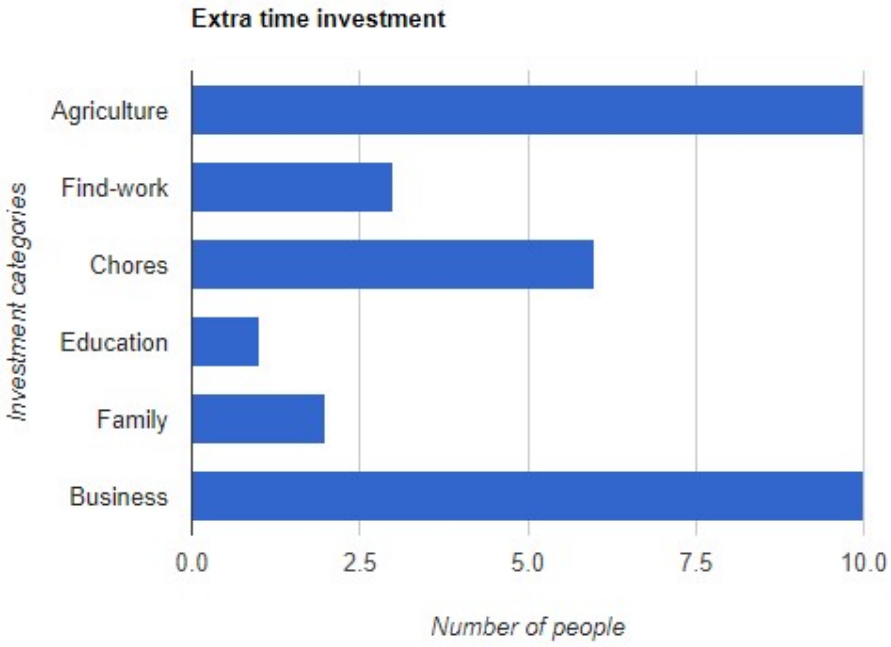

Figure 27: Extra time investment. Source: own image

5.6.2 Money saving

As can be seen in chapter 5.3, 37 percent of ICS users (bought + both bought and collected) buy fuel for their ICS. The 'Cooking fuel bought' section asks about the prices of cooking fuel and the extent to which this has increased or decreased over the years. Of all the respondents (both ICS users and non-ICS users), about 88 percent indicate that the prices of cooking fuel have increased over the years, as can be seen in Figure 28. Because an ICS demonstrably consumes less fuel, ICS users may be better able to adapt than non-ICS users, who may not see a decrease in their fuel consumption. This is covered in the questionnaire and asked in an open question.

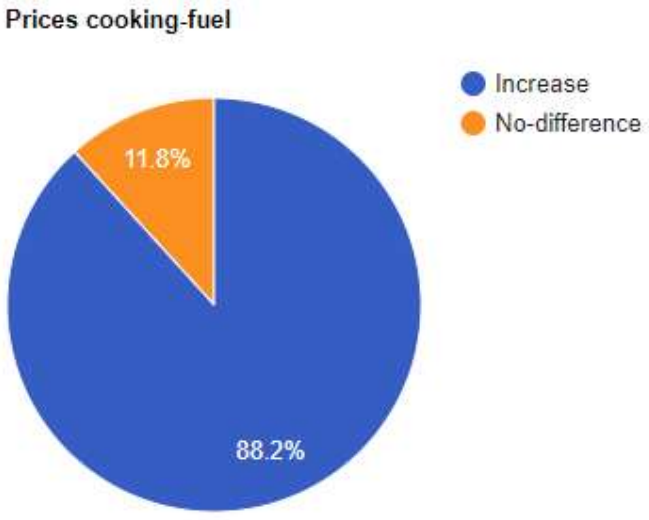

Figure 28: Price changes of cooking fuel over the years. Source: own image.

In the section for ICS users only, a more in-depth look is provided in terms of the money-saving aspect of an ICS. The question is whether having an ICS has a direct impact on the financial situation of the users (in terms of saving money), and if so, whether and in which area the extra available money is invested. Of the ICS users, 88 percent indicate that having an ICS saved money. When asked further, respondents who buy their cooking fuel indicate that they need to buy less, and it also appears that those who buy their cooking fuel mainly answered that their ICS saved money. The next question for those who indicate that the ICS has saved money is what they do with the excess money, in other words: where is it invested in? As can be seen in Figure 29, the money saved is mainly invested in basic needs, such as food, water, or in this case, as the respondents indicate, more firewood. The extra firewood that is purchased will then be stored for later use. In second place, as is also the case with 'Extra time investment', comes extra investments in agriculture, followed by extra investments in business.

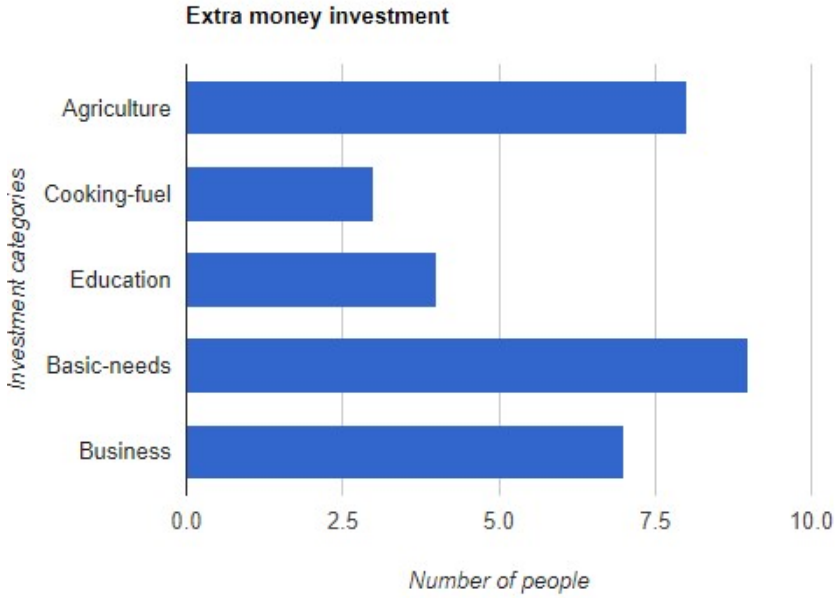

Figure 29: Extra money investment. Source: own image.

6. Conclusions & recommendations

In this section, an attempt will be made to answer the research question stated in the introduction, supported by the three sub questions stated in the Methodology chapter.

As seen in the main research question, the aim of this research is to clarify the possible correlation between climate change adaptation and the EnDev ICS intervention project and creating a methodology assess if this is the case. The reason for attempting this is that it is often claimed that there is a link between these two aspects, but it has not been proven with empirical studies that this correlation actually exists. By creating a methodology to measure this, this uncertainty can be resolved, as it can be measured to what extent an ICS intervention project in a given area affects the degree of a given community to adapt to the effects of climate change. A case study approach has been chosen because it gives a comprehensive picture of the dynamics of a particular community. However, this approach offers limited possibilities to generalise the aspects of the community to a larger scale. In fact, this research is not intended to give a very high representative picture of the phenomenon in the community, but mainly to test the methodology that has been created to measure the change in degree of climate change adaptation by means of the ICS intervention of EnDev, and thus to act as a set-up for further research. As stated, this study tries to establish a fair link between climate change adaptation and the ICS intervention, based on pre-acquired information. This has led to a number of (possible) connections: two direct connections (forest cover and agriculture), and one indirect connection (socio-economic status), which should increase someone's' resilience and adaptive capacity (see chapter 3.2.2), and therefore enhance the climate change adaptability of an ICS user. Based on the main research question and the three sub questions, an expert interview and almost 70 household questionnaires are used to investigate these connections in Kitui County, Kenya.

Drawing on the first sub question, the expert interview was conducted with a IGAD climate change expert in Nairobi to find out whether forest cover is actually decreasing as a result of climate change. The answer was quite clear: yes, it is decreasing because of the increasing drought due to climate change, but deforestation also affects the decreasing forest cover. It is a combination of factors, and not just due to climate change. However, climate change has (indirectly) an amplifying effect on deforestation, which in turn leads to an increasing negative impact of deforestation. Respondents in Kitui County cited climate change and the related drought as the main reason for decreasing forest cover. However, they indirectly indicate that the cutting of trees or the removal of branches also has an effect on reducing forest cover. It can be argued that the increasing drought prevents new trees from growing, and when branches are removed from trees, they do not grow back as quickly as before, because of drought (regeneration). This is again a combination of factors. Trees or branches are cut, and climate change (increasing drought) means that trees do not grow back as quickly or that new branches are regenerated less quickly. Because the majority of respondents collect their fuel wood and remove it from the immediate vicinity of their homes, they suffer greatly from the reduced availability of firewood. ICS users indicate that they are using less fuelwood than before with their traditional cooking method, and are therefore better able to cope with the fact that less wood is available. In addition, non-ICS users indicate that they are cooking longer and consuming more wood, and have greater difficulties in collecting enough firewood than ICS-users.

Based on the second sub question regarding the (negative) effects of climate change on agriculture, it was necessary to find out of the ICS enables people to reduce their dependence on agriculture. Of the 37 respondents that have an ICS, quite a few are active as a stove builder. This was probably mainly due to the targeted-sampling method, in which

the network of stove builders was used. However, this did provide an opportunity to gain insight into the extent to which having an ICS and being involved in the production process changed their source of income and hence their dependence on agriculture. There is unanimity among the respondents that the involvement in the ICS production process has a positive effect on the financial situation of a respondent, and thus their main source of income is shifted from agriculture to production (although most respondents are still active in agriculture on the side). The main sector of investment of the extra money created is invested in the storage of basic needs (food, water and extra firewood) and education.

The second component of the agriculture sub question is nutrition. Nutrition turned out to be one of the more difficult sections to examine. Many people did not understand the underlying idea, and therefore gave rather contradictory answers. In general, derived more from the open questions in the nutrition section, the outcome was that having an ICS provided qualitatively improved meals due to the intensity of cooking, and people were able to cook more with the same amount of firewood as a traditional cooking method. In other words, without using extra firewood (or even less), it was possible to cook more and better, even if there were changes in certain crops over the years.

The final and third sub question asks of the access to an ICS provided people with chances to enhance their socioeconomic status, and therefore enhance their adaptive capacity and decrease their resilience. The respondents seemed to be fairly unanimous about the socioeconomic development. Almost all of the ICS users indicated that their socio-economic status had improved, and that they had more chance of economic growth since acquiring an ICS. They have a higher availability of time because less fuelwood is needed (i.e. less time has been spent collecting or buying it), and the extra time is invested in factors that can lead to a higher socio-economic status such as owning a business, extra time in farming or looking for work. In terms of money, the difference between ICS users and non-ICS users is less, because only a small proportion of ICS users buy their firewood, so an actual difference is difficult to prove. It could be argued that the difference in proportion of respondents that buy firewood between non-ICS users and ICS users is due to the fact that a non-ICS user consumes more wood which may not be present and therefore has to buy it. Next, having an ICS saves money, because it does not have to be bought, as the ICS uses less, and therefore the available wood to collect is sufficient. In any case, 88 percent of ICS users indicate that having an ICS saves them money, money that is invested in sectors similar to those in which money is invested, namely business, agriculture and basic needs - all things that contribute to a high socio-economic status.

In general, it can be stated, whether conservative or not, that having an ICS for the respondents in Kitui County has had a positive effect on the degree of climate change adaptation. Some relationships are somewhat stronger (forest cover, displacement of source of income and socioeconomic status) than others (health and nutrition), but generally there is consensus. Looking at the purpose of this research, the creation of a methodology to measure the impact of such a project on climate change adaptation, a basis for further research has been laid in terms of cause and effect process and methodology. Further continuation and refinement of the methodology could entail that the questions need to be sharpened, it is proven to be difficult sometimes for respondents to understand the context, and thus to give an answer that answered the question correctly. Some adjustments should also be made to the structure of the questionnaire in order to better distinguish between the direct and indirect links between the ICS project and climate change adaptation.

As stated earlier, the results of this actual study may not be representative of a larger scale than the respondents' immediate surroundings in Kitui County, but this was not what the emphasis of this study was on. The emphasis was on being able to prove such correlations between the two phenomena using a clear methodology that can be applied to different

geographical locations and among different demographical target groups. Access to this set-up will allow EnDev to create a better starting position for its donors, and climate change adaptation can, when the methodology is refined and made more comprehensive, be included in policy documents and, in addition to the known mitigation effects, emphasis can also be placed on the climate change adaptation effects of EnDev's ICS intervention project.

Those are, some of the recommendations to be made after conducting this research. Some more detailed recommendations are to simplify the questionnaire. Because it has the form of a case study, the structure of the questionnaire seemed not to fit the respondents in every way, and some last-minute adjustments had to be made. Mainly the structuring of the questionnaire could be done better, basing the questions on the sub questions used in this research, instead of the sections that are now used. Also, some questions could be simplified, because some people did not even realise the climate was changing, until I explained what was going on. Something that also proved to be challenging is language. Before the start of the questionnaire, the decision was made that the translator would do everything (asking and entering in the tablet), because that would be a lot more efficient, and would therefore save time. After the first two questionnaires, however, it turned out that the translator did not interpret the information correctly, so there were contradictory answers. Then the principal researcher (the author of this thesis) took over the questionnaires, which also gave the opportunity to ask further questions when an unclear or interesting answer was given. A two-sided translation is therefore highly recommended. Sometimes, the respondents got the idea that the researcher was there to provide direct benefit to them, in the form of providing money or something related. Therefore, it should be made extra clear that the researcher is not providing direct benefit to respondents, which will decrease the chance of biased answers. In relation to this, it might be helpful to rethink the sampling method. In Kitui, Kenya, there was no other choice then to use the network of stove builders, for practical reasons. In other regions, however, sampling could be easier because of better infrastructure or more accessible networks. Overall, however, access to this set-up for measuring climate change adaptation can, when the recommendations are taken into consideration, the methodology is refined and made more comprehensive, be included in policy documents and, in addition to the known mitigation effects, emphasis can be placed on the climate change adaptation effects of EnDev's ICS intervention project.

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8. Annex

Type	Identifier	Description	Choices
SECTION	**A**	**General Section**	
Q_INTEGER	A1	Interview number	
Q_GEOTAG	AGPS	GPS data of the interviewed household	
Q_INTEGER	A2	Age of interviewee	
Q_MULTCHOICE	A3	Sex of interviewee	0:Male|1:Female
Q_INTEGER	A4	Phone number of interviewee	
Q_DATE	A5	Date of interview	
Q_TEXT	A6	County of residence	
Q_MULTCHOICE	A7	Marital status of interviewee	0:In a relationship|1:Married|2:Single|3:Divorced|4:Widow|5:Other
Q_TEXT	A7Other	Other (Marital status of interviewee)	
Q_MULTCHOICE	A9	Level of education of interviewee	0:No Education|1:Pre-primary education|2:Primary education|3:Secondary education|4:Tertiary education
Q_INTEGER	A10	Number of household members	
Q_INTEGER	A11	Number of people that regularly eat in this household	
Q_INTEGER	A12	How many adults permanently live in this household?	
Q_INTEGER	A13	How many children permanently live in this household?	
Q_MULTCHOICE	A16	Who is the head of the household?	0:Husband|1:Wife|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_A16	Other (Who is the head of the household?)	
Q_MCHOICEINC	A17	What is the occupation of the head of household?	0:Unemployed|1:Farming|2:Salaried/Employed|3:Businessman /self employed|4:Part time employed|5:Other
Q_TEXT	A17Other	Other (What is the occupation of the head of household?)	
Q_BOOLEAN	A18	Are there other wage earners in the household?	
Q_MCHOICEINC	A18a	What is the occupation of the other wage earner(s)?	0:Unemployed|1:Farming|2:Salaried/Employed|3:Businessman /self employed|4:Part time employed|5:Other
Q_TEXT	A18aOther	Other (What is the occupation of the other wage earner(s)?)	
SECTION	**G**	**Climate change section**	
Q_BOOLEAN	G22	Have you experienced a changing climate over the years?	
Q_TEXT	G23	In which way?	
Q_BOOLEAN	G1	Have you experienced changing rainfall patterns over the years?	
Q_BOOLEAN	G2	Did these changes change your environment?	
Q_BOOLEAN	G3	Was there more or less fuelwood available due to these changes?	
Q_BOOLEAN	G9	Have you ever experienced floods?	
Q_BOOLEAN	G10	Has there been a change in frequency or intensity of these floods over the years?	

Q_MCHOICE INC	G11	How has there been a change in frequency or intensity of these floods?	0:More floods|2:Less floods|1:Higher intensity|3:Lower intensity|4:Other
Q_BOOLEAN	G12	Did these floods have impact on availability of fuelwood in your collection/buying area?	
Q_BOOLEAN	G4	Have you experienced changing drought patterns over the years?	
Q_BOOLEAN	G5	Did these changes change your environment?	
Q_BOOLEAN	G6	Was there more or less fuelwood available due to these changes?	
Q_BOOLEAN	G13	Did the environment in your neighbourhood/village change?	
Q_TEXT	G14	In which way?	
Q_BOOLEAN	G15	Did this have an impact on availability of fuelwood in your collection/buying area?	
Q_BOOLEAN	G7	Have you experienced changing forest cover patterns over the years?	
Q_TEXT	G72	Why do you think forest cover patterns are changing?	
Q_BOOLEAN	G16	Have there been positive effects of the changing climate for you personally?	
Q_TEXT	G17	In which way?	
Q_BOOLEAN	G18	Have there been negative effects of the changing climate for you personally?	
Q_TEXT	G19	In which way?	
Q_TEXT	G20	What do you do personally to deal with the positive effects of climate change?	
Q_TEXT	G21	What do you do personally to deal with the negative effects of climate change?	
SECTION	**B**	**Cooking section**	
Q_MCHOICE INC	B1	Who regularly does the cooking in your household?	0:Husband|1:Wife|2:Child(ren)|3:Other family members|4:Maid|5:Other
Q_TEXT	B1Other	Other (Who regularly does the cooking in your household?)	
Q_TEXT	B2	What is the most common dish for breakfast?	
Q_INTEGER	B3	How many minutes do you need to cook this dish on the stove?	
Q_TEXT	B4	What is the most common dish for lunch?	
Q_INTEGER	B5	How many minutes do you need to cook this dish on the stove?	
Q_TEXT	B6	What is the most common dish for supper?	
Q_INTEGER	B7	How many minutes do you need to cook this dish on the stove?	
COMPUTED	B8	Total daily cooking time (in min)	
Q_BOOLEAN	B9	Did cooking change over the years?	
Q_TEXT	B10	In what way did cooking change?	
Q_MCHOICE INC	B11	Does this have to do with changing food types or availability?	0:Food types|1:Food availability|CSXX_OTHER_ITM:Other|CSXX_NA_ITM:None of Above
Q_TEXT	CSXXXX_OTHER _B11	Other (Does this have to do with changing food types or availability?)	
SECTION	**C**	**Cookstove section**	
Q_MULTCH OICE	C1	How many stoves do you regularly use for the preparation of your meals?	0:1|1:2|2:3|3:More than 3
Q_MCHOICE INC	C2	Which type of stove(s) do you use?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove

			(Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)| 4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C2	Other (Which type of stove(s) do you use?)	
Q_MCHOICEINC	C3	Which type of stove(s) do you use to cook breakfast?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)| 4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C3	Other (Which type of stove(s) do you use to cook breakfast?)	
Q_MCHOICEINC	C4	Which type of stove(s) do you use to cook lunch?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)| 4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C4	Other (Which type of stove(s) do you use to cook lunch?)	
Q_MCHOICEINC	C5	Which type of stove(s) do you use to cook supper?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)| 4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C5	Other (Which type of stove(s) do you use to cook supper?)	
Q_MULTCHOICE	C6	Which stove is your main cooking stove?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)| 4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C6	Other (Which stove is your main cooking stove?)	
Q_INTEGER	C7	For how many years have you had this stove?	
Q_MULTCHOICE	C8	Which stove is your secondary cooking stove?	0:Three-stone fire|1:Artisanal Firewood stove (Rocket, Jiko Kasasa, Uhai)|2:Industrial Firewood stove (Burn Manufacturing, Envirofit, Ecozoom, Biolite, Cook n Lite, Scode)|3:Artisanal Charcoal stove (KCJ, Jiko Upesi, Jiko Smart)

			|4:Industrial Charcoal stove (Jikokoa, Envirofit, Ecozoom)|5:Industrial Gasifier stove (Wisdom)|6:LPG|7:Electrical| 8:Gas|9:Electricity|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_C8	Other (Which stove is your secondary cooking stove?)	
Q_INTEGER	C9	For how many years have you had this stove?	
Q_MCHOICEINC	C10	Which type of fuel do you use with your main stove?	0:Agricultural residue|1:Firewood|2:Maize cobs|3:Maize / sorghum stalks|4:Twigs|5:Sawdust|6:Charcoal| 7:Kerosine|8:Gas|9:Electricity|10:Other
Q_TEXT	C10Other	Other (Which type of fuel do you use with your main stove?)	
Q_MCHOICEINC	C11	Which type of fuel do you use with your secondary stove?	0:Agricultural residue|1:Firewood|2:Maize cobs|3:Maize / sorghum stalks|4:Twigs|5:Sawdust|6:Charcoal| 7:Kerosine|8:Gas|9:Electricity|10:Other
Q_TEXT	C11Other	Other (Which type of fuel do you use with your secondary stove?)	
Q_MCHOICEINC	C12	Do you buy or collect your cooking-fuel?	0:Collect|1:Buy|2:Both
SECTION	**D**	**Cooking-fuel collection section**	
Q_INTEGER	D1	How many times per week does your household collect cooking-fuel?	
Q_MCHOICEINC	D2	Who regularly collects the cooking-fuel?	0:Husband|1:Wife|2:Boy|3:Girl|4:Maid|5:Other
Q_TEXT	D2Other	Other (Who regularly collects the cooking-fuel?)	
Q_MCHOICEINC	D3	Where does the collected fuel come from?	0:Natural forests|1:Forest plantations|2:Bushes in village|3:Own farm|4:Trees in urban areas|5:Dumps, construction sites|6:Other
Q_TEXT	D3Other	Other (Where does the collected fuel come from?)	
Q_MULTCHOICE	D4	How long does it take to go from your house to the edge of the main cooking fuel collection area and back, and to collect cooking fuel?	0:Less then an hour|1:A few hours|2:Half a day|3:Full day|4:More than a full day|5:Other
Q_TEXT	D4Other	Other (How long does it take to go from your house to the edge of the main cooking fuel collection area and back, and to collect cooking fuel?)	
Q_MULTCHOICE	D5	What time period are you able to collect cooking fuel?	0:All year round|1:Only in the dry season|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_D5	Other (What time period are you able to collect cooking fuel?)	
Q_MULTCHOICE	D6	Did the availability of cooking fuel increase or decrease over the years?	0:Increase|1:Decrease|2:No difference
Q_MULTCHOICE	D7	Did it get more or less difficult for you to collect cooking fuel, due to the availability?	0:More difficult|1:Less difficult|2:No difference
Q_TEXT	D9	Why do you think this is?	
Q_TEXT	D92	How do you cope?	
Q_BOOLEAN	D10	Do you ever have a surplus of collected cooking fuel?	
Q_MCHOICEINC	D11	What do you do with the cooking fuel that you do not use?	0:Sell|1:Store|2:Give away|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER_D11	Other (What do you do with the cooking fuel that you do not use?)	
SECTION	**E**	**Cooking-fuel bought section**	
Q_INTEGER	E1	How many times per week does your household buy cooking-fuel?	

Q_MCHOICE INC	E2	Who goes to buy the cooking-fuel?	0:Husband|1:Wife|2:Child(ren)|3:Other family member|4:Maid|5:Other
Q_TEXT	E2Other	Other (Who goes to buy the cooking-fuel?)	
Q_MULTCH OICE	E3	How long does it take to go from your house to the edge of the main cooking fuel buying area and back, and to buy cooking fuel?	0:Less than an hour|1:A few hours|2:Half a day|3:Full day
Q_MULTCH OICE	E4	What time period are you able to collect cooking fuel?	0:All year long|1:Only in the dry season|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER _E4	Other (What time period are you able to collect cooking fuel?)	
Q_MULTCH OICE	E6	Did it get more or less difficult for you to buy cooking fuel, due to the availability?	0:More difficult|1:Less difficult|2:No difference
Q_MULTCH OICE	E5	Did the price of cooking fuel increase of decrease over the years?	0:Increase|1:Decrease|2:No difference
SECTION	**I**	**Forest cover section**	
Q_BOOLEAN	I1	Does the use of cooking fuel (collected or bought) have an effect on the availability of cooking fuel?	
Q_MCHOICE INC	I2	What do you do to cope?	0:Skip meals|1:Undercook meals|2:Purchase or trade meals|3:Other
Q_TEXT	I2Other	Other (What do you do to cope?)	
Q_MULTCH OICE	I3	Do you have the idea that your ICS uses less or more fuel than your previous cooking method?	0:Less|1:More|2:No difference
Q_BOOLEAN	I4	Do people plant trees to be used as fuel in your neighbourhood/village?	
Q_TEXT	I6	What is the motivation for planting trees?	
Q_BOOLEAN	I7	Do people produce charcoal in/around your village?	
Q_BOOLEAN	I8	Does this have an effect on nature in your environment?	
Q_TEXT	I9	In which way?	
SECTION	**H**	**HHs with ICS intervention section**	
Q_MULTCH OICE	H1	Is there a difference in cooking time, in comparison to your previous cooking method?	0:It goes faster|1:It goes slower|2:There is no difference
Q_INTEGER	H2	How much time is saved per meal (estimation, on average)	
Q_MCHOICE INC	H3	Are you able to cook better/longer with your ICS?	0:Better|1:Longer|2:No difference
Q_MCHOICE INC	H8	What do you see as an advantage of the improved firewood stove	0:More comfort|1:Fuel saving|2:Time saving|3:Reduced exposure to smoke|4:Money saving|5:Clean kitchen| 6:Less burns or other accidents|7:Less physical inconvenience|8:Higher quality of food|9:Higher quantity of food| 10:Using it for productive use|11:Involvement in production chain|CSXX_OTHER_ITM:Other
Q_TEXT	CSXXXX_OTHER _H8	Other (What do you see as an advantage of the improved firewood stove)	
Q_MULTCH OICE	H10	Do you use more or less fuel since you have an ICS, in comparison to your previous cooking method?	0:Less|1:More|2:No difference
Q_BOOLEAN	H11	Are you involved in the ICS production process?	
Q_TEXT	H111	What is your role in the production process?	
Q_MULTCH OICE	H12	Did this increase or decrease your financial situation, comparing to before you were involved?	0:Increase|1:Decrease|2:No difference
Q_TEXT	H13	What do you do with the extra money you make?	

Q_BOOLEAN	H14	Do you use your ICS to engage in 'Productive Use' (i.e. cook meals which are sold)	
Q_MULTCHOICE	H15	Did this increase or decrease your financial situation, comparing to before you were enaged in productive use?	0:Increase|1:Decrease|2:No difference
Q_TEXT	H151	What do you do with the extra money you make?	
Q_MULTCHOICE	H16	Being a famer, does the access to the ICS decrease or increase your dependency on agriculture?	0:Increase|1:Decrease|2:No difference
Q_TEXT	H17	Can you explain how?	
Q_BOOLEAN	H161	Do you still have to spend the same time and effort in agriculture as before?	
Q_BOOLEAN	H18	Does having an ICS save time?	
Q_TEXT	H19	What do you invest the extra time in?	
Q_BOOLEAN	H20	Does having an ICS save money?	
Q_TEXT	H21	What do you invest the extra money in?	