Cooking with the sun

- An analysis of Solar Cooking in Tanzania, its adoption and impact on development

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Abstract

This study aims to analyse solar cooking projects in Tanzania regarding their adoption and impact on development.

Biomass is a traditional source of energy in Tanzania which counts for 90 percent of the total energy use. The high use of biomass is claimed to have negative environmental, economic and health impacts. In this way, Solar Cooking seems to present an alternative solution since it does not require the use of firewood or charcoal, which prevents people from cutting trees, and particularly women from spending hours for fuelwood collection or even from spending money to buy it. In addition, Solar Cooking does not pollute the environment since it does not produce smoke. However, several studies showed that decades of efforts to implement and improve solar cookers for developing countries have not helped to achieve the breakthrough of this technology.

The specific objectives of this thesis are to find out which factors limit/enable the adoption of solar cookers, to investigate why people decide to use/ not this technology, and to find out in which way the use of Solar Cooking could be increased. In addition, the study investigates the ways in which Solar Cooking contributes to a development. The discussion of these objectives is based on the Capability Approach and the Innovation- Decision Model according to Rogers. The study focuses on three solar cooking projects in Tanzania.

I argue that Solar Cooking is adopted to a certain degree in Tanzania but that the wider success is influenced by different factors including economic affordability, technology, social/ cultural values, sustainability, infrastructure, information and the area where the solar cooking projects takes place. In addition, the study shows that solar cooking leads to an improvement of women's perception of their own health and a considerable time gain which is mainly used for income generating activities and domestic work.

Key words: Solar Cooking, Capability Approach, Innovation Diffusion Theory, Energy, Tanzania.

Dedication

The study is dedicated to my beloved father Ewald Otte who unfortunately could not experience the finalisation of my work. This study would not be possible without his support and interest for my studies during all this time.

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List of Abbreviations

ESAF- Enhanced Structural Adjustment Facility

FAO- Food and Agriculture Organization (of the United Nations)

GTZ- Gesellschaft für Technische Zusammenarbeit

IEA- International Energy Agency

IMF- International Monetary Fund

KASI- Kilimanjaro Association of the Spinally Injured

KASIWOCO- Kilimanjaro Association of the Spinally Injured Women's Committee

LPG- Liquefied Petroleum Gas

MDG- Millennium Development Goals

NGO- Non Governmental Organization

SCI- Solar Cookers International

TaTEDO- Tanzania Traditional Energy Development and Environment Organisation

TRETA- Trans Regional Environment Technology Organization

UN- United Nations

UNDP- United Nations Development Programme

UNEP- United Nations Environment Programme

WHO- World Health Organization

YWCA- Young Women's Christian Association

Exchange rate from: 10.04.2009	
100,000 USD (US Dollar)	132,550,000 TZS
100,000 TZS (Tanzanian Shilling)	0,075 USD
1 USD (US Dollar) = 1.325,50000 TZS (Tanzanian-Shilling)	

Source: http://www.bankenverband.de/waehrungsrechner/index-xi.asp?channel=

CHAPTER 1: INTRODUCTION

1.1 Introduction

Solar Cooking is a way of using the sun's power to cook (Chikuwa, 2008). In times where governments start discussing for limited resources such as oil and coal, the promotion of solar energy for heating and cooking can play an important role. There is a high potential of solar energy available in the world. According to Abelsen (2007), the fraction of solar energy that reaches the Earth's surface annually is considered to be more than 10.000 times higher than the current world energy consumption. In this way there is a high interest in Solar Cooking. Around the world NGOs, scientists and engineers are involved in designing, producing, distributing and evaluating solar cookers (Biermann et. al. 1999).

For Tanzania, Solar Cooking could present a suitable solution to overcome the claimed rural energy crisis. According to Kimambo (2007) and the UNDP & GTZ (2005), 90 percent of the total energy use in Tanzania comes from biomass. The high use of biomass is claimed to have negative environmental, economic and health impacts, while Solar Cooking seems to protect people from these negative impacts since it is inexhaustible, clean and the sun as a cooking fuel is freely available for everyone. In addition, Solar Cooking is considered to have positive impacts on people's lives and that it even contributes to the fulfilment of the UN Millennium Development Goals.

Tanzania is characterized by a range of solar cooking projects which aim to improve the living conditions of Tanzania's population and to eradicate poverty, particularly in rural areas of the country.

Unfortunately, decades of efforts to implement and improve solar cookers did not help to achieve the breakthrough of this technology (GTZ, 2007). There are different factors assumed to prevent a broad application of solar cookers in developing countries. One widely used explanation is that the use of solar cookers is significantly inconsistent with people's lifestyles (Thomas, 2003). In addition, there is a lack of information regarding the positive impacts of Solar Cooking on people's lives in Tanzania.

This thesis investigates the factors influencing the success or failure of Solar Cooking in three different projects in Tanzania. In addition, the interest lies in exploring the real impacts of Solar Cooking on people's lives.

1.2 Rationale of the study

1.2.1 Personal motivation

In June 2007 an interdisciplinary seminar was given at the Justus Liebig University of Giessen in Germany about the application of renewable energies. During this seminar, I was able to give a presentation about field applications of renewable energies in Mozambique. The seminar made me aware of the importance of finding a suitable and reliable energy supply, particularly for the rural poor in developing countries. In this way I heard the first time about Solar Cooking. I was fascinated by the simple idea that sun rays can be converted to heat and conducted into a cooking pot. The fact that most of the developing countries are characterised by a high amount of sunny days seems to make them perfectly applicable for the use of Solar Cooking.

However, the literature review showed that many solar cooking projects could not succeed so far. This fact made me interested in analysing the why people are using or not solar cookers and which reasons influence the adoption of the cookers. My personal aim is to create an analytical framework which identifies the enabling/limiting factors of solar cooking projects and which might be of help for future approaches of implementing Solar Cooking. In addition, my personal interest is on the impacts of solar cooing on people's lives. As a student of Development Studies I am interested in finding out in which way Solar Cooking contributes to a development.

1.2.2 Position of the researcher

Solar Cooking is a broad term which combines various types of solar cookers which are developed around the world. These types of solar cookers vary in its construction, application and intended target group. This study provides a short technical background to Solar Cooking but does not include any technical tests related to the functioning of different types of solar cookers. Furthermore, the thesis presents the advantages and disadvantages of two solar cooking technologies, but does not aim to conclude which one seems to be the most appropriate.

The focus of this study is on a people's approach. It is investigated what influences people's choice on Solar Cooking and, in this way, the success of solar cookers within an analytical framework which is partly based on the Innovation Decision Model according to Rogers. In addition, the impact of Solar Cooking on development is analysed within the Capability Approach which understands development as the expansion of people's freedoms to live the life they want to live and to do the things they want to do. In this way, I investigate the ways

in which Solar Cooking leads to the expansion of a certain defined capability set. The capability set comprises time autonomy, health, political participation, education and knowledge, income generating activities and leisure time.

1.3 Objectives of the study

The aim of this study is to find out what influences the success or failure of solar cooking projects. In this way the thesis investigates the factors which influence the success or failure of current solar cooking projects and the individual decision whether or not to adopt solar cookers. The research objectives comprise the following:

- *Assess and identify the factors which enable or limit the success of Solar Cooking*
  - What limits or enable the success of Solar Cooking?
  - Why do people decide to use or not use solar cookers?
  - What can be done to increase the adoption of Solar Cooking?
- *Assess and identify the impacts of Solar Cooking on people's lives*
  - How does Solar Cooking lead to development?

1.4 Organisation of the study

The study is divided into nine chapters. **Chapter 1** provides the introduction to the study including a description of the study area. **Chapter 2** gives an overview of the energy situation in Tanzania while **Chapter 3** provides an essential background to Solar Cooking. The theoretical considerations for this study are offered in **Chapter 4**. **Chapter 5** explains the qualitative research design applied in this study.

Chapter 6 presents the first chapter of the analysis part. Three different solar cooking projects are presented including their achievements and the influence of the identified factors on the projects. The impact of Solar Cooking on people's lives and the ways in which it leads to a development is discussed in **Chapter 7**. An external view on Solar Cooking including interviews with three researchers and different institutions in the field of solar energy, outside of the three solar cooking projects presents the third part of the analysis **Chapter 8**. **Chapter 9** presents the overall conclusion and recommendations of this study. It combines the two research objectives and highlights the lessons learned from the research.

1.5 Facts about Tanzania

Capital: Dodoma

Official language: English, Swahili

Government: Republic

Independence: Tanganyika 9th December 1961, Zanzibar 12th December 1963 (Hansen, 2006), United Republic of Tanzania: 26th April 1964 (Fitzpatrick, 2002)

Head of State: Jakaya Mrisho Kikwete

Climate: Subtropical

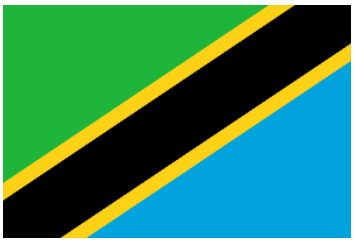

Figure 1 Flag of Tanzania

Population: about 41 Million (CIA, 2008a)

Religion: 30% Christians, 35% Muslims 35% Indigenous (mainly Islamic religion on coastal areas, Zanzibar) (Norad, 2003)

1.5.1 Tanzania's Geography

Tanzania is located in East Africa between longitude 29° and 41° East, Latitude 1° and 12° south. Tanzania is the biggest of the East African countries[1] by surface area. The country is bordered by Kenya and Uganda in the North, Rwanda, Burundi and Democratic Republic of Congo in the West. In the South Tanzania is bordered with Zambia, Malawi and Mozambique while the Eastern part is bordered by a coast line close to the Indian Ocean (Tanzania government, history, 2008).

Tanzania comprises an area of 945,000 km^2, including 881,000 km^2 of mainland and 2,000 km^2 of Zanzibar. (In comparison Norway has a total area of 323,802 km^2 (CIA, 2008b, 2008)). Tanzania's landscape is full of variations including high mountain areas, savannahs, lakes and coastlines with both coral reefs and mangrove forests. Africa's highest mountain, Kilimanjaro, as well as Africa's largest inland lake, Lake Victoria, are located in Tanzania (Globalis, 2008).

1.5.2 Study area

The study is based on three different solar cooking projects in Tanzania. The three different projects areas are marked on Figure 2 which presents a map of Tanzania. A short description of each area is given in the following.

[1] The East African countries comprises Kenya, Uganda and Tanzania (Tanzania government, history, 2008)

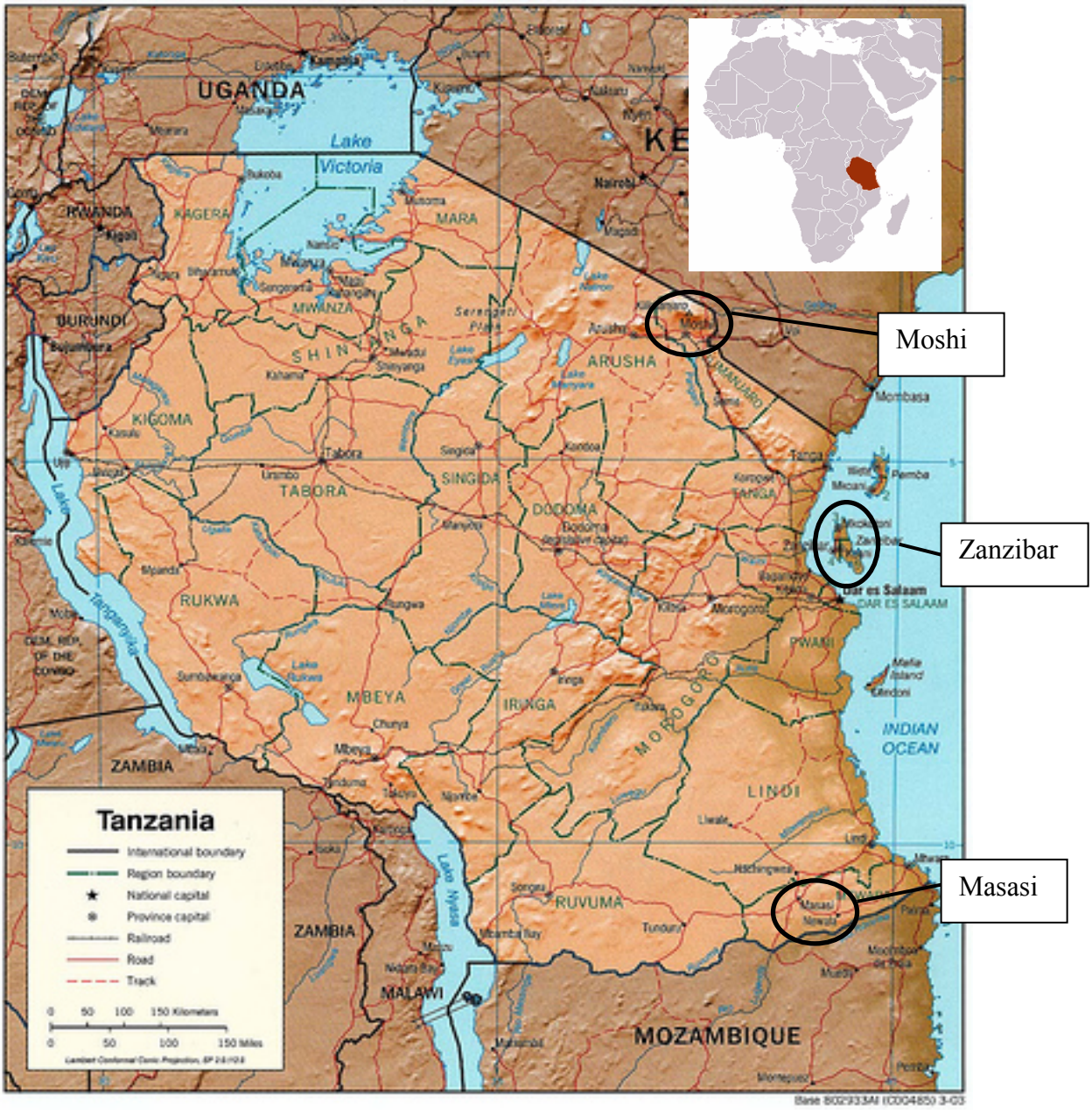

Figure 2 Map of Tanzania

Source: Texas (2003), Iserengeti (2009)

1.5.2.1 Moshi

Moshi is a town located in the northern part of Tanzania, at the foot of Kilimanjaro, at an altitude of about 800 m (Fitzpatrick, 2002). It belongs to the Kilimanjaro region and is located in Moshi urban district. Moshi has a population of 143.799 (Population & Housing Census, 2002a) and is the regional capital, besides being an important educational centre in Tanzania. It comprises one of the largest Christian communities in Tanzania. In addition, Moshi presents one of the starting points for a trip to Kilimanjaro.

The solar cooking project by KASIWOCO (Kilimanjaro Association of the Spinally Injured Women's Committee) is located in Moshi town but encompasses participants within the town as well as in villages outside of Moshi.

1.5.2.2 Zanzibar (Mahonda)

Zanzibar comprises the islands Unguja, Pemba, and several islets. It is located in the Indian Ocean about 25 miles from the Tanzanian mainland (Zanzibar Net, 2009). For hundreds of years Zanzibar has been characterised as an important trade centre. Egyptians, Phoenicians, Indians, Portuguese and Arabians embossed the island. Today, Zanzibar is a multicultural society. Over the last years the infrastructure has greatly expanded which led to an increase of the number of tourists entering Zanzibar by 35 percent between 1995 and 1999 (Tanzania Government Zanzibar, 2009).

The solar cooking project coordinated and initiated by Solar Africa Network is present in 5 villages on Zanzibar Island (known locally as Unguja, but often referred internationally as Zanzibar). Mahonda, the study area, represents one of the villages.

1.5.2.3 Masasi

Masasi town, with a population of 75.517 (Population & Housing Census, 2002b), is located in Masasi district which is a part of the Mtwara region in the southern part of Tanzania close to the border of Mozambique. It lies off the edge of the Makonde plateau and is considered as a forgotten place by tourists (Fitzpatrick, 2002). The Masasi District comprises 5 divisions, 22 wards and 156 villages with a total population of 347.908 (DED, 2009).

The solar cooking project initiated by Solar Circle is currently supervised by the Anglican Church in Masasi town. The project is mainly focused on Masasi town.

CHAPTER 2: ENERGY in TANZANIA

2.1 Introduction

The following chapter gives the energy background for this study. The chapter will start by giving an overview of Tanzania's energy resources. Furthermore, the focus will be on energy consumption patterns in Tanzania and its associated harmful effects. In addition, the chapter will shortly discuss the potential of solar energy and radiation in Tanzania. Last, but not least, this section will discuss the importance of solar energy for development.

2.2 Energy resources in Tanzania

Tanzania is characterized by a variety of energy resources in different forms. These energy resources, which are required for sustainable development, include biomass, solar, wind, hydro and geothermal energy.

However, despite this enormous potential, the region's energy sector remains largely underdeveloped. Tanzania's sources of commercial energy are primarily dominated by petroleum, hydropower and coal. Petroleum is imported and the transport sector presents the main consumer of petroleum. Currently, there are several companies exploring for oil in Tanzania, but no reserves have been found thus far (Tanzania Government History, 2008). Tanzania's hydropower potential is estimated at 4700 MW. At the moment, the already exploited hydro power capacity is 561 MW out of the total installed electrical capacity of 859 MW. Additionally, Tanzania imports electricity from Uganda (8MW) and Zambia (5MW) (GTZ, 2008). Tanzania also has coal reserves which are estimated at 1200 million tonnes of which 304 million tonnes are proved. Efforts are taken to promote the usage of clean coal briquettes as a substitute to biomass fuels for cooking in public institutions and for household applications. Current renewable energy technologies in Tanzania include solar photovoltaics (PV), solar thermal, wind turbines and biogas plants are being developed. Smaller attempts on local scale also include Solar Cooking, which is the focus of this study. The Tanzanian government is trying to create an atmosphere conducive to the expansion of energy supply and efficient utilization of energy. Unfortunately, strategies for the successful implementation of necessary policies are still too weak to accommodate the growing energy challenges in the country. Several energy programmes and projects have already developed which could be used as a stepping stone for further interventions. (GTZ, 2008)

2.3 Household energy consumption in Tanzania

In recent years Tanzania has made important steps forward in reaching economic growth and stability (United Republic of Tanzania, 2008). According to the Poverty and Human Development Report (2007), Tanzania's real GDP growth has been on, in average six percent during the period from 2000 to 2006.

However, it is still a long way to improve the living conditions of Tanzania's population and to eradicate poverty, particularly in rural areas of the country (Dahle, 2007). One major problem limiting Tanzania's development process is its lack of energy supply, especially in the rural areas. According to Mwandosya, et al. (1997), Tanzania is regarded as being at the top of the list of wood energy dependent economics in Africa. Figure 3 presents an overview of patterns in energy consumption in East African countries. The figure shows that it is estimated that approximately 90 percent of households in Tanzania use biomass[2] for cooking. Additionally, only 38 percent have access to electricity in urban areas, while the situation in rural areas of Tanzania is even worse, where only two percent of the population are connected to the grid (UNDP & GTZ, 2005).

	Population (million)			Energy consumption		Electrification	
	Total	Urban	Rural	Biomass	Modern	Urban	Rural
Kenya	31.9	10.5	21.4	70%	30%	46%	4%
Rwanda	8.1	0.5	7.6	90%	10%	48%	1%
Tanzania	36.5	12.0	24.5	90%	10%	38%	2%
Uganda	24.4	3.0	21.4	93%	7%	8%	1%
Total EAC	**100.9**	**26.0**	**74.9**	**92%**	**8%**	**40%**	**5%**

Figure 3 Basic patterns of energy consumption in East African countries

Source: UNDP & GTZ (2005)

Biomass has several advantages which makes it interesting to people. According to Nandwani (1996), the fact that it is easy to store and that it can be used for cooking at any time at any place are the major advantages. In addition, the commercial production and distribution of biomass fuels generate significant employment and income in rural areas of developing countries, including Tanzania (IEA, 2006). This shows that the use of biomass itself is nothing to worry about, but unsustainable ways of harvesting and the use of inefficient cooking technologies make it to a matter of concern.

[2] Biomass includes fuelwood, charcoal, agricultural waste and animal dung

Laiser & Bura (1999) estimate that an average family burns about four tonnes of wood per year for cooking and heating water. In addition, the traditional technologies used to convert biomass to energy are not efficient. Many people make use of a three-stone fire[3] which only has 10 to 15 percent energy efficiency (GTZ, 2007). Furthermore, the processes involved in particularly producing and using charcoal are inefficient and resource intensive (around 10 kg of woods is necessary to produce 1 kg of charcoal) with the result of large quantities of biomass must be used to manufacture enough fuel to charcoal the energy needs of the urban population (Schlag & Zuzarte, 2008). Beside the enormous energy loss through the use of normal three-stone fires, several other negative effects must be considered which harm the environment and people's health. Particularly at risk is the health of the women who are performing the cooking duties. The harmful effects of traditional cooking fuels are the major reasons for promoting the idea of Solar Cooking.

2.4 Harmful effects of traditional cooking fuels

2.4.1 Health

According to the WHO (2008), cooking and heating with solid fuels on open fires or traditional stoves result in high levels of indoor air pollution. People in developing countries are exposed to high levels of pollution for three- seven hours per day over many years. It is mainly women who are traditionally involved in the cooking process, leading to a much higher exposure to pollutants in women than men. Additionally, mothers often carry their children on their back while cooking and therefore the children spend many hours inhaling smoke and pollutants. The exposure to pollution from biomass fuel combustion due to the use of open fires can lead to a number of respiratory diseases such as Acute Respiratory Infections (ARI), Chronic Obstructive Pulmonary Disease (COPD), Tuberculosis, Asthma, Low Birth Weight, Cataract and Blindness (Bruce et al. 2000 citied in Kilabuko & Nakai, 2007: 283). The UNDP & GTZ (2005) estimate that 500,000 people die each year because of exposure to indoor air pollution in Sub- Saharan Africa. Figure 4 shows that smoke from biomass combustion is a significant cause of death, causing more deaths than malaria.

[3] The three-stone fire is an open wood- burning fire built on the ground with a pot on top

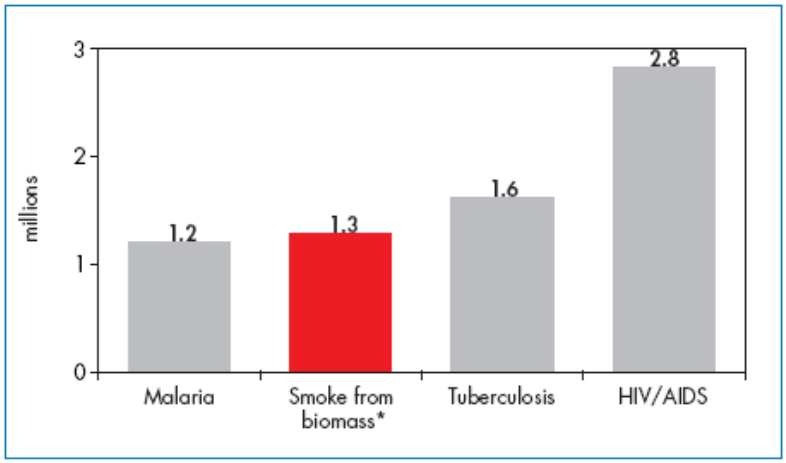

Figure 4 Annual Deaths Worldwide by Cause

Source: IEA (2006)

2.4.2 Environment

According to the IEA (2006), traditional cooking practices are inefficient, unsustainable and can have serious impacts for the environment, including land degradation and air pollution at local and regional levels. Sawe (2005) claims that the high dependence on biomass for energy is one issue which is besides of clearing of land for agriculture and commercial logging greatly contributing to environmental degradation. Particularly the production of charcoal is inefficient and can lead to local deforestation and land degradation. According to IEA (2006) in Tanzania, especially near the border with Kenya, the supply of energy resources is insufficient to meet the demand. This area is characterized by a high consumption of fuelwood and charcoal due to a high population density and low levels of production of biomass.

2.4.3 The Burden of Fuel Collection

In many rural areas of Tanzania, women and children are responsible for gathering fuelwood. The average fuelwood load in Sub- Saharan Africa is around 20 kg but loads of 38 kg have also been recorded (Rwelamira, 1999 cited in IEA, 2006: 428). The large quantities of time spent by women and children for gathering fuelwood has negative impacts on children's education, women's and children's health and women's engagement in income- generating activities. In addition, the time spent collecting firewood prevents children, especially girls, from attending school. The gathering of fuelwood reduces women's economic opportunities.

2.4.4 Economic burden

According to Laiser & Bura (1999) the high consumption of biomass is compounded by a high population growth which leads to an even higher demand for firewood. Particularly in rural areas but also in urban areas characterized by a lack of infrastructure, families suffer because of increasing scarcity and expenses of traditional cooking fuels (Wentzel & Pouris, 2007). The UNDP & GTZ (2005) estimates that in Tanzania an average poor household spends around 35 percent of its income on energy.

2.5 Solar energy for cooking [4]

The health, environmental, economic and burdens associated with the current method of generating cooking electricity shows how important it is to find alternative supplies of energy in Tanzania. The development of renewable energy technologies, particularly solar energy, represents a further option on the way to improve the current energy situation in Tanzania, if the solar systems can be used to prepare food (Schwarzer & da Silva). The sun is the world's most significant source of energy which emits vast amounts of energy (Quaschning, 2005). According to Abelsen (2007) the annual global use of solar energy is much less than the amount of solar energy received on the Earth's surface. The fraction that reaches the Earth's surface annually is more than 10.000 times higher than the world energy consumption.

Unfortunately, although there are large amounts of solar energy available, the harnessing of this energy is hampered by several challenges. The access to solar energy on a short- term basis can be uncertain; the total incoming radiation usually does not vary much but it is difficult to predict on a day to day basis due to local weather patterns. Solar radiation also is characterized by seasonal variations[5]. According to Johansson, et al. (2004) the applicability of solar energy depends on the geographical location, the typical weather conditions and land availability. In the context of Tanzania this means seasonal variations during the two rain seasons. There are two annual rain periods while on rain period takes place from March to May (the long rain season called "Masika") while the other one occurs from November to January (short rain season called "Vuli") (Fitzpatrick, 2002). There are two alternatives to overcome the problem of varying solar energy availability. The first alternative is to adapt to the variations, which means to store the energy. The second option is to invest in an alternative system to cover the energy demand when solar energy is not available or sufficient,

[4] Other alternative ways of energy besides the use of solar energy are presented in the Appendix I Alternative energy supplies for cooking

[5] Section 2.6 will focus more on Tanzania's solar radiation

which is expensive. Improved energy storage is therefore important in order to increase the application of solar energy possibilities and to make it competitive with conventional solutions (Abelsen, 2007).

However, solar energy seems to be an appropriate alternative for Tanzania if the current problem regarding the reliability of solar energy can be overcome. Solar Cookers International stresses this statement by claiming that Solar Cooking is most applicable in countries which are generally dry and sunny for at least six months of the year. Geographically, this means that latitudes between the equator and 40 degrees are usually the best for Solar Cooking. SCI (2008a) compiled a list of twenty countries in the world with the highest potential for Solar Cooking[6] including Tanzania ranked in 9th.

2.6 Tanzania's solar radiation

It is necessary to assess the potential solar radiation in Tanzania to determine whether different solar technologies, such as Solar Cooking, can be applied in that country. According to Stine & Geyer (2001), solar radiation can be described as the summation of solar energy which has fallen on a collector over a certain period of time. Solar radiation is absorbed, reflected or diffused by solid particles in its path (Zekai, 2008). Incoming radiation at any given point may vary in strength since it is dependent on several different factors. The Earth's geometry, its distance from the sun, geographical location of any point on the earth, astronomical coordinates and the absorption of radiation in the atmosphere all affect the solar radiation received at a given location.

According to Alfayo & Uiso (2002), the potential application of solar energy in Tanzania has not been well researched and documented. In order to overcome this lack of data and research in solar radiation, Alfayo & Uiso (2002) developed an empirical model to estimate global solar radiation which can be used to draw solar radiation maps for Tanzania. The model divides Tanzania into different zones according to the location of the solar radiation measuring stations. The authors report the solar radiation potential of the different zones as well as a final result for the entire country.

The results of this study showed that maximum measured solar radiation varied from 23MJ/m^{-2}/day^{-1} in the Central and Southern Highland zones, to the minimum level of solar radiation of 13 MJ·m^{-2}·day^{-1} received in June in the North Eastern Highlands Zone (including Moshi). The study also showed that the levels of radiation vary from month to month. In

[6] The criteria for this ranking comprise annual average of sunlight, cooking fuel scarcity and population size

general, relatively low radiation levels were reported from May to August (winter months) while high radiation levels from October to March (summer months). It can thus be concluded that clear seasonal and geographical variations exist in solar radiation levels in Tanzania. The study shows that the available radiation and its general distribution in Tanzania is higher than 13 MJ $\cdot m^{-2} \cdot day^{-1}$. Radiation in this amount is enough to produce 600 k Wh m^{-2} of energy per m^2 ground area per month. This quantity of energy is sufficient for domestic applications for a majority of Tanzanian families. The results of this model showed that about 90 percent of Tanzania has a high level of solar radiation. Using data collected from all of the investigated zones, it can be concluded that Tanzania has a high solar energy potential for domestic use and that more than 50 percent of the country's potential can be commercially harvested through the entire year (Alfayo & Uiso, 2002).

2.7 (Solar) Energy for development

Alfayo & Uiso (2002) consider a reliable energy supply important to enable basic human needs such as food and shelter. According to the IEA (2004) energy is implicated in economic, social, environmental and human development. For any country to improve the welfare and to enhance the quality of its people's lives, a reliable energy supply must be found.

In September 2000, during the UN Millennium Summit, the United Nations member states agreed on eight Millennium Development Goals (MDG) which must be reached by 2015. The goals comprise targets addressing the reduction of extreme poverty by promoting gender equality, education, health and environmental sustainability. According to the UN (2005), even though the provision of adequate, affordable and reliable energy services is not explicitly mentioned as one of the goals, it is obvious that it will play an important role in the achievement of these targets. Solar Cookers International takes up the same argument in claiming that Solar Cooking supports all eight Millennium Development Goals. In the following, the eight goals are listed with the arguments by Solar Cookers International.

Eradicate extreme poverty and hunger

Many families in developing countries live in extreme economic poverty, which means that they live on less than 1 US Dollar per day (World Bank, 2008), which makes the purchase of expensive fuelwood difficult. SCI (2009b) claims that solar cookers reduce the fuel consumption by 33 percent and pay for themselves within two months through fuel savings.

Achieve universal primary education

The argument here is that firewood has to be collected and it is mostly women and girls who are responsible for collecting the cooking firewood. Women and girls have to walk long distances to find firewood, which takes time away from attending school. Solar cookers do not need any fuelwood and enables the girls to attend school instead of spending time collecting firewood.

Promote gender equality and empower women

Women and girls spend hours gathering firewood, cooking food and consequently, suffer from negative health effects caused by the smoke of open fire. By comparison, solar cookers do not require the gathering of firewood and the cooking does not need as much attention as cooking with conventional firewood. This means that women and girls have more time that they can use for generate income, increase food production or receive education

Reduce child mortality

According to SCI (2009b), water-borne diseases and diseases caused by smoke are the primary factors which increase the child mortality rate of a country. Solar-cooked meals are all smoke-free. Additionally, solar cookers easily pasteurize water and milk to improve sanitation.

Improve maternal health

The smoke caused by firewood also impacts the health of young women in developing countries and is linked to low birth weight and infant mortality. Compared to using firewood, Solar Cooking is free of smoke, which improves the health of family members.

Combat HIV/AIDS, malaria and other diseases

SCI (2009b) claims that in developing countries, it is mainly the extended family that cares for sick family members and orphans. This takes time away from livelihood or income-generating activities. Cooking with a solar cooker requires less supervision so that other activities can be done concurrently. Also, it is possible with larger cookers to reach high temperatures of 150˚C (300˚F), which is enough to sanitize water in rural clinics and households for those who have a weak immune system.

Ensure environmental sustainability

Solar cookers save firewood that is now rare in many developing countries and contribute in this way to ensure the environmental sustainability. According to Tucker (1999), optimistic studies have estimated that solar cookers could replace 36 percent of the developing world's use of firewood.

Develop a global partnership for development

To create widespread access to solar cookers in developing countries, a beneficial participation of government, commercial and humanitarian sectors is necessary which complements broader local, national and international activities towards all of the MDGs.

2.8 Conclusion

This chapter aimed to provide an overview of Tanzania's energy situation, with particular focus on its household energy consumption. It is important to understand the role of household energy consumption in order to understand the motives for implementing Solar Cooking. It was shown that approximately 90 percent of Tanzania's households are using biomass for cooking and that only a few households have access to the regional electrical grid. The high biomass fuel consumption is accompanied by many disadvantages regarding the environment and people's lives. In order to overcome this, solar energy could provide a solution for the current energy situation.

Also, the chapter presented results of a study by Alfayo &Uiso (2002) which aimed to estimate the potential applicability of solar energy in Tanzania. The study showed that the solar radiation in Tanzania is sufficient to provide energy for domestic applications for the majority of Tanzanian families. This makes Tanzania in this way applicable for Solar Cooking. Furthermore, the chapter focused on the importance of energy and particularly on the importance of Solar Cooking for development.

CHAPTER 3: SOLAR COOKING

3.1 Introduction

Solar cookers are a crucial component of this study. Thus, in order to be able to gain a broader understanding of the results of this study, it is important to provide the reader with essential background information about the issue of Solar Cooking. The chapter will start by presenting a historical outline of Solar Cooking around the world and in Tanzania in particular, followed by an explanation of the operation of Solar Cooking. Additionally, different types of solar cookers will be presented. A special focus will be put on two different types of solar cookers, which are the solar box cooker and the parabolic concentrating solar cooker as these were the two models applied in the investigated projects.

3.2 History of Solar Cooking

The concept of Solar Cooking is not new and its application can be found worldwide. According to Kimambo (2007), the first reported solar cooker user was a Swiss man called Nicholas de Saussure (1740- 1799) who built a black insulated box cooker with several glass covers. De Saussure reported that he was able to successfully cook fruits even without the use of reflectors. On the African continent, the first reported solar cooker was used at the Cape of Good Hope in 1837 by an Englishman, John Fredrick Herchel. In 1869, the first book about solar energy, *Solar Energy and its Industrial Applications,* was published by Augustin Mouchot. Mouchot also designed and built solar cookers for French soldiers in Africa in 1877 (Wentzel & Pouris, 2007). But solar cookers had not only been developed in Europe and Africa; solar cookers were concurrently developed in Asia. In Bombay, an Englishman, William Adams carried out experiments on solar cookers in 1878. Adams' method was to use planar glass mirrors arranged in a shape of an inverted eight-sided pyramid that focused light through a cylindrical bell jar and into the food container. In America, Samuel Langel first used a box type cooker at Mount Whitney in California in 1884.

The Second World War, with its fuel shortages and rationing, led to an increased interest in solar energy after the war and as a potential area of investment (Lair, 2005 citied in Wentzel & Pouris, 2007: 6). In the 1950s and 1960s, most of the basic solar stoves designs were tried and disseminated, leading to increased public interest. Different happenings led to an increased attention to solar energy. One major event was the First World Symposium on Solar Energy in Tucson and Phoenix in 1954, where several solar cookers and ovens were exhibited (Telkes, 1959).

Furthermore, the oil crisis of the early 1970s contributed to the support of renewable energy sources. Last, but not least, the expanding populations in China and India had led to higher fuelwood consumption, encouraging government research on energy alternatives in the 1970s (Wentzel & Pouris, 2007).

In general, solar cooking technology has been continuously used and improved upon to make solar cookers more acceptable for the intended users during the 20th century. Several organisations are now working on the development and promotion of Solar Cooking in developing countries, as for example ULOG group Switzerland, EG Solar[7] in Germany and Solar Cookers International, which were all founded in the 1980s. Perhaps the most comprehensive study of Solar Cooking was conducted between 1996 and 2004 by the GTZ and the Department of Minerals and Energy (DME) in South Africa involving field testing of solar cookers and dissemination of the cookers (GTZ, 1999). Today, there are many more institutions and organisations involved in attempts to improve the efficiency and the social acceptance of solar cookers. It is difficult to find literature that estimates the number of solar cookers used globally today. However, a list of countries which have at least 1000 solar cookers was prepared by Nandwani (1996) and can be found in the Appendix II.

3.3 Solar Cooking in Tanzania

Solar Cooking has become increasingly popular in Tanzania in the past years. Geographically, Solar Cooking is especially popular in the dry central regions of Tanzania where fuel wood resources are completely exhausted in many places. The first type of solar cooker to be introduced was the box type solar cooker (Kimambo, 2007). According to Kimambo (2007), in Tanzania, some solar cookers are imported while some cookers are produced locally. There are different institutions which have been involved in the development and dissemination of solar cookers in Tanzania, for example, the University of Dar es Salaam; Tanzania Industrial Research and Development Organisation (TIRDO); Tanzania Traditional Energy Development Organization (TaTEDO); Enviro Care; the Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC); and also religious organisations such as the Anglican Church in Masasi. This last organisation is responsible for one of the projects analysed in this study.

[7] Entwicklungshilfe Gruppe Solarkocher der Staatlichen Berufsschule Altötting e.V.

3.4 Solar Cooking in general

A solar cooker, in principle, is a way of using the sun's power to cook (Chikuwa, 2008). The general principle behind Solar Cooking is sunlight is converted to heat energy that is then retained for cooking. In these terms, it can be assumed that the sunlight represents a type of "fuel" for the cooker. To use a solar cooker efficiently, it is important to locate the cooker in an outdoor location that is sunny for several consecutive hours, is protected from wind and where food is safe

3.5 Types of solar cookers

Globally, there are a wide variety of solar cookers designs[8]. According to Kimambo (2007), solar cooker designs can be divided into four main categories: solar box cookers, also known as sun ovens, panel cookers, collector cookers and concentrating, also known as reflector or parabolic cookers because of their parabolic shape. The following section presents a short description of the solar box cooker and the parabolic concentrating solar cooker designs since these were the two applied technologies in the studied projects.

3.5.1 Solar box cookers

The solar box cooker typically consists of an insulated container with a cover of either glass or transparent material in a single or several layers (Kristjansdottir, 2004) Short wave solar radiation is trapped inside the cooker and converted to heat (Konttinen, 1994 citied in Kristjansdottir 2004: 4). On the bottom of the solar cooker is an absorber plate. Heat is transferred into the cooking vessel from the bottom, top and the sides of the cooker box. To make the box cooker more efficient, it is important that black or dark surfaces are used for cooking since they get very hot in the sun due to high absorption of solar energy. This means that food cooks best in dark, thin metal pots. Additionally, a transparent heat trap around the dark pots let the sunlight in and keeps in the heat. For solar box cookers an insulated box with glass or plastic window is used which is shown in Figure 5.

[8] The study covers only direct solar cooker types since these were the ones used in the projects. There will be no explanations regarding indirect solar cooking systems

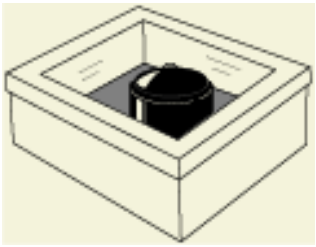

Figure 5 Insulated box with black pot and glass/ plastic window
Source: SCI (2008b)

According to Kimambo (2007), the solar box cooker is the most commonly used solar cooker type in developing countries because of its ease of construction and use. It can reach internal temperatures up to 180°C. Currently, there exist many different designs of solar box cookers but in general, solar box cookers can be divided into two main categories, based on the presence or absence of reflectors (SCI, 2009a). Box cookers with reflectors can be divided into five sub groups according to the number of reflectors used in the design. The first solar box cooker without reflectors was probably made by Nicholas de Saussure (1740- 1799), which was simply a black insulated box cooker with several glass covers. Many other versions of this type of box cooker were developed and modified over years.

However, it was realized that in order to make box cookers more efficient and reliable, reflectors had to be attached (SCI, 2009a). The first box cooker to include one reflector was probably the Gosh cooker, named after its inventor and which became popular all over the world. The Gosh cooker's design consists of a typical box- type cooker with a double glazed cover and a simple reflector. The Gosh design was improved and modified by different scientists over years, resulting in the emergence of many different variations of the cooker. One important variation was the incorporation of three holes in the glaze, with the purpose of making the handling of the cooking vessel easier (Grupp et al, 1991 citied in SCI, 2009a). Due to problems related to the effectiveness of the Gosh cooker during colder and cloudy days, box type cookers with double reflectors were developed. Agarwal was the first who added another reflector in 1981 (SCI, 2009a). His concept did not include any mechanisms for tilting, which is important for increasing cooker efficiency. However, even without the ability to tilt the reflectors, shorter cooking times were reported for the two-reflector design. After some time, variations of two-reflector solar box cooker were developed and further modified, including reflector tilting capabilities. But to further improve the performance of the cookers, it was necessary to develop three-reflector designs. Figure 6 presents the design of a three-reflector box cooker.

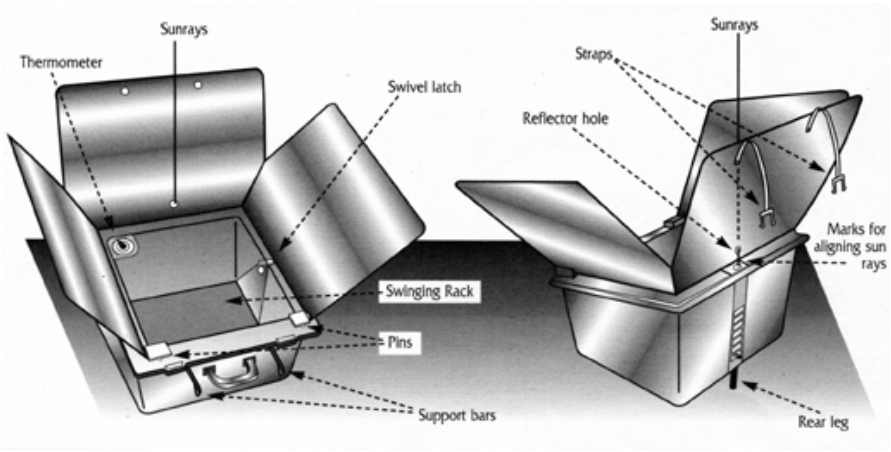

Figure 6 Solar box cooker design with three reflectors

Source: SCI (2009a)

In addition to the three-reflector solar box cooker, there were also attempts to develop a solar box cooker with four reflectors, but initial designs showed that the cooking time was not reduced by 25 percent as compared to a single mirror cooker (SCI, 2009a). A successful commercial four-reflector oven was developed by Sun Ovens International Inc., which is promoted as the "Global Sun Oven." This solar box cooker has been developed to meet up to 70 percent of the needs of a six to eight person family in a developing country (Sun Oven, 2008a). Figure 7 presents the" Global Sun Oven". In addition to the "Global Sun Oven," Sun Oven International Inc. promotes also a village-sized sun oven called "Villager Sun Oven," which was designed for communities that require a higher volume of cooking (Sun Oven, 2008b). The design of a Villager Sun Oven is shown in Figure 8.

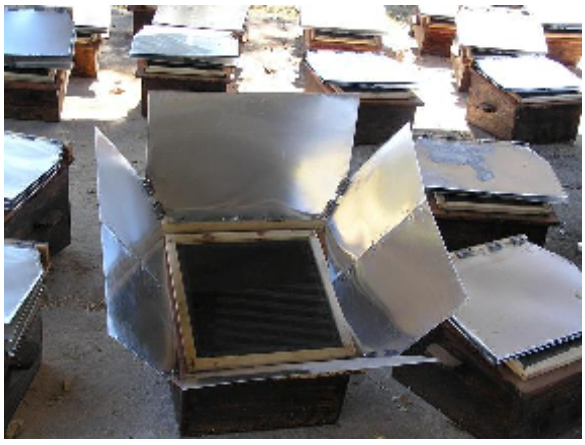

Figure 7 Global Sun Oven

Source: Pia Otte, (2008)

Figure 8 Villager Sun Oven

Source: Pia Otte, (2008)

3.5.2 Parabolic concentrating solar cookers

The name of the parabolic concentrating solar cooker comes from its parabolic (dish) shape. Parabolic concentrating solar cookers have a high efficiency (Kristjansdottir, 2004). The parabolic cooker concentrates direct solar radiation into a focus point. The cooking pot is then placed in the focal point. Due to the use of mirrors and/or lenses, the parabolic cooker can reach temperatures up to 250°C which is much higher than the temperatures reached with a box cooker (180 C) (GTZ, 2007). Additionally, the parabolic concentrating solar cooker has a short heat-up time. The parabolic cooker is usually constructed of aluminium or steel and can differ in its sizes and applications. Larger types of cooker can cook food for about 20 people (PDC 2002 citied in Kristjansdottir 2004: 17). Figure 9 shows a typical design of a parabolic solar concentrating cooker.

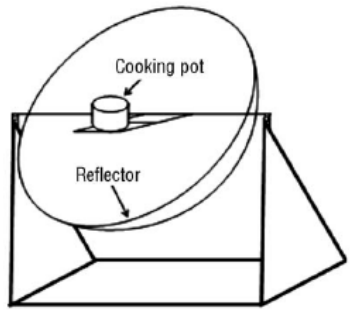

Figure 9 Domestic-size parabolic solar concentrating cooker
Source: Kaushik & Gupta (2008)

Parabolic concentrating solar cookers can be distinguished by the different types as well as their target group. Community-size solar cooker and domestic-size solar cookers are available. The community-size solar cooker is a system which enables Solar Cooking inside the house. An example of a community size parabolic cooker is the *Fix Focus Parabolic Reflector for Community Kitchens* which was developed by Wolfgang Scheffler (Solare Brücke, 2009). The Scheffler Community Kitchen uses large parabolic dishes to heat a stove inside the building through a hole in the external wall[9]. According to Chikuwa (2008), the first system was built in 1986 while today the cooker is mainly used in India and Africa.

However, the focus of this study is more on domestic parabolic solar cookers since these models were applied in two of the undertaken projects. One widely applied type of parabolic solar cooker is the SK 14, developed by Dr. Ing. Dieter Siefert. The SK 14 is used by Solar

[9] This type of solar cooker differs to the cookers applied in the projects since it includes an option of thermal energy storage

EG, a German charitable organisation, and other organisations. It has a diameter of 1400 mm and a performance of up to 700 Watt (EG-Solar, 2007). The cooker can cook for up to 20 people when a 12 litre pot is used. The dish has to be moved every 15- 20 minutes to realign with the sun's position. (EG- Solar, 2009). Figure 10 shows one SK 14 model of parabolic concentrating solar cookers.

Figure 10 Solar parabolic concentrating cooker SK 14
Source: Pia Otte (2008)

3.5.3 Comparison of the two solar cookers

Both cooker types are characterized by several advantages and disadvantages which play an important role for the successful implementation of the cookers. The solar parabolic concentrating cooker has the advantage over the boxer cooker that it reaches higher cooking temperatures due to the use of lenses or mirrors. In addition, the parabolic cooker has shorter heat up times. Tests regarding the duration of the heating time for water confirm the arguments that the parabolic solar concentrating cooker is more efficient. Table 1 shows that heating water from a temperature of 40°C to 80°C takes around 27 minutes with the parabolic solar cooker while the box cooker takes around 48 minutes. The cooking duration for beans, a typical dish in Tanzania varies enormously between the two cooker types. The parabolic concentrating cooker takes around three to four hours, whereas the box cooker prepares the beans between five and eight hours.

There are also differences in the heat losses experienced in each of the two solar cooker types. The box cooker loses heat approximately three times more quickly than the parabolic solar concentrating cooker. Furthermore, the cookers vary in their application: while the box cooker

is appropriate for a family, the parabolic solar concentrating cooker is able to cook greater quantities for large families and institutions.

Selected results	**Parabolic Concentrator cooker (Type SK 12)**	**Conductive box cooker**
Dimension cooking position	143x 163x 125 (cm)	88x 101.5x 96 (cm)
Heating time for water from cold start (40- 80°C)	27 min	48 min
Heating time for water from cold start (40- 96 °C)	38 min	66 min
Max. temperature	198°C after 130 minutes	147 °C after 130 minutes
Heat loss with lid open	Cools from boiling temperature to 83°C in 15 min	Cools from boiling temperature to 83°C in 5 min
Cooking duration for beans 10	3- 4h	5- 8h
Application	Cooker for large family, small institutions	Family size cooker

Table 1 Efficiency comparison SK 12 and box cooker

Source: Table is modified after Biermann et. al. (1999)

On the other hand, the parabolic cookers have the disadvantage that it takes a lot of space. Table 1 shows that box the parabolic concentrator and the box cooker types vary in their size. The parabolic cooker with a dimension of 143x 163x 125 cm is relatively big in comparison to the box cooker with a dimension of 88x 101.5x 96 cm.

A further disadvantage of the parabolic concentrating solar cooker is that it is very sensitive for wind and that it has to be tracked more frequently than the box cooker. In addition, the cooker can hurt eyes; cause burns and is expensive (GTZ, 2007). According to GTZ (2007) a parabolic solar cooker is more difficult to build and even if it is possible to produce it locally, it is often necessary to import parts. Further the user has to be careful when cleaning the cooker. If the reflector surface is scratched or dented the effectiveness of the cooker is limited (Kristjansdottir, 2004).

The opinions regarding which cooker type is more appropriate for developing countries differ between researchers and organizations. For example, Ibragim and El- Reidy, who tested a solar box cooker in Egypt, claim that the box cooker is the more promising solution due to its low cost and ease of construction from locally available materials (Ibrahim & El- Reidy, 1995). On the other side, there are organizations that promote different types of the parabolic reflecting solar cooker such as for instance EG Solar e.V. or Solare Brücke e.V. The presented advantages and disadvantages of the two technologies are summarized in Table 2.

[10] Laiser & Bura (1999:237) The type of solar parabolic cooker which was tested was a SK 14 but the results can be assumed to be similar to the SK 12

Solar box cooker		Parabolic solar cooker	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Does not require high tracking	Reaches lower temperature of up to 180°C	Reaches high temperatures of up to 250°C and high performance (up to 700 Watt)	Tracked frequently
Very easy and safe to use	Long heat up time, slow cooking	Short heat up time	Dangerous to use (can burn eyes, cause burns)
			Difficult to clean
Affordable			Expensive
Local production is feasible (locally available materials are used)			Difficult to produce locally, parts have to be imported
			Very sensitive to wind

Table 2 Comparison solar box cooker and parabolic concentrating solar cooker

3.6 Conclusion

This chapter aimed to give a Solar Cooking background for this study. In the subsequent chapters, different solar cooking projects will be analysed. In order to be able to follow up with these chapters, it was important to give to the reader a short background about Solar Cooking, its history, with a focus on Tanzania and its technology. Two types of direct solar cookers were more detailed explained since they present the applied technology in the research projects. The chapter showed that these two solar cooking technologies comprise different advantages and disadvantages in terms of performance, user friendliness, range of applications and a feasible local production. The next chapter will introduce the theoretical background for this study.

CHAPTER 4: THEORETICAL FRAMEWORK

4.1 Introduction

According to Mikkelsen (2005) the use of theories is important for the research process since it provides the researcher with concepts, basic assumptions and direct the researcher to the important questions. For the analysis of the research objectives, two core theories were applied which frame the background for my investigations. In order to identify and assess the factors which enable/ limit solar cooking projects the Theory of Innovation Diffusion was applied. In addition, concepts from an article about identifying the market barriers to clean cooking fuels in Sub- Saharan Africa by Schlag & Zuzarte (2008) was used that helped in developing an analytical framework. Furthermore, the impacts of Solar Cooking on people's lives were analysed in view of the Capability Approach by Amartya Sen.

The chapter will begin by mapping the major trends of development theories in order to enable the understanding of the underlying reasons which led to the creation of the Capability Approach. Furthermore, the major concepts of the Capability Approach will be explained and discussed in the context of Solar Cooking. In addition, the Theory of Innovation will be introduced and analysed in order to assess and identify the influencing factors on the diffusion of Solar Cooking. Special focus will be laid within this theory on the adoption perspective mainly claimed by Rogers.

4.2 Development Theories

The term development has carried different meanings over time. In its present sense the term emerged for the first time during the post war era (Nederveen Pieterse, 2001). In the 1950s development was understood as economic growth- as defined by the modernization theory. It was taken for granted that all nations pass through the same five stages of economic development the so called Rostow´s Stages of Growth (Rostow, 1990). In this way it was assumed that developing countries would follow the same stages that European countries went through decades ago. These stages comprise a transformation from a traditional society characterised by a strong dependency on the agricultural sector and the use of traditional means of production to an age of high mass- consumption with a modern industrial society with a high income and productivity rates achieved through the use of modern technology.

History has shown that the concept of modernization theory and its classical understanding of development as catching up with the advanced (developed) countries did not succeed.

Modernization did not seem attractive any longer because of different reasons such as for example ecological problems and the consequences of technological changes.

With the understanding of Alternative Development in the 1970s the focus of development for the first time shifted to social and community development. The concept of Alternative Development emphasised for the first time on people's agency in the sense of people's capacity to effect social change (Nederveen Pieterse, 2001).

In the mid 1980s with the movement of Human Development an understanding of development as capacitation came up which followed Amartya Sen´s work on capacities and entitlements. Development in Sen´s approach is defined as a process of expanding people's choices. Sen´s definition of Human Development was taken up by the Human Development Report in 1990 which defines development as the enlargement of people's choices. *"Human development is a process of enhancing human capabilities- to expand choices and opportunities so that each person can lead a life of respect and value."* (UNDP, 2000:2) Over the years the Human Development concept has been applied to a systematic study of global themes comprising several topics as for example Human Rights, the Millennium Development Goals and recently Human Development in the context of climate change (UNDP, 2007).

4.3 Capability Approach

The Capability Approach is a theoretical perspective pioneered by Amartya Sen and recently further developed by Martha Nussbaum and a number of other researchers as Ingrid Robeyns and Sabina Alkire who applied the Capability Approach in an empirical and theoretical analysis. The Capability Approach arose from a dissatisfaction with current welfare economic approaches which were focusing in their measurement of welfare on the growth of the national product, the rise of personal incomes, or industrialization (Sen, 1999).

In comparison, the Capability Approach focuses on expanding people's real freedoms and has a strong emphasis on people's "agency". The idea behind it is a picture of people as agents who have their own goals and make their own choices (Gasper, 2007). Development in this approach is seen as an expansion of capabilities. It is important that people have the freedom to live the kind of lives they want to live, to do what they want to do and be the person they want to be (Sen, 1999). The central statement is that policies should focus on what people are able to do and to be, their quality of their life, and the removing of obstacles in their lives so that they gain more freedom to live the kind of life they want to live. Once individuals have

these opportunities, they can choose the options that they value most. Robeyns (2005) illustrates this by arguing that every person should have the opportunity to be a part of the community and to practice a religion and if someone prefers to be a hermit or an atheist, he or she should also have this option (Robeyns, 2005). In addition, Robeyns (2005) argues that the Capability Approach can not be understood as a theory which can explain social terms as for instance poverty. Rather it provides a tool which conceptualizes and evaluates such issues.

An important distinction in the Capability Approach is the distinction between the means (goods and services), functionings and capabilities. A 'mean' is defined as something that has certain characteristics, which makes it of interest to people. These characteristics of goods and services enable a functioning. 'Functionings' are `beings and doings` such as for example being nourished being confident, or taking part in a group decision (Alkire, 2002). According to Sen there is no definitive list of basic functionings because different sets will be relevant to different groups in distinct settings. The focus on functionings in the evaluation of well- being distinguishes the Capability Approach from other approaches which evaluate well- being for example in the space of utility or in terms of income per capita.

Another important term in the capability framework is 'achieved functionings'. Achieved functionings are the particular functionings a person has successfully pursued and realized. Alkire (2002) claims that assessing Human Development with a focus on achieved functionings alone is not complete. In order to make the approach complete the introduction of the concepts of capabilities is necessary. 'Capability' reflects the ability of a person to achieve a given functioning (doing or being). According to Sen (1993) the capability of a person reflects the alternative combinations of functionings a person can achieve, and from which she or he can choose. This means that capabilities are people's potential functionings. But what is now exactly the difference between a functioning and capability? Robeyns (2003) make the difference between a functioning and a capability more clear in the following quotation. She argues that *"The difference between a functioning and a capability is similar to the difference between an achievement and the freedom to achieve something, or between an outcome and an opportunity"* (Robeyns, 2003:63).

However, according to Tjelta (2005) the term capability comprises multiple types of freedoms and not all capabilities are equally important. In addition, one can talk about elementary and more complex capabilities. Elementary capabilities in the context of poverty can be understood as "the ability to avoid undernourishment and related morbidity and mortality". On the other hand, complex capabilities can comprise more sophisticated social capabilities as

for example taking part in the life of the community and achieving self- respect (Tjelta, 2005). An important term of the Capability Approach is the Capability Set. 'Capability Set' describes a set of attainable functionings a person can achieve. According to Clark (2005) it is likely for a person to choose between different capabilities. The capabilities represent person's real opportunities or positive freedom of choice. Robeyns developed a Capability Model which is presented in Figure 11. The figure shows that the relation between means (Goods and Services) and achieved functionings is influenced by three different conversion factors.

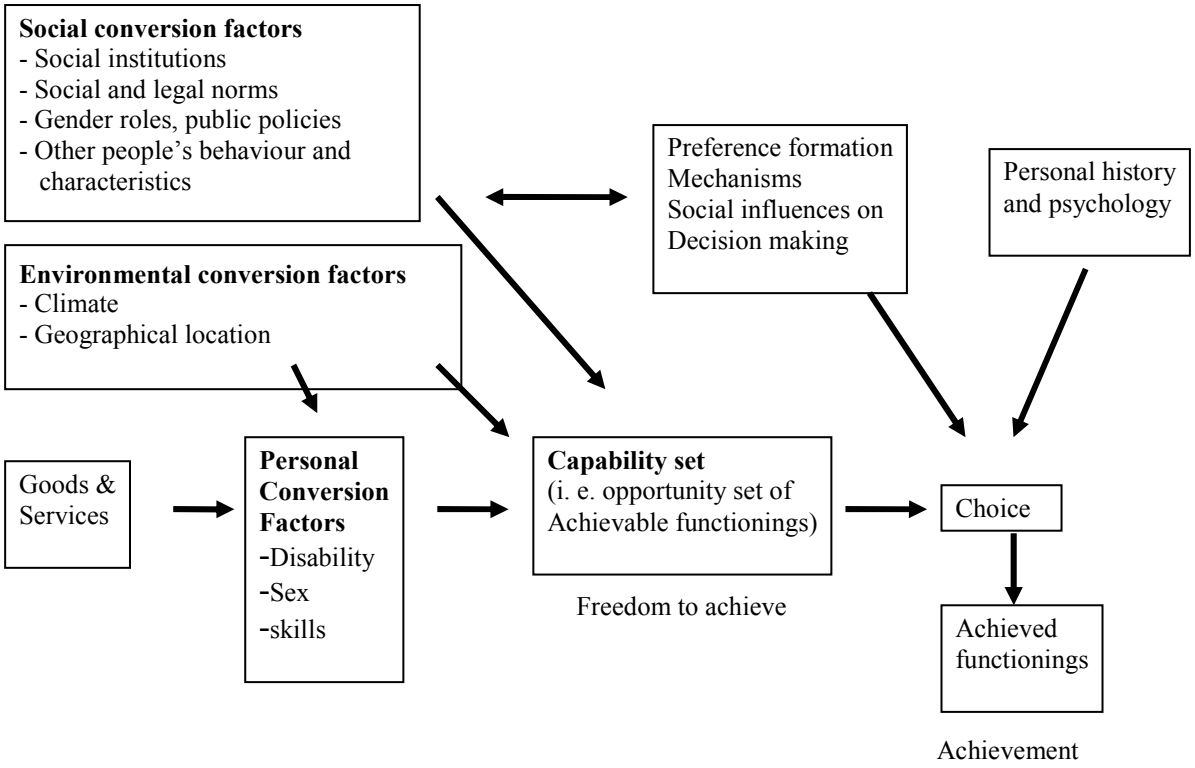

Figure 11 Capablity Model

Source: Robeyns (2005)

The three conversion factors comprise the *personal conversion factors* (e.g. physical condition, sex, reading skills etc.), *social conversion factors* (e.g. public policies, social norms, gender roles, power relations), and *environmental conversion factors* (e.g. climate, geographical location). According to Robeyns (2005), these three conversion factors play an important role in the conversion from characteristics of goods to an individual functioning. In addition, Figure 11 shows that besides the conversion factors, there are special circumstances such as for example the personal history and psychology which can influence the choices that people make from the capability set.

The model is exemplified in Robeyns (2005) in the following way. Let us assume that we have a bike. A bike is a good which has a certain interest for people because it can transport people from one to another place and is faster than walking. This means that a bike enables the functioning of mobility, to be able to move yourself freely and more rapidly than walking (Robeyns, 2005). In addition, we assume that all conversion factors contribute in a positive way to the usage of a bike. This means for example that the person is in a physical healthy condition *(personal conversion factor)* to use a bike. In addition, the geographical location as for instance the existence of bike roads *(environmental conversion factors)* allows the usage of a bike. Besides these factors, public policies *(social conversion factors)* promote the usage of a bike as a mean of transport which contributes positive to the person's decision to use a bike. This means that the conversion factors contribute to the use of the good (bike) to enable a functioning (faster mobility). But besides the conversion factors, there are still other circumstances which function as inputs in the creation or expansion of capabilities. For instance, personal history can play an important role- if a person has any negative experience with cycling maybe from his/ her childhood, he or she can still choose not to cycle even though all of the conversion factors influence the good (bike) and its functioning (faster mobility) in a positive way.

4.3.1 Criticism

The Capability Approach has also been criticised from several different angles. The critiques vary from concerns which claim that the approach does not pay adequate attention to forces of power and societal structures, to allegations of excessive individualism and encouragement of partneralism (Tjelta, 2005). In addition, major criticism is related to the issue of how far Sen´s framework is operational and measurable. How can we identify valuable capabilities? (Clark, 2005) The most well-known contributed approach to identify the capabilities can be found in the writing of Martha Nussbaum. Her approach differs from Sen´s in several aspects. The most notable one is that she unlike Sen developed a list of central human capabilities. The headings of the last version of the list were: life, bodily health, bodily integrity, senses, imagination and thought, emotions, practical reason, affiliation, other species, play and political and material control over one's environment (Clark, 2005). Nussbaum has always claimed that her list needs further elaboration and adaptation by context but still it is a list that she defends as universally valid (Robeyns, 2005). Comparing the most recent lists with the original one, shows that the core categories have not changed over time (Clark, 2005). Furthermore, the list is highly abstracted and for each country or community it can be made more specific. Sen argued against this list. He claims that it is not right to develop a universal

list of capabilities since this is used for different purposes each of which need their own list (Robeyns, 2005). This study is more related to the contribution of Amartya Sen since it allows the development of a context related list of capabilities.

4.3.2 The application of Sen´s Capability Approach in context of Solar Cooking

The section so far has given a short overview of the important concepts within the Capability Approach. The question now is how can this approach be applied for Solar Cooking? As mentioned before a good has certain characteristics which make it of interest to people. These characteristics enable a functioning. It is assumed that solar cookers may imply numerous advantages like better health, more time, physical health, energy saving etc. According to the Capability Approach this means that people's interest in solar cookers is not because it is an object made from certain materials rather because of its advantages. In addition, the relation between a good (here solar cooker) and the functionings to achieve certain beings and doings is influenced by different conversion factors.

First it is influenced by *personal conversion factors* which could be sex, skills or even disability which influence how a person can convert the characteristics of a solar cooker into a functioning. If, for example a person does not know how to use a solar cooker, then the solar cooker will be of limited help to enable different functionings of Solar Cooking. Second, *social conversion factors* play an important role. If norms or values of the social culture do not allow the use of solar cookers, the solar cooker will be of limited help to enable the functionings. Third, the *environmental conversion factors* can influence the conversion of the characteristics of a Solar Cooking into a functioning. If the geographical location is not appropriate for Solar Cooking, or if solar cookers are not available in a specific area, it will again be of limited help. On the other hand, a lack of other energy sources such as for example wood or charcoal can lead to an increased use of solar cookers in that area. In this case the environmental conversion factor *"lack of fuel"* would contribute to enable different functionings.

It was shown in the previous paragraph that the use of solar cookers may imply different advantages which make a solar cooker for people of a certain interest. The focus of this study is on these advantages within the Capability Approach and in which way these advantages are converted into functionings. According to Robeyns(2005) the Capability Approach has an unspecified character which leads to a need for specification before it can be applied. In order

to specify the approach it is necessary to develop a list of relevant capabilities. Due to this necessity a set of capabilities was defined.

The selection of this capability set is based on different sources. The selection is to a large extent based on a comparative field study about Solar Cooking between 1996 and 2004 in South Africa which was initiated by the Department of Minerals and Energy (DME) and the GTZ and based on arguments by Solar Cookers International that Solar Cooking helps in achieving the UN Millennium Development Goals. In addition, the selection was also based on an article by Ingrid Robeyns (2003) who applied the Capability Approach to conceptualize gender inequality. In the following sections the selected capabilities and the reasoning behind their selection are presented.

4.3.2.1 Time savings

Ahmad (2001) writes that Solar Cooking is less flexible with regard to cooking procedure and time compared to traditional cooking since different factors have to be considered like the weather and the time interval between start of Solar Cooking and meal time. On the other hand, there is a time saving aspect assumed. Ahmad (2001) claims that the food cooked with a solar cooker, cooks more or less by itself and does not require permanent attendance. The same effect was reported in a comparative field study about Solar Cooking in 1996 in South Africa by the Department of Minerals and Energy (DME) and the GTZ (Wentzel & Pouris, 2007). In this study two different kinds of time savings were assumed, namely:

- Time saving which results from the reduction of wood gathering
- Potential time savings in the actual cooking process

The study investigates in which way Solar Cooking leads to an increase of freedom in the time use of its users. It is to be acknowledged that it is the time of women which is regarded here since they are the ones mainly involved in the cooking process.

4.3.2.2 Physical Health

The dimension of physical health comprises the fact of being able to live a life of normal length in good health (Robeyns, 2003). Traditional ways of cooking are considered to damage people's health, especially through respiratory diseases from indoor air pollution (UN, 2005a). In addition, the collection of fuelwood can lead to serious long term physical damage (IEA, 2006). The study investigates the ways in which Solar Cooking contributes to a healthier life[11]

[11] Particularly of women and children

since it does not require the collection of fuelwood and it helps to prepare food without producing smoke (SCI, 2009b).

4.3.2.3 Income generating activities

Solar Cooking can have an impact on household economy but the degree of the impact depends on the organisation of the household economy and to the extent to which the household is linked to the wider economic network (Wentzel &Pouris, 2007). The field study about Solar Cooking in South Africa by the Department of Minerals and Energy (DME) and the GTZ between 1996 and 2004 showed that savings could be achieved through Solar Cooking. In addition other economic benefits could be observed including increased labour activity. The study investigates the various ways in which way Solar Cooking can have an income generating function. Examples for earlier income generating activities with solar cookers were reported during the solar cooking field test in South Africa. Here the solar cookers were placed at a tavern in Huhudi. The cooker was used to prepare food which was sold in the Tavern. The use of the solar cooker for preparing food as opposed to normal firewood led to a saving of money.

4.3.2.4 Leisure activities

Leisure activities combine activities such as watching TV, reading, walking, doing sports etc. According to Robeyns (2003) these activities are important in terms of relaxation, creativity and are important aspects of individual well- being. The study investigates how solar cookers help facilitate an increase in leisure activities.

4.3.2.5 Political Participation

Solar cookers do not need firewood or charcoal which removes the necessity for girls and women to spend time in collecting wood. Therefore the argument is that the time which is not used anymore for gathering firewood can be used to taking active part in political decision making (SCI, 2009b). The study investigates ways in which Solar Cooking leads to an increase in political participation.

4.3.2.6 Education

One of the eight Millennium Development Goals by the UN is the achievement of universal primary education by 2015. According to UN (2008a), the total number of children of primary school age who were out of school dropped from 103 million in 1999 to 73 million in 2006. However, in Sub- Saharan Africa 38 million children of primary school age are still not enrolled in school (UN, 2008). In addition, the costs for fuelwood have increased in Sub Saharan Africa which means that the expenses for energy get higher and less money is

available for school fees or material. Solar cookers are considered to lead to savings of fuelwood which enable families to save money for school expenses and prevent children from collecting fuelwood (SCI, 2009b). The study investigates how Solar Cooking contributes to an increase in education.

4.3.2.7 Social relations

According to Robeyns (2003) social relations combine two major aspects the social network and the social support. Social network is the number of people a person has in his/her network, the frequency of contacting them and group membership. The dimension of social support is related to the type and amount of support someone receives. The study investigates ways in which Solar Cooking contributes to an increase in social relations.

The section presented how the Capability Approach can be a tool in identifying people's impacts of Solar Cooking. Figure 12 presents the applied Capability Approach related to Solar Cooking according to the framework by Robeyns (2005) presented before in Figure 11. The dashed boxes in the figure represent the dimensions I intend to analyse in this study.

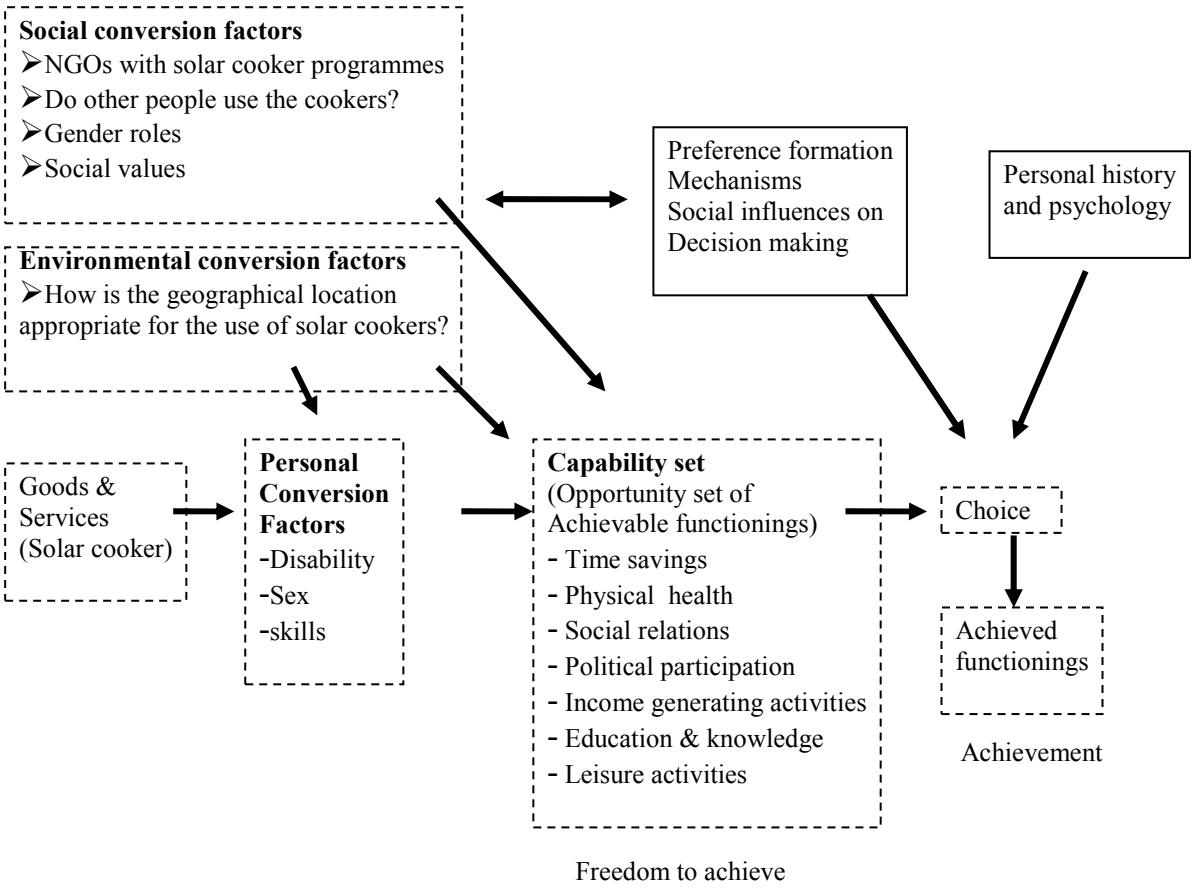

Figure 12 The Capability Approach applied for Solar Cooking

Source: Developed framework based on Robeyns (2005)

4.4 Innovation Diffusion Theory

Innovation Diffusion is not a new concept. According to Rogers (2003) research on Innovation Diffusion started in various different disciplines already as early as the 1940s and 1950s. Today, work on diffusion has achieved a prominent position and is widely used to analyse the transmission of epidemics like the diffusion of HIV/AIDS (Mayhew, 2004).

Diffusion of an innovation has traditionally been defined as the process by which innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003). The diffusion process is characterized by four key elements which are innovation, channels of communication, time and the social system. ***Innovation*** has been defined differently by different people. Feder defines innovation as technological factors which can change the production (Haavik, 2003). According to Rogers (2003) the term innovation is not limited on its technological aspect rather it can be any idea or object which is perceived as new by members of a social system. ***Communication*** is the way by which the information is transmitted to or within the social system (Mass media, TV, newspaper or face-to- face transmission). ***Time*** is related to the time in which the innovation is diffused or the relative speed with which it is adopted by members. The ***social system*** comprises individuals, organizations, agencies that share a common "culture". According to Rogers (2003) the social structure of the system affects the innovation's diffusion in several ways.

Diffusion research investigates how these major factors and a multitude of other factors, interact to facilitate or impede the adoption of a specific product or practice among members of a particular adopter group. Rogers (2003) claims that most research has been conducted with regard to the diffusion process. Diffusion Innovation has in general enabled the understanding of how innovations cause changes in a social system and on the other side how social forces shape innovation and their proliferation.

4.4.1 Directions within Innovation Diffusion

Within the field of geography Innovation Diffusion has been of special interest for several decades. *"The spread of a phenomenon, idea or technique throughout a population or region incorporates basic geographic elements of distance, direction and spatial variation, and thus forms a valid field of geographic interest"* (Brown, 1981:16). Traditionally innovation diffusion has been characterised within geography by two main directions which can be traced back to Torsten Hägerstrand and Carl O. Sauer (Jones 1980, Löfgren, 1997 citied in Haavik, 2003: 54)

Hägerstrand presents with his model of diffusion (1968) the basic principles for studies regarding diffusion and acceptance. Hägerstrand´s model comprises the existence of a mean information field which regulates the flows of information around a regional system. The model can be characterised as micro oriented and with a short time horizon (Mayhew, 2004). The flows are moderated by barriers and filters. Barriers can be of physical, cultural and/or socio economical origin and can limit the development of information into innovation (Haavik, 2003). Filters comprise permeable and semi permeable barriers as for example mass media. Hägerstrand focuses on innovation progress as a spatial process. Less focus is on the social aspects of the innovation process which is also one of the weaknesses of his approach. Information can not be regarded as an independent variable. Diffusion of Innovations has to be considered within a cultural context where communication is affected by socio-economic structures (Fløysand (1993:6) citied in Haavik (2003:55)). This implies that contextual factors must be taken into consideration when studying innovation processes. Hägerstrand's work mainly had an impact on economic urban geography and was primarily more concerned with location and locational process rather than landscape (Haavik, 2003).

The second direction in Innovation Diffusion is presented by Carl O. Sauer. Sauer's discourse has adopted some of the cultural and natural geographical conditions that were not included in Hägerstrand's framework of innovation diffusion. Sauer's approach is rather macro oriented. Sauer argues that the contribution to diffusion in geography is seen in reconstructing diffusion pathways and tries to evaluate the influence of barriers (Haavik, 2003). He focuses on the innovation's origin and spreading in a longer time horizon than Hägerstrand (Haavik, 2003) On the basis of registered spatial distributions Sauer drew conclusions about the factors that affect the origin and the way of spreading for specific innovations (Jones 1980; Löfgren 1997 citied in Haavik, 2003).

According to McEachern & Hanson (2008) understandings of diffusion process have generally focused on two different perspectives within the diffusion process which are the adoption perspective mainly supported by Torsten Hägerstrand (1965) and Everett Rogers (1995) and the market and infrastructure perspective mainly presented and advanced by Brown (1981, 1999). While the market perspective focuses more on the demand side of innovation diffusion, the adoption perspectives looks at society as comprising individuals with free will where everyone has the same potential to adopt an innovation. In the following section these two perspectives will be shortly presented, though the adoption perspective is chosen for this study.

4.4.1.1 Market and infrastructure perspective

The main focus of the market and infrastructure perspective is on the supply side of Innovation Diffusion. It is assumed that not all individuals have an equal opportunity to adopt an innovation. The approach therefore emphasizes on the process by which innovations and the conditions for adoption are made available to individuals or households. Brown (1981) argues that the focus is on the supply aspect of diffusion.

In comparison to the adoption perspective, individual behaviour is not understood as a free will rather it presents choices within a constraint set which the government and private institutions establish and control. This leads to the conclusion that the focus of this direction within Innovation Diffusion is more an *institutional* rather than an *individual* perspective. Recognizing the supply side of diffusion shifts the attention from the adopter to the diffusion agency (Brown, 1981). The location of these agencies provides the general outline of the spatial pattern of diffusion since it determines where and when the innovation will be available. In addition, Brown (1981) claims that the operating modus of each agency creates differing levels of access to an innovation depending on the potential adopter's economic, locational, social and demographic characteristics. Furthermore, he argues that the establishment of diffusion agencies and the operating procedures of each agency are aspects of marketing the innovation. The marketing of an innovation comprises the development and utilization of infrastructure. In this way the structure of public infrastructure as for example, information or transportation have a strong influence on the rate and spatial patterning of diffusion. In this way the diffusion is shaped by the *market and infrastructure context of innovation adoption and diffusion* (Brown, 1981).

4.4.1.2 The adoption perspective

The adoption perspective assumes that individuals in a social system do not all adopt an innovation at the same time. Individuals are assumed to adopt innovations in a sequence over-time which makes it possible to classify them into adopter categories on the basis of when they first begin using a new idea (Rogers, 2003). Communication through mass media is regarded as an effective way of creating awareness of an innovation in society while interpersonal communication with previous adopters affects attitudes towards new ideas. In Hägerstrand´s view the adoption of an innovation is primarily the outcome of a learning or communication process (Brown, 1981). In this way the identification of the spatial characteristics of information flows and resistance to adoption is a crucial phenomenon to examine.

4.4.2 Criticism

The Theory of Innovation Diffusion has been criticized from different angles. McEachern & Hanson (2008) have criticised that understandings of Innovation Diffusion have tended to focus either on the adoption perspective (which focuses on the characteristics of the individual) or the market infrastructure perspective (which emphasizes the institutional context) instead of developing a complementary approach. In addition, within the adoption perspective of Innovation Diffusion much criticism has been remarked regarding its pro-innovation bias. Pro- innovation bias- the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system- includes that it should be diffused more rapidly and that it should neither be re- invented nor rejected (Rogers, 2003). According to Rogers (2003) pro- innovation bias is often assumed and implied in diffusion research. The lack of awareness of the pro- innovation bias makes it potentially dangerous in an intellectual sense.

4.4.3 Innovation Diffusion and Solar Cooking

In order to structure and find adequate answers for identifying the factors which limit or enable the successful implementation of solar cooking projects, an analytical framework was developed. The framework is partly based on concepts of the adoption perspective within Innovation Diffusion Theory (mainly by Rogers), an article by Troncoso, et al. (2007), Wareham (1997) and an analysis by Schlag and Zuzarte (2008) which identified market barriers to clean cooking fuels in Sub- Saharan Africa. It was explained that an innovation is defined as an idea, practice or object that it is perceived as new to an individual or another unit of adoption (Rogers, 2003). Solar cookers are in this way an innovation since they can be perceived as a new technology to a population in a certain area for cooking food. According to Rogers (2003), an innovation is always developed out of the recognition of a problem or a need, which stimulates one to create a solution to solve a problem or special need. As said in CHAPTER 2 negative environmental, economic and health reasons due to the use of traditional cooking methods led to the development of Solar Cooking.

4.4.3.1 The Innovation- Decision Process

One of the research objectives of this study is related to the factors which influence people's choice of cooking with a solar cooker. The basic understanding of how people decide to adopt a new innovation as, for instance, a solar cooker is based on Roger's Model of Innovation-Decision Process. Rogers (2003) claims that the process of innovation- decision consists of a series of choices and actions over time through which an individual decides whether or not to apply the innovation further in the process (Rogers, 2003). An individual's decision about an

innovation is in this framework not regarded as an instantaneous process. Rather, it is a process that occurs over time and which persists over time. In this way a model of the Innovation- Decision Process was developed which consists of a series of different actions. According to Haider & Kreps (2004) the understanding of the Innovation- Decision Process is essential to maximize the scope of diffusion and the rate of adoption of an innovation.

The following part will present the sequential stages of this model and relate it to Solar Cooking. The innovation decision model consists of five different stages. The first stage is ***knowledge***. According to Rogers (2003) knowledge occurs when an individual (or another decision- making unit) is exposed to an innovation's existence and understanding of its functioning. Rogers (2003) distinguishes between three different types of knowledge which comprise *awareness-knowledge, how- to knowledge* and *principles- knowledge.* The first type *awareness-knowledge* includes the information that an innovation exists. In the case of Solar Cooking, this comprises campaigns which make people in a particular region aware of the existence of Solar Cooking. *How- to knowledge* presents the information necessary to use an innovation in the right way. In terms of Solar Cooking, workshops and trainings are needed to teach people how to use the technology. The third type of knowledge which is *principles-knowledge* comprises information dealing with the functioning principles of how an innovation works. In the context of Solar Cooking, this includes knowledge about basic physical laws, in order to understand that a solar cooker has to be moved towards the sun's rays.

The second stage in the Innovation- Decision Process is the ***persuasion*** stage. In this stage the individual forms a favourable or unfavourable attitude toward an innovation (Rogers, 2003). At this stage the individual seeks for information about the new idea. An individual usually wants answers to questions like "What are the innovation's advantages and disadvantages in my situation?" The outcome of this persuasion stage is either a favourable or unfavourable attitude to the innovation. In terms of Solar Cooking this could comprise advantages of Solar Cooking such as its positive health factor because it is smoke-free or the fact that it saves fuelwood, all of which result in people developing a positive attitude towards Solar Cooking.

The third step of the innovation process is the ***decision*** stage. This stage comprises the engagement in activities that lead to a choice to adopt or reject an innovation by an individual (or another decision- making unit). In terms of Solar Cooking this can comprises the active participation of potential users in solar cooking workshops/projects where people learn to prepare food with a solar cooker.

The fourth stage is the ***implementation*** stage which takes place when an individual (or another decision- making unit) puts an innovation to use. This stage includes the active use of an innovation. According to Rogers (2003) the decision for an individual to adopt a new idea and the actual use of an innovation are two different issues. This means that the single decision to use a solar cooker does not mean that a solar cooker is implemented. Ahmad (2001) reports about a solar cooker programme in Gujarat in India where households obtained solar cookers which have been stored under beds or storage rooms.

The last stage in the innovation diffusion process presents the ***Confirmation*** stage. In this stage the individual (or other decision- making unit) seeks reinforcement for the innovation-decision previously made. According to Rogers (2003) it can happen that an individual reverse the decision if it is exposed to conflicting messages about the innovation. In the perspective of Solar Cooking, negative messages about solar cooking technologies by the social network could reverse the decision of a solar cooker user and lead to a disuse of the cooker. Figure 13 presents the Model of Innovation- Decision Process according to Rogers.

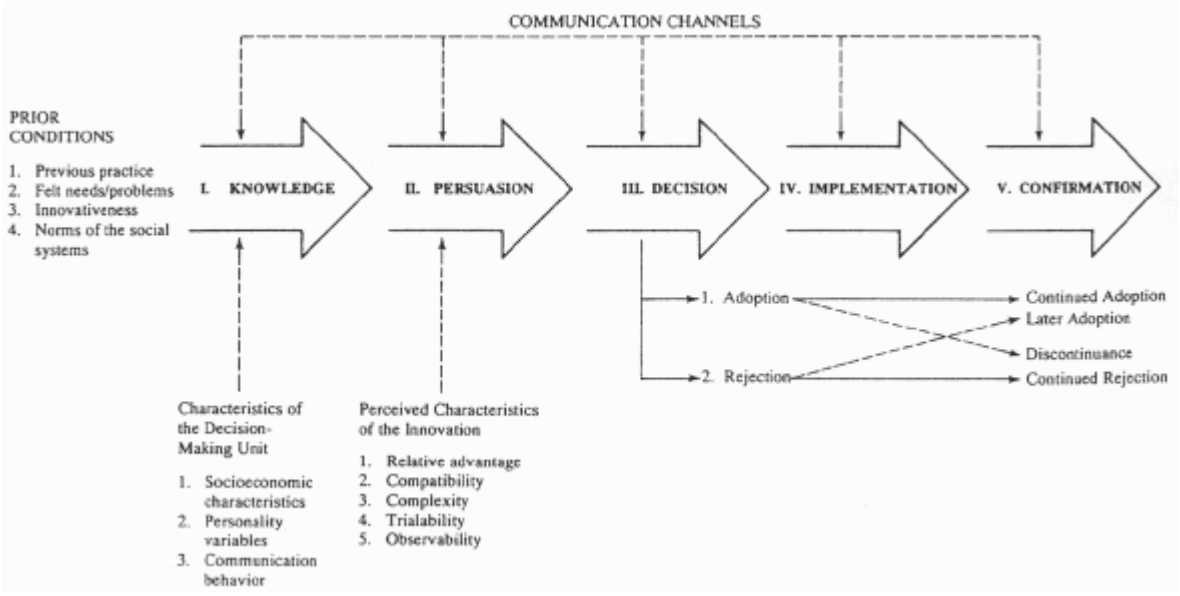

Figure 13 Model of Innovation Decision Process

Source: Rogers, (2003)

The Innovation- Decision Model has not been without criticism. Much criticism has been raised regarding the empirical measurement of these stages. Rogers (2003) argues against this criticism that the stages are meant for simplifying a complex reality and provide a basis for understanding human behaviour change when introducing an innovation. I am aware of the abstraction of this model. However, this study aims to investigate what influences people's choice in deciding whether or not to use solar cookers. In this way Rogers model presents a suitable theoretical framework to analyse why individuals decide whether or not to adopt solar cookers.

4.5 The analytical framework

Troncoso, et al. (2007) mentions different conditions which have to be fulfilled in order that an individual adopts an innovation. First of all she claims that an innovation is adopted by users if it represents a relative advantage and if it more useful than the one it is substituting. In addition, it must be compatible with the attitudes, values, beliefs and needs of a potential user. Furthermore, it must be easy to understand and implement, and its effects and benefits must be visible for the potential user.

This study aims to investigate how different factors influence the adoption of solar cookers. The factors mentioned by Troncoso, et al. (2007) present a first perspective but does not provide the entire picture. A study by Schlag & Zuzarte (2008) about the analysis of market barriers to the use of clean cooking fuels in Sub- Saharan Africa includes other factors which influence the adoption of clean cooking fuels. Troncoso, et al. (2007) and Schlag&Zuzarte (2008) present two different perspectives, while Troncoso, et al. (2007) focuses on the individual decision, Schlag& Zuzarte (2008) focus on a market perspective. However, based on the article by Troncoso, et al. (2007), Schlag& Zuzarte (2008) and Wareham (1997), seven factors were in identified which are assumed to have an enabling/ limiting[12] impact on the decision of an individual for adopting Solar Cooking. The seven different dimensions comprise economic affordability, social/ cultural values, information, infrastructure, technology, sustainability and area of the project. In the following the dimensions are explained in more detail.

Economic affordability

According to Wareham (1997) solar cooking technologies have to be low cost and affordable for the local population in order to obtain a successful implementation. Most of the intended

[12] Depending on their way of occurrence the impact can be enabling or limiting

users in Tanzania are relatively poor. If the price for the technology can be kept down success of the solar cookers is more probable.

Social/ Cultural values

Social and cultural values play an important role in implementing Solar Cooking successfully. According to Troncoso et al. (2007) cooking technologies such as solar cookers have to be compatible with the attitudes, beliefs and needs of a potential user. Wareham (1997) claims that the successful use of a solar cooker can only take place at places where the cookers coincide with people's traditional way of cooking. The use of solar cookers requires that the meal is prepared at a particular time of the day when there is strong sunlight but in some cases the does not correspond with people's traditional cooking times.

Information

Information is a crucial component in order to make people aware of the possibility of Solar Cooking. Limited information flow is a barrier to solar cooking programme since it gives potential users limited information about Solar Cooking as an alternative to traditional fuels and its potential benefits. In this way a lack of information prevents the distribution of solar cookers.

Infrastructure

Infrastructure is an important factor strongly related with the information flow. The existence of a well developed infrastructure system is a prerequisite for a successful information flow. For instance poorly constructed roads limit the possibility of transportation from one village to another in order to give solar cooking demonstrations.

Technology

A well designed technology which is possible to produce with local resources creates a good initial situation for solar cooking projects. In addition, solar cookers have to be user friendly, light weight, easy to use, rugged and large enough to provide for the cooking demands of an entire family (Wareham, 2007).

Sustainability

To ensure that a solar cooking project is not a temporary project which appeared only at a certain area for a limited time the project has to be sustainable. This means that the NGOs have to ensure that the solar cooking project will not collapse after a certain time. Sustainability comprises the ability to sustain the solar cooking project so that the amount of

people involved in the project can be increased over time. In addition, it implies that the introduction of Solar Cooking is made in a way that it can survive in the long term.

Area

The area plays an important role for solar cooking projects. The areas where Solar Cooking is implemented have to be dry and sunny for at least 6 months of the year. SCI (2008a) claims that latitudes between the equator and 40 degrees are usually the best for Solar Cooking.

So far the section has presented the different factors which were identified as having an influence on the successful implementation and diffusion of solar cooking projects. Figure 14 presents how the factors are considered as having an influence on the Individual- Decision Process in an analytical framework. The different factors are considered to have a positive/ negative influence on the decision process of an individual depending on their occurrence. For example a solar cooking technology which is heavy and not easy to store can lead to the formation of a negative attitude towards Solar Cooking of an individual. In addition, the figure shows that the different dimensions are connected through arrows which indicate that the dimensions are considered as interrelated and can not be seen separately. For instance it is assumed that a lack of infrastructure in a certain area can lead to a limited access to information about Solar Cooking.

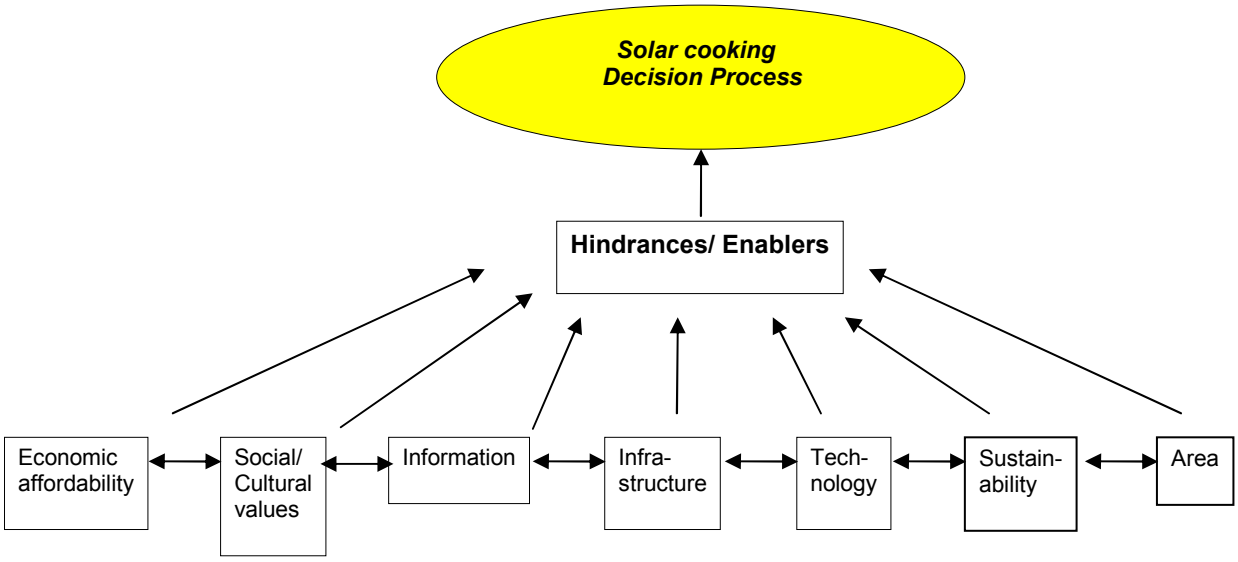

Figure 14 Analytical framework

4.6 Conclusion

This chapter aimed to give an overview of the theoretical background to this study. The Capability Approach was introduced and discussed in greater detail with regard to my research objective about the impacts of Solar Cooking on people's life. Different capabilities were identified which will be analysed in terms of their expansion in CHAPTER 7. Furthermore, the Theory of Innovation Diffusion was introduced while particular focus was given to the Innovation- Decision Model by Rogers. The model by Rogers provides the basic background for understanding the process of how an individual decides on the use of solar cookers. In addition, seven different dimensions were identified which are assumed to have an impact on the Innovation- Decision Model and thus on the success of Solar Cooking. The chapter is of importance in terms of understanding the theoretical background of the research objectives of this study. However, in order to understand how the concepts presented were operationalized, a section explaining and discussing the methodology background of this study will be given in the following chapter.

CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY

5.1 Introduction

The following chapter presents the methodological background to this study. It will start by giving an explanation of the choice of my methodological approach followed by a presentation of this approach. The chapter is divided into three sub sections according to the chronological progress of my research. The first section presents the preparatory stage which comprises the research considerations that were undertaken before the fieldwork. The second part presents the fieldwork stage of my study which includes issues as, for instance, where and with whom the interviews took place, validity and reliability of the conducted data, the limitations of my study, and the consideration of an interpreter and research ethics during the fieldwork. The third stage describes the analysis stage of my research which took place after the fieldwork. In this part, I will present how the data was analysed and I will argue about the reasons for choosing a certain way of analysis.

5.2 The preparatory stage

Before the fieldwork, extensive preparations had to be done which include several decisions regarding the methodological approach, the study area, the sampling, and the way of analysing the data. The preparations started already in October 2007. In this time, a literature review took place and first concepts and theories were chosen in order to write a research proposal. My interest was on the issue of renewable energies for developing countries. Renewable energy is a broad term which encompasses different sources of energy including hydropower, biomass energy, solar energy, wind energy, geothermal energy, and ocean energy (Johansson, et al., 2004). In order to narrow down my research I decided to focus on solar energy and more specifically on Solar Cooking as a supposed alternative way of cooking in developing countries.

The first step in this way was to review the literature about current solar cooking projects in developing countries. The literature review showed that solar cooking projects have been implemented by different organisations in several developing countries over decades around the world. However, a wider implementation of Solar Cooking did not take place. This problematic regarding a successful implementation of Solar Cooking made me interested and encouraged me to relate my research to this question. Besides, the literature review showed that there is a lack of academical writing regarding the impacts of Solar Cooking on people's lives. Most of the literature related to the positive impacts of Solar Cooking on people's lives

is written by solar cooking proponents. This led me decide to take up the question of the impacts of Solar Cooking on people's lived as another research objective. In further preparations the research methodology had to be chosen. In general, it was the question if a quantitative or qualitative methodology seems to be appropriate.

5.2.1 Choice of methodological approach

The choice of a research method is not an easy task. The decision between quantitative or qualitative methodology should be determined by the appropriateness of the method for the aspired study phenomenon (Flick, 2006). According to Mikkelsen (2005), the quantitative and qualitative research approaches share basic principles of science but they are also characterized by significant differences. Both approaches have their strengths and limitations. Quantitative data techniques can be seen as data condensers which aim to compress data in order to see the overall picture. Important elements are statistical analysis including a strong focus on variables. In addition, quantitative research techniques tend to be independent of the context and aspire to include as many cases as possible in their study to gain an overall picture of the research interest.

In comparison, qualitative data techniques can be more understood as data enhancers to see key aspects of cases more clearly (Neuman, 2003 citied in Mikkelsen 2005:141) In addition, qualitative research is situational constrained, the researcher is involved in the research process and the focus is not on variables but on interactive processes between informants and researcher. According to Brocktington & Sullivan (2003), qualitative research is used in many areas of human geography which seeks to explore the meanings of people's worlds. It is concerned with exploring and explaining human environments, and human experiences within a variety of conceptual frameworks (Winchester, 2005). In addition, the data collection takes place in natural settings, rather than in artificial, constructed contexts. The knowledge which is produced through qualitative research is situated and constructed. As a qualitative researcher you are interested in analysing how people see and experience the world and how they make particular representations of the world as it is.

In this study a qualitative research approach seemed appropriate since the interest is not related to a statistical analysis of certain facts regarding, for example, the question about how many people in a special area do apply solar cookers or not, rather the aim is to find out the underlying personal reasons for deciding to use or not to use solar cookers. In addition, qualitative research methods present the appropriate research tool for exploring and explaining the personal impacts of Solar Cooking.

According to Kvale (1996), qualitative research includes a variety of techniques. In general it can be divided between three main types of qualitative research which are: Conducting interviews, participatory observation and text analysis. There are no strict rules for choosing one of the methods, but the choice of a methodology depends on the purpose of the research. The approach chosen in this study is a combination of qualitative interviews between coordinators of different solar cooking projects, their users, researchers in the field of solar cooking and several other actors involved in Solar Cooking.

5.2.2 Choice of study area

Tanzania was chosen as study area because of its multitude of solar cooking projects. The major source of information for finding solar cooking projects was the internet at this time. It was easy to find information related to Solar Cooking in Tanzania and particularly the website www.solarcooking.org was of help in the beginning to get an overview of different attempts of Solar Cooking worldwide, including Tanzania. Solar Cooking seems to be a present issue in the Tanzanian society as Figure 15 shows. The picture is originally a stamp from Tanzania which shows a woman demonstrating the usage of a panel solar cooker to a group of people in Tanzania. According to SCI (2008c), this stamp was released by the Tanzania Post Corporation in 2004 as part of the 75th anniversary of Girl Guiding in Tanzania.

Figure 15 Stamp Solar cooking in Tanzania

Source: SCI (2008c)

During the preparations for my fieldwork from June to August 2008, I contacted via email different solar cooking projects in Tanzania and before my departure I was able to make an agreement with two different projects. In addition, while staying in Zanzibar, I could get in contact with another project. This project is directed by Solar Africa Network, which is a Zanzibarian NGO, and became the first project I went along with during my fieldwork. The second project was initiated by Solar Circle, an American organisation, and is currently supervised by the Anglican Church in Masasi, which is located in the southern part of

Tanzania. The third project is located in Moshi, close to Kilimanjaro, the northern part of Tanzania and was initiated by YWCA (Young Women´s Christian Association) and KASI Women Committee (KASIWOCO), the women's wing of KASI (Kilimanjaro Association of the spinally injured) in this region.

I have to mention that it was my intention to choose projects in different parts of the country in terms of being able to compare them and to find out if there are different results regarding my research questions related to the project's location. I especially appreciated to get in contact with one project in Zanzibar, since Zanzibar is characterized by huge differences to the mainland. Besides having its own constitution, voting rights and its own president, Zanzibar was for a long time influenced by the Arabic culture, the result being that Islam is the dominant religion and practiced by most of the Zanzibarians (Zanzibar Net, 2009).

5.2.3 Sampling

Besides finding an appropriate study area, I had to decide about my target group of interviewing or sampling. In the beginning of this chapter it was mentioned that the qualitative research approach does not aim to a statistical generalization through the conducted data. I decided to make use of a non- representative sample which means that individuals were selected on my own experience.

The snowball sampling was applied, which means that my existing informants recommended me future informants from among their acquaintances (Przyborski & Wohlrab-Sahr, 2008). In addition to the interviews with users of solar cookers, the sample includes interviews with the coordinators of the different solar cooking projects, three interviews with experts in Solar Cooking, and several interviews with other institutions involved in Solar Cooking. The contact to these organisations developed while I was in Tanzania and was not arranged in beforehand. The interviews with the different institutions comprises one interview with Estomih N. Sawe the executive Director of TaTEDO (Tanzania Traditional Energy Development and Environment Organisation) in Dar es Salaam, one interview with Vitalis K. Kimario from TETRA (Trans Regional Environment Technology Organisation) who is working with renewable energies and, among other things also with reflecting solar parabolic cookers and solar box cookers. Another interview was conducted with a local engineer from Nandra Engineering in Moshi.

5.2.4 Data sources

The study is based on two major data sources which are primary and secondary data. The primary data comprises the data collection during the phase of my fieldwork in Tanzania from June to July 2008, as well as one interview with Jørgen Løvseth who is working on the development of a Small Scale Concentrating Solar Energy System with heat storage for developing countries at the Norwegian University of Science and Technology (NTNU) in November 2008 in Trondheim.

5.2.4.1 Primary Sources

Primary data is data which is collected and analysed by the researcher (Mikkelsen, 2005). In my case, the study is based on the use of primary data which combines interviews with solar cooking users, coordinators of the solar cooking projects and experts in this field.

5.2.4.2 (Semi- structured) Interviews

The purpose of a qualitative research interview is to obtain qualitative descriptions of the lived world of the subject with respect to interpretations of the meaning of the described phenomena. According to Kvale (1996) the interview is a stage where knowledge is constructed through the interaction of interviewer and interviewee. In my case, the purpose is to describe and understand why people decide to use solar cookers or not and what are, in their experience, the impacts of Solar Cooking on their lives. The following citation by Kvale (1996) reflects my intended interest. *"The qualitative research interview attempts to understand the world from the subjects´ points of view, to unfold the meaning of peoples´ experiences, to uncover their lived world prior to scientific explanations"* (Kvale, 1996:1)

The interview seeks to interpret the meaning of central themes in the lived world of the subject which is, in this case, Solar Cooking. In addition, the interview seeks to obtain qualitative knowledge expressed in normal language instead of statistical quantification. In general it can be distinguished between three major types of interviews: The structured, semi-structured and unstructured interview. According to Dunn (2005), these three forms can be placed along a continuum with the structured interview at one end and the unstructured interview at the other. The difference between the interviews is that structured interviews follow a predetermined and standardised list of questions while unstructured interviews include no list of questions. Here the conversation is mostly directed by the informant rather than by a set of questions. This study is based on semi-structured interviews since it represents, for me, a kind of compromise between structured and unstructured interviews, and therefore the most appropriate alternative. One essential element of semi-structured interview

is the usage of an interview guide, which includes a list of general issues I want to cover in an interview[13]. I decided to conduct semi- structured interviews because of its openness to change the sequence and forms of questions in my interview guide which means that I still have some sort of freedom in my questioning. In addition, the researcher exhibits an openness to new unexpected phenomena, rather than developing predetermined categories and schemes of interpretation (Kvale, 1996).

The interviews with the users of solar cookers took place at their home places since this was assumed to be the most comfortable place for the informants. The interviews with the coordinators varied in their type of place from project to project. In Zanzibar the interview with the volunteer of Solar Africa Network was conducted at the guesthouse where I was staying during this time. In Masasi, the interview with the coordinator of the sun oven project was conducted at the coordinator's home place while the interview with the supervisor of the solar cooking project in Moshi was conducted at the office of the YWCA (Young Women's Christian Association). The interviews with the researchers and other actors in the field of solar cooking took place at their work places.

To conduct the interviews I decided to use a digital voice recorder because of its several advantages. The data collection was easier with the use of a voice recorder since it facilitates the short- hand writing skills. Due to the use of a digital voice recorder I was not busy taking notes. Instead, I could be more attentive and critical listening. Furthermore, the voice recorder let me more time to organise the next question and it was easier to maintain the natural conversation. On the other hand, the use of a digital voice recorder can comprise different disadvantages or weaknesses. According to Kvale (1996), the use of a digital voice recorder can remind the informant of the formal situation of the interview. In some cases during my fieldwork it seemed that the digital voice recorder caused much attention in the beginning of the interviews which was fortunately forgotten during the interview course. However, the best solution for me was to combine note- taking and audio recording, even though it was a challenging task.

5.2.4.3 Observation

According to Kearns (2005), in general two types of observation can be identified, controlled and uncontrolled observation. Controlled observation is determined by a clear and explicit definition on what, how and when something has to be observed. This type of observation can be more related to natural science and its experimental approach to research and is therefore

[13] The interview guides of this study can be found in Appendix III- Interview guides

suitable for physical geographers. However, this approach is characterized by two limitations. First, the focus is on particular elements of the known world. Second, only directly observable aspects are of the researcher's interest. In contrast, most of the observations conducted by social and cultural geographers can be described as uncontrolled observation (Kearns, 2005). This type of observation is not restricted or limited to a determined phenomenon. In addition, the term "observation" itself tempts to let us think of a simple dichotomy between participant and non- participant in a social situation. In reality, there is not such a thing as non-participant, rather there is a multitude of possible researcher roles which comprise complete observer, observer- as- participant, participant- as- observer or complete participation.

During my fieldwork in Masasi I was able to observe different public demonstration related to the use of solar cookers. In this case, my role was a kind of observer-as- participant. I was a newcomer who observed the demonstration surrounded by people from Masasi who were interested the solar cooker's functioning. In addition, I got the possibility of observing the direct application of the solar cookers at the user's home place. In some cases, my informants were already preparing food when I arrived, in other cases they built up the cooker and prepared the food to prove me the functioning.

5.2.4.4 Secondary Sources

Secondary data is information which is collected by other people and which has already been collected for some other purpose (Mikkelsen, 2005). This means that secondary data may not provide the information necessary to answer the specific research question but it can help the researcher further in the research process (Polonsky&Waller, 2005). Secondary data is a vital guide to the geography and the research topic. The data provides a comparison of the intended research area between now and the past. Secondary data can be analyzed to demonstrate the potential relationships between variables- in this study case, between Solar Cooking, its impacts on people's lives and the factors influencing solar cooking projects. In addition, secondary data allows the researcher to compare his/her case study material with other areas at the same scale. For my research, the literature review of solar cooking projects in developing countries, their achievements, limitations and impacts on people's lives were important in order to identify the factors which influence the decision of using solar cookers and to find out the potential impacts of their usage.

The collection and use of secondary data took place through the entire research process, starting from the preparations of the study, the fieldwork, and up to the analysis of the data. The study involves the review of literature including different reports related to the issue of

Solar Cooking, articles by Solar Cookers International, scientific articles about the Energy situation in Tanzania as well as general articles about the technological background of Solar Cooking. In addition, the internet was used in collecting secondary data, even though it has to be considered as a critical source, it was particular useful for the presentation of the different types of solar cookers and the discussion about their advantages and disadvantages.

5.3 The fieldwork stage

The section before showed that extensive preparations were done by me before going to the field. However, it is impossible to plan every single step in the research process since the researcher is not able to predict the entire procedure of the fieldwork. The following section presents the methodological operations which were done during the fieldwork.

5.3.1 Validity and Reliability

According to Collingridge & Gantt (2008), all studies either of quantitative or qualitative nature aim to be valid and reliable. In general, validity refers to the extent to which research measures what it is supposed to measure (Collingridge & Gantt, 2008). It can be distinguished between three subcategories, construct validity, content validity and criterion validity. Construct validity is related to the concern and whether we are really assessing and underlying construct or not. Content validity refers to the question whether the applied methodological tool provide an adequate measure of the construct of interest. Criterion validity is related to the strength of the relationship between the applied measurement tools and other measures of the same phenomenon. In qualitative research, validity means selecting an appropriate method for the intended research question and to apply this method in a coherent, justifiable and rigorous way. In this way, qualitative and quantitative interpretations of validity are similar. According to Collingridge & Gantt (2008), both methods are concerned with producing legitimacy results. In the context of qualitative interviews, *"Validity means whether an interview study investigates what is intended to be investigated"* (Kvale 1996:88)

In quantitative research, reliability often refers to repeatability or consistency of research findings (Kitchin & Tate, 2000). In quantitative research reliability is reached if repeated research leads to similar results. Furthermore, methods are reliable when they are free from bias and thought to provide us with an accurate representation of the world (Collingridge & Gantt, 2008). In qualitative research, reliability is an equally important issue. However, what is understood with reliability differs often in a certain way. According to Collingridge & Gantt (2008), reliable qualitative methods produce a rich and meaningful description of

phenomena. Reliability, in a qualitative context, is not focused on obtaining the exactly same results over time but rather achieving the consistent similarity in the research results. It is important to consider that is a part of the entire research processes. According to Kvale (1996), an increased reliability of interview findings is desirable in order to counteract haphazard subjectivity, but in the same way a strong emphasis on reliability may counteract creative innovations and variability.

During my fieldwork, questions regarding the reliability and validity of my findings were raised. I could discover that, in some cases, informants who were using solar cookers tended in the beginning, to provide me mainly with information regarding the advantages of Solar Cooking. A reason for this information could be that I, as a researcher, came as an "outsider" to this society. The informants normally knew that I was in contact with the NGO they were cooperating with. It can be assumed that the informants wanted to present the solar cooker to me in a positive way in order to give no wrong impressions back to the organisation. One of the weaknesses of interviews is the uncertainty of the trustworthiness of the informant's report and the quality of the interview itself which can have influence on validity and reliability in the qualitative research (Kvale, 1996). In addition, I had to be aware of emerging biases when conducting interviews with key informants (Mikkelsen, 2005). Regarding the interviews with the coordinators of the solar cooker projects, it is obvious that the conducted interviews present just one side of the coin. Therefore, I conducted interviews with researchers in the field of solar energy, who are working with solar cookers but are not promoting the distribution of a special cooking type to get a more realistic picture.

5.3.2 Limitations of the study

The study is characterized by different limitations. First of all, I had limited time for my fieldwork, around two months. This seems enough time but due to long distances between the different projects, and sometimes, poorly constructed roads, a large amount of time was used for travelling. In addition, it was not always an easy task to get appointments with the informants.

Besides, there are limitations regarding the generalisation of this study. The study is only performed among solar cooker users, in particular three projects in three different areas in Tanzania. This excludes the voices of non- users of solar cookers which should have also been taken into consideration. In addition, the study is specific to its context. The findings of this study may not be used to generalise across settings as the findings are context specific

(with regard to cooking traditions or types of cookers used, for example) and the participants were few in numbers.

5.3.3 Research assistant- Interpreter

"Belonging to a dominant group in the society can mean that we carry with us the power dynamics linked to such an affiliation." (Dyck and Kearns 1995 citied in Keans 2005: 197) Being a white European Woman who does not speak the national language, created invariably challenges for conducting my interviews. The interpreter was in this way an advantage since I was an outsider of the Tanzanian society who does not speak the language properly and who is not familiar with the cultural background. According to Mullings (1999), researchers who study a group to whom they belong, have an advantage because they are able to use their own knowledge of the group to gain more insights into their opinions. The interpreter helped me to get closer to the informants since he/she is a local person who helped me to build up the bridge between the informants and me.

On the other hand, the usage of an interpreter also involves disadvantages as for example a problem of power relations and interpretations. How can I still control the conversation when the translator is mostly talking to my informants? How can I interpret the data? Maybe the informants used other words in their language than the interpreter used when translating into English. In this case, I have to rely on the statements of the interpreter. During the fieldwork I worked together with different interpreters which varied in their degree of qualification which, in turn, had influence on the quality of my conducted data. In most of the cases it was difficult for me to conduct interviews directly with the solar cooker users, since their English was limited and my knowledge of Swahili was even more limited. I appreciated that some of the informants tried to carry out the interviews in English but which sometimes led to a reduced quality of data, since the informants had problems to express themselves in an appropriate way.

5.3.4 Research ethics

Ethical issues arise throughout the entire research process but find particular awareness during the fieldwork process. It is very important to emphasize on ethical issues from the beginning of the research through to the final report. Mainly there are three ethical guidelines for human research which have to be considered during the field work: Informed consent, confidentiality and consequences (Kvale, 1996).

Informed consent means to inform the informants about the overall purpose of the investigation and the main feature of the design, as well as any possible risks and benefits from participating in the research process. Furthermore, informed consent means also to obtain the voluntary participation of the informant, with his or her right to withdraw from the study at any time (Kvale, 1996). Confidentiality is really important in the research process and more problematic in a qualitative research approach than in a quantitative approach. It implies that private data identifying the informants will not be reported. In this way all my interviewees were informed by me about the overall purpose of the research and their identities are, in this way, protected since their names were changed in the report[14]. Furthermore, to keep confidentiality, the transcriptions were erased after they were no longer of use.

5.4 The analysis stage

The last section comprises the analysis of the conducted data. In this study, the analysed data is based on conversations which were recorded during the interviews. During the data collection, the transcription of data was already done in order to make the later process of writing up easier. Back from the fieldwork, the first step of the research analysis was to structure the gathered data.

5.4.1 Data Analysis

According to Kvale (1996), the analysis can not be considered as an isolated stage. Rather it is a part of the entire research process. Analysis means to separate the entire interview, the story told by the informant into parts. The analysis of the interview data already takes place when deciding about the way of transcribing the interviews (Kvale, 1996). It comprises a process of selecting and cutting interview data with regards to the intended research. According to Kvale (1996), it can be distinguished between five approaches of qualitative interview analysis which help to analyse the meanings of the interviews. These approaches comprise meaning condensation, meaning categorization, narrative structuring, meaning interpretation and generating meaning through ad hoc methods.

In order to identify the enabling/ limiting factors of solar cooking projects in Tanzania, the approach of meaning categorization was applied. The interviews with the solar cooker users and coordinators of the projects were analysed with regards to the seven dimensions which were defined in the theoretical framework in CHAPTER 4. The aim of meaning

[14] The names of the solar cooker users were changed while the names of the researchers and project leaders were kept, after agreeing on this

categorization is to reduce long statements to the given categories in order to give information of the occurrence or non- occurrence of these dimensions. In this way, every interview was coded according to the seven assumed influencing dimensions. The categorization of the meanings of the informant's statements was chosen as a way of analysing due to its different advantages. First, the categorizations into seven dimensions structured the extensive and complex interviews and gave an overview of how each of these dimensions occurs among the solar cooker users and coordinators of the projects. Second, the categorization made it possible to test the hypothesis if (and if yes in which way) the seven predetermined dimensions influence the adoption of Solar Cooking. In addition, through the categorization it became possible to compare the statements of the informants in the three different projects.

The second research question which is related to the impacts of Solar Cooking on people's lives was analysed in a similar way. According to the theoretical background, a set of capabilities was defined in beforehand including health, social relations, political participation, education and knowledge, income generating activities, leisure activities, and time autonomy.

The third analysis part comprises the interviews with the three researchers and different institutions involved in Solar Cooking. Here, the interviews were categorized with regards to three major interview questions which comprise

- What are the problems related to Solar Cooking?
- How can Solar Cooking be improved?
- Does Solar Cooking 'have a future'?

The statements of the researchers were compared to the data gained from the interviews with the coordinators and solar cooking users. The interviews comprised originally much more questions but I limited the analysis on the three mentioned ones which were, by me, considered as most important for a comparison.

5.5 Conclusion

The aim of this chapter was to present the methodological background of this study which is essential for the subsequent analysis part. The chapter was divided in three sections according to the chronological research process. However, it is difficult to divide the single steps of this research process into three sections rather are the steps more a continuous process but for an easier understanding of the research process this approach was chosen.

CHAPTER 6: SOLAR COOKING PROJECTS IN TANZANIA

6.1 Introduction

The aim of this chapter is to give an overview of three different solar cooking projects I observed during my fieldwork in Tanzania in the summer of 2008. Beside a general presentation of the projects, the chapter will focus on identifying and assessing the factors which limit or enable the successful implementation of solar cooking projects. In CHAPTER 4, seven potential factors assumed to have an impact on the success or failure of Solar Cooking were identified. Additionally, I want to determine if, besides the predefined dimensions, other factors exist which influence the success or failure of the solar cooking projects and have not been considered in the framework. Furthermore, the chapter will present in which way the different factors influence the decision process of an individual on Solar Cooking.

6.2 The sun oven project in Masasi

The following section will investigate in the solar cooker project in by the Anglican Diocese of Masasi. The information is mainly based on qualitative interviews conducted with Joyce Liundi[15], the coordinator of the project and the Sisters of the Anglican Church, who are involved in the project and using solar cookers. In addition, interviews conducted with Sisters from the Catholic Church, who are using solar cookers and interviews with the local users of solar cookers in Masasi present the basis for this section.

6.2.1 Description of the sun oven project in Masasi

In 2004, the Diocese of Masasi received visitors from the American NGO Solar Circle, which focuses on the establishment of Solar Cooking in Tanzania (Solar Circle, 2008).

Solar Circle brought 14 box cookers to Masasi. In the long run, Solar Circle established, in collaboration with the Diocese of Masasi, a solar cooker project in February 2006. According to Liundi, the aim of the project is to save families, especially women, from spending many hours for searching firewood, enabling them to spend this time for income generating activities, education or home activities like gardening or growing food. Furthermore, the project aims to contribute to the protection of the environment and to empower families by providing a free and reliable energy source as well as improving their nutrition, health and quality of life, all of which has been successfully achieved (Liundi, 2007). In order to spread the idea of Solar Cooking and to enrol more people in the project, a team of nine motivators

[15] The interview took place at Joyce Home in Masasi (12.07.2008)

was established. The task of the nine motivators was to demonstrate the effectiveness of the solar cookers in order to create awareness of Solar Cooking in the society and to inform people about the health hazards of using normal firewood for cooking in Mtwara region (Liundi, 2007). The motivators carried solar cookers from village to village and gave solar cooker demonstrations in public places such as markets, hospitals, bus stops and schools. According to Liundi, the approach of the motivators was to cook several types of food and distribute it to people so that they could taste the food and realize that there is no difference compared to the food prepared with fuelwood. A solar cooking brochure was also distributed in Masasi to make people aware of Solar Cooking in the village. In July 2008, I participated in a short demonstration of using a normal sun oven at the Masasi Primary School. Sister Anne demonstrated the usage of the sun ovens to the school authorities (see Figure 16).

Figure 16 Public demonstration of using a sun oven in Masasi Primary School
Source: Pia Otte (2008)

According to an interview with the store keeper of the Masasi Primary School, the school consists of approximately 30 pupils and food at the school is normally cooked with firewood, which is very expensive. The food normally prepared for the children is beans and rice or porridge. The store keeper reported that he is interested in Solar Cooking because of the enormous costs for firewood nowadays and the health risks caused by the firewood smoke. In the end, the director of the school decided to take a sun oven, which was a donation from Solar Circle. Besides giving demonstrations to the Masasi's population, the sisters' camp of the Anglican Church itself has its own sun oven. The camp comprises around 30 or 40 sisters but owns unfortunately only one box cooker which is not enough to prepare food for the entire camp. In an interview from July 2008, the Anglican Sisters reported that they use the sun oven for baking bread or frying nuts. But the sisters still have to use firewood for

preparing lunch and dinner since one sun oven is too small to prepare food for all the sisters. Figure 17 shows the fireplace at the Anglican Sisters' Camp.

Figure 17 Fireplace at the Sister's camp of the Anglican Church in Masasi

Source: Pia Otte (2008)

In addition to the "normal" sun oven[16], Solar Circle donated two village sized sun ovens to the Mtwara region. These ovens provide cooking facilities for an entire school or community. One of the village sized cookers is located at Rondo Secondary School in the Masasi region while the second is located at the Catholic Sisters' Camp in Masasi town. Figure 18 and Figure 19 show the community sun oven at the Catholic Sisters' Camp in Masasi.

[16] Also called "Global sun oven" according to sunoven.com

Figure 18 Village sized sun oven in the Catholic Sister´s Camp in Masasi

Source: Pia Otte (2008)

Figure 19 Village sized sun oven inside view

Source: Pia Otte (2008)

6.2.2 Achievements so far

Besides the 14 solar cooker samples from the USA, Solar Circle established, in cooperation with Anglican Diocese, a small industry in Masasi that produces its own solar ovens based on the design from the USA.

> *We saw that women were appreciating the technology, the ovens they received, when we saw there is a "need" in Masasi community we tried to find out how we can proceed with local resources we have in our area. (Interview Liund, July 2008)*

The aim of starting local production of the sun oven was to make solar cookers available and affordable for the people in Masasi, since the import of solar cookers from the US, combined with purchase prices and transport costs, was too high. The local production creates new job opportunities for carpenters and engineers in the region. The implementation of the village sized sun oven in the Catholic Sisters' Camp of Masasi led to several positive changes in the way of cooking, the time of cooking and even the taste of the food. In an interview with Sister Mary[17], who is in charge of the food preparation at the Catholic sister's camp in Masasi, several questions were asked related to the type of food prepared, the duration of the cooking time and the usual starting point for cooking.

Sister Mary reported that the sisters normally prepare cake and bread and fry cashew nuts with the sun oven. She is also able to cook normal food with the sun oven, such as rice, beans and ugali (porridge) and can boil water for tea. Sister Mary reported that she can prepare up to

[17] The interview took place at the catholic Sister's camp (10.07.2008)

10 loaves of bread on a good sunny day. Furthermore, the sister described cooking with the big sun oven as easier, since she does not have to watch the food the whole time like with the normal firewood. She just has to move the cooker occasionally to keep it facing the sun rays. In addition, using the sun oven for preparing food makes it possible for her to carry out other domestic activities, such as laundry or garden work while the food is cooking. The sisters sometimes organise seminars in the catholic camp and they invite people to join. If the weather conditions allow, the sisters prepare food for the guests with the sun oven. Furthermore, the sisters save money because the costs for firewood are reduced when using the sun oven. As well as being an easier way of cooking, Sister Marry reported of an improvement of the quality of the food cooked in the solar cooker.

> *The bread baked wit the sun oven tastes better; it is not as dark as the bread beaked with the normal firewood. (Interview Sister Mary, July 2008)*

6.2.3 Factors influencing the achievements of the project

The following section will show in which way the seven identified dimensions have an influence on the sun oven project in Masasi. The sun oven project has to overcome different challenges in order to reach a successful implementation and application of Solar Cooking. With the establishment of the local production of solar cookers, the project has a certain advantage, but there are several steps necessary to make the implementation more successful.

Economic affordability

One, if not the biggest, challenge of the project is to overcome the problem related to the economic affordability of the solar box cookers. Most of the people in Masasi are relatively poor and are therefore cannot afford a box cooker, which costs normally around 70.000 TZS (53 US$). To counter this problem, Solar Circle introduced an instalment payment system, where people do not have to pay the entire price for the cooker at once. Rather, they can pay back a small portion of the total price on a monthly basis. Unfortunately, even this mechanism of paying seems difficult for people in Masasi.

> *Now all the materials we are using are very expensive and we are all suffering from poverty, so people can not afford ovens about 75US$. After discussing how to go through the price, our friends told us to subsidize the price for other women to have access to the technology. That is why you find the ovens for 25000 Tanzanian Shillings […]. They (the people) like to introduce the technologies but it is not easy to afford them; even 10000 Shillings is too much (Interview Liundi, July 2008)*

This quotation shows how serious the situation is and how difficult it is to afford 10 000 TZS per month for a solar cooker which is equal to about 7,50 US$. Another approach to solving the problem of economic affordability is to pay for the cookers destined for poor families. But Liundi has her doubts about this kind of intervention.

> *But now few people from America and UK are willing to pay for poor families, to support poor families that they can use the technology but we have to be careful because some people can complain that they had to pay and others not. […] We are just giving people the fish but not teaching them how to fish. (Interview Liundi, 2008)*

According to Liundi, the solution is not just to donate sun ovens to the poor, since this could create inequalities in the society. People could start asking questions such as "*Why do I have to pay for the cooker and my neighbour not?"* Another question is how can one define or even measure who belongs to the poor and who does not?

Sustainability

To implement solar cookers successfully, it is necessary to create awareness of the importance of Solar Cooking in the society. This awareness can, for instance, be created through public demonstrations showing the use of solar cookers. As mentioned before, in 2007, the Diocese of Masasi had approximately nine motivators who travelled from village to village to demonstrate the use of solar cookers. Unfortunately, these motivators are no longer employed by the Diocese due to problems related to salaries. On the other hand, the project was able to develop a local production of solar box cookers which is an essential step forward to ensure the project's sustainability.

Information

To implement solar cookers in the wider society, the information has to be spread around the region so that people learn about the existence of solar cookers. The project by Solar Circle and the Anglican Diocese of Masasi is limited to Masasi town and does not reach the wider outskirts of the district, which leads to a lack of information regarding Solar Cooking in these areas.

> *[…]Women, just Masasi community but in our office we had the idea to benefit other people from this project, to use that technology. We are just working within Masasi because it is difficult with people who are supporting us. They say it is too expensive to go far just working in Masasi ward not in Masasi district it was too wide. […] (Interview Liundi, July 2008)*

Social cultural values

Social and cultural values can have influence on the implementation of solar cookers. Liundi reported that it is not an easy task to change people from the traditional three-stone fire to the use of a solar cooker. In addition, people in Masasi know each other; if someone tells a negative story about Solar Cooking, people can start believing this, without making their own judgement.

> *Sometimes it is difficult to change people there are some who destroy the project because they can send bad messages about the project. We tried to avoid that so we talked to them and explained them why we made that decision. (Interview Liundi, July 2008)*

Regarding the traditional type of food, the women did not report any problems. The following quotation shows that a solar cooker does not limit the kind of food that can be prepared. They are still able to prepare the same type of food as with the three stone fire.

> *I prepare the same food than before, but usually we do for baking the solar oven. But we also use it for beans and rice during the sunshine. I also boil water with the oven after cooking for drinking water. […] (Interview, woman using solar cooker, July 2008)*

Technology & area

In several interviews with women using the sun ovens, as well as in the interview with the coordinator of the project, the limited use of the solar cookers during the rain season was mentioned. The sun oven can just be used in the direct sun, which means that it only works efficiently if there is a clear sky. The informants reported that the sun oven is of limited use during cloudy days and especially during the rain season. But even on sunny days, preparing food with a sun oven takes longer than with firewood. The performance of the locally produced sun ovens does not compete with the performance of the original ones from the USA. However, the Anglican Diocese is working on improving the performance of the cookers and seems to be making progress as the following quotation shows.

> *The original American one is very strong; even the performance is better we had a test last month to compare them and used all the ovens and the result was the same, which encourages us for the future that we can do something. (Interview Liundi, July 2008)*

Problems related to the performance of the cookers were not only mentioned regarding the small sun oven, but the Global sun oven also seems to have the same disadvantages. Sister Mary in the Catholic Sisters' Camp reported that the cooking time increases when using the

solar cooker. Cake baking takes approximately 45 minutes, while beans take up to 2 ½ hours. In comparison with firewood, cooking beans takes on average 1 ½ hours. Cooking usually starts around 10 AM on a sunny day because the sun is strong at this time. There are also problems with using the sun oven during the rain season. Sister Mary cannot use the sun oven at all from January to April, although from June to November, she does not experience any problems.

Due to the fact that the sun oven is difficult to use during the rain season, the sisters still have to use charcoal and firewood on cloudy and rainy days. Besides, the rain season has an impact of the local production of the solar cookers. Liundi reports that they only sell sun ovens during the sunny periods since no one is interested in buying a solar cooker during the rain season.

Infrastructure

There are no problems reaching people within Masasi town, but families in the outskirts are difficult to reach due to poor road conditions and long distances. This makes the promotion of Solar Cooking to these families an enormous challenge.

6.3 Solar Africa Network (Zanzibar)

The following section is based on interviews with a volunteer[18] working for the Solar Africa Network and participants of the solar cooking projects. Additionally, information from the Solar Africa Network homepage and a study about the evaluation of the solar cooking project by Neidel (2006/07) is provided.

Solar Africa Network is a Zanzibarin NGO that engages in local community projects and assists local government institutions in the facilitation and implementation of renewable energies and to create efficient energy consumption alternatives (Solar Africa Network, 2008a). The overall aim of the Solar Africa Network is to improve the challenging current energy situation in terms of improving the environmental aspects related to energy consumption and to develop new and sustainable initiatives of energy supply in the East African region. Solar Africa Network was founded in 2000 and currently consists of three different projects on Zanzibar and in Tanzania. One of the projects presents a solar cooking project on Zanzibar I visited in June 2008.

[18] The term “volunteer” is used since the informant preferred to remain anonymous

6.3.1 Description of the "Moto" project Zanzibar

"*Moto"* was initiated by Antje Förstle in 1997 as a joint partnership with Solar Africa Network. The project aims to improve women's economic situation in a way that establishes a cooperative labour network of women in rural areas under environmentally and sustainable conditions (Neidel, 2006/07). Sustainability here is not only seen in an environmental but also in a social perspective. In this way, the project does not tear apart existing family structures, since the project is organized such that women can work from home. The word *"Moto"* is taken from the Kiswahili language and means fire. Fire is very important on Zanzibar since many women do not have access to electricity and therefore use an open fire for cooking.

The project *"Moto"* contains the production of "*ukili*" baskets which are mainly sold to Zanzibar's tourists although a small number are exported. The colouring of the palm fibres used in the baskets was traditionally done with an open fire. The *"Moto"* project uses a solar cooker instead. Each co-operative uses one or two solar cookers. The fibres are boiled with natural dyes (roots, bark, soil etc.) with the solar cooker. The time of boiling depends on the intensity of the colour required. A parabolic solar concentrating cooker (SK 14) is used for boiling the water for the colours. The parabolic cooker is not donated to the women; rather, they must contribute half of the cost of the cooker. The cookers are used for the production of handicrafts as well as for cooking. *"Moto"* started with a donation of solar cookers from Germany. Today, *"Moto"* is present in five villages on Zanzibar with twelve co-operatives, which comprises in total over 120 members (Solar Africa Network, 2008b). There have also been groups of women involved on Pemba recently (Neidel, 2006/07).

To involve women in the project, *"Moto"* aired a radio commercial to which interested women replied (Interview volunteer[19], July 2008). Afterwards, a workshop was organised to train the women how to use the solar cooker, how to produce the handicrafts and how to organize a co-operative. The women are now paid according to the purchase order. The women who join *"Moto"* are mainly housewives who are looking for a way to generate income to support their families.

6.3.2 Achievements so far

The project is generally doing well. Membership in the program is in high demand among Zanzibar's women, and the baskets produced by the women of *"Moto*" are well known on Zanzibar (Interview Volunteer, June 2008) "Moto" established a shop in Stone Town where

[19]. The interview took place at Zanzibar Beach House (26.06.2008)

they are selling the *"ukili"* to tourists. The two pictures below show the handicraft shop of *"Moto"* in Stone Town.

Figure 20 *"Moto"* handicraft shop in Stone Town Zanzibar

Source: Pia Otte (2008)

In addition to these general achievements, there are improvements on an individual basis. Neidel (2006/07) found that the women of the *"Moto"* project have improved financially. Furthermore, women reported about other positive changes through the *"Moto"* project. For instance, an increase in their knowledge and better working conditions, since the women can work autonomously. The women are able to choose their own working hours, working speed and workspace. More of the individual improvement will be discussed in CHAPTER 7.

6.3.3 Factors influencing the achievements of the project

In June 2008, it was possible for me to visit one of the women's co-operatives in Mahonda and to conduct interviews with some of the women. During the conversation it became clear that factors different from those assumed in the analytical framework have influence on the success of the project.

Economic Affordability

According to the interview with one of the co-operatives, the price for the parabolic concentrating solar cooker is around 200.000 TZS, which is around 150 US$ and quite expensive for people in Zanzibar. To overcome this problem, Solar Africa Network places the parabolic reflecting solar cookers at their disposal. This means that the villages pay back a part of the procurement expenses after the beginning of the project. However, according to Neidel (2006/07), these procurement expenses were not paid back until now. In the co-operative I visited, the women just have one solar cooker for a total of six women, which is not sufficient to prepare food for everyone. In the interview, the women told me that more people would like to join the project but that these people cannot afford a cooker.

Sustainability

In comparison to the sun oven project, the solar cooker project by Solar Africa Network seems to be more sustainable since the approach of introducing and maintaining the solar cookers is a different one. The solar cookers are introduced as a business to the women, which consists of boiling the colour for the handmade *"ukili"* baskets which are sold to tourists. In this way, the parabolic concentrating solar cooker has an important function which makes the cooker valuable. Boiling water for producing the colour with an open fire would cost more money and thus make the business less cost efficient. The solar cooker works without fuelwood and is thus a big advantage and which makes the cooker interesting for potential users.

However, Rita[20], one woman of the co-operative, has her doubts about the project itself. She reported that she is facing seasonal variations of the number of orders she receives. From January to May, she is almost unemployed while from the end of June up to December, she has plenty of orders due to the high tourist season. Furthermore, she reported that the prices for basic needs (such as food or clothes) in Zanzibar go up every day, which makes it difficult for her to survive in the low season. April and May are difficult times because she is at the end of her funds. Rita also does not know if increasing the number of women participating in the project is a good solution. Her argument is that if more women participate, but the demand for baskets does not simultaneously increase, she might earn less money, which would make the time between January and May even harder.

Information

The *"Moto"* project description in the beginning of this section showed that information about Solar Cooking is spreading among Zanzibarian women. The use of a radio advertisement increased the information flow. Many women are interested in joining the project, which led to the project being implemented in five villages with around 120 members on Zanzibar.

Social cultural values

According to the interviews with the women's co-operative, there are no problems related to the acceptance of solar cookers due to social and cultural values. However, Neidel (2006/07) reports that it is not easy to change old traditions. A long process of talking, explaining and training of the people is essential in order to succeed.

[20] The interview with Rita took place at one of the co- operatives (26.06.2008)

The women reported that many of their neighbours are interested in joining the solar cooking project but until now there are not enough solar cookers available. As a result, the neighbours come to the co-operatives and use the cookers for cooking as well. The women did not report any changes with respect to the traditional type of food they prepare. Rita reported that she is using the cooker for every kind of dish, including *pilau*, which is a typical spicy rice dish in Zanzibar.

Technology & Area

In an interview with Rita, problems related to the solar cooker's technology were mentioned. Rita reported that in the beginning of the workshop, she was afraid of touching the cooker because she was not sure whether the cooker was electric and that she would receive an electrical shock if she touched the cooker. The workshop helped her understand how to use the solar cooker and encouraged her to start using the cooker. This means that a workshop is necessary in order to learn how to use the solar cooker. The women in the co-operative reported that they are using the solar cooker for cooking as well if there is enough sun, but that use of the cooker for this purpose is limited during rainy or cloudy days. They reported that there is a lot of rain in Zanzibar during March and April, which means that they cannot use the cooker during those times. The women also mentioned that the cooker's reflection can hurt the eyes that and that it occupies a large space for storage, which many of them do not have available.

6.4 Solar cooking project in Moshi by YWCA and KASI Women's Committee

The following solar cooker project was initiated by YWCA (Young Women's Christian Association) of Moshi and KASI women's committee in Moshi. The section is based on a report by KASI including the goals and the outcome of the solar cooking workshop and conducted interviews with the supervisor and the participants of the project.

6.4.1 KASI Women's Committee Moshi

KASI Women's Committee (KASIWOCO) is the women's wing of KASI (Kilimanjaro Association of the Spinally Injured) located in Moshi close to Kilimanjaro in the northern part of Tanzania. KASI was founded in 1993 and the women's committee was formed in 2004 (Urassa, 2003). KASIWOCO was formed due to the reason that it was recognized that women with spinal cord injury have specific issues and rights that need to be addressed. The mission of KASIWOCO is to "*physically and economically empower women and girls with spinal cord injuries through a sustainable process of full participation and integration into society.*"

(Urassa, 2003) The aim is to have a society in which disabled people are able to live together and enjoy economical and social independence. Another goal of the association is to provide a forum for disabled women to meet and plan ways to improve their lives. KASIWOCO is run by women and girls, and works independently of KASI. The activities of KASI are many and comprise, among other things, counselling, training, rehabilitation and the planning of income generating activities for spinally injured women.

6.4.2 Description-of the KASI solar cooker project for spinally injured women

In 2003, a five day workshop was organised in cooperation between the YWCA and KASI. The workshop took place in the YWCA rehabilitation centre and involved participants who were interested in Solar Cooking. The aim of the workshop was to teach members of the KASI committee how to use solar energy for cooking as a sustainable source of energy and to improve their social and economical status. The cooker type used during the workshop and later distributed to participants was a parabolic concentrating solar cooker of type SK14.

According to a solar cooking report by Urassa (2003), the emphasis of the solar cooking workshop was on different outcomes. First, the participants of the workshop learned how to use a solar cooker, including the precautions necessary while using the parabolic solar cooker. During the workshop, several participants suggested that in order to be able to use the solar cooker as a wheelchair user, the cooker should have wheels so that it can be moved easily. At the end of the workshop, six women were given solar cookers for their own use at home. According to the interview with Faustina Urassa[21], the coordinator of the project, the women were chosen with regards to where they lived[22], whether they had enough storage space for the parabolic cooker, and their motivation to actively contribute to the society.

> *We visited them to make sure that they had a place where they can put the solar cooker. Before we gave them the solar cooker, we visited them and we interviewed them. But most of them I know because we had been together because we attended some workshops together. So I know they are very active. I know them. We asked them if they are interested and they said that they were very interested. (Interview Urassa, July 2008)*

[21] The interview took place at YWCA in Moshi (18.07.2008)
[22] The choice was not only limited on women living in Moshi town, also women living in villages outside of the town as for example in Machame were considered

6.4.3 Achievements so far

The five[23] women who are currently using the solar cookers are doing fine and were able to improve their economic situation in several ways and have facilitated their cooking chores. The parabolic reflecting solar cooker (SK 14) is not without its problems but still makes cooking easier for the women, especially during the dry season. Also, the workshop on Solar Cooking itself acted as a kind of social gathering for the participants. For some participants, it was their first time to leave their home and meet other disabled people (Urassa, 2003).

6.4.4 Factors influencing the achievements of the project

The solar cooker project by KASI is influenced by several different factors. The following section will show in which way these factors influence the KASI solar cooking project.

Economic affordability

In comparison to the two projects previously presented, the solar cookers were donated to six women of KASIWOCO, which excludes a problem related to the economic affordability of the cookers.

Sustainability

In an interview with the coordinator of the KASI solar cooking project, different problems regarding the financing of the project were mentioned. In 2003, KASIWOCO received a unique donation of six solar cookers, but the demand is much higher than the available number of solar cookers.

> *We do not have more cookers, this is the problem and most… all of KASI women members need solar cookers. (Interview Urassa, July 2008)*

Urassa also reported:

> *[…] The project is going on but how? We are still using the same solar cooker. There is no increasing [sic] of other members to use solar cookers. (Interview Urassa, July 2008)*

The two statements reflect the problem of financing the solar cooker project. In this case, it seems that there is demand for solar cookers but the supply to fill the requests is lacking.

Information

There is an existing network among the KASI women, created by KASI and the YWCA, that provides potential solar cooker users with information. The women of KASIWOCO know about solar cookers and their advantages. They would be interested in joining the project if it

[23] Originally, solar cookers were given to six women, but unfortunately one of them has since passed away

was still taking place. Also, information about solar cooking is spreading among the neighbours of the women who are using solar cooker.

> *Many people from the neighbourhood have come and seen how I am using it and they have liked it very much, but I only allow my neighbours in my compound to use the solar cooker. (Woman using solar cooker, July 2008)*

> *I am the only one using a solar cooker but the neighbours are very much interested and everybody who passes stop and ask me what it is and I explain then […] (This woman has her solar cooker outside in front of her house close to a road because she does not have enough space inside) (Woman using solar cooker, July 2008)*

Social & cultural values

From interviews with the solar cooker users and the project coordinator, problems regarding the acceptance of solar cookers due to existing social and cultural values were not mentioned. Urassa reported a high general interest among women to join the project, but unfortunately, not enough solar cookers are available. The women of the KASI project also did not report any changes to the type of food that can be cooked in the solar cooker.

On the other hand, the women of the project reported about changes in their cooking times. The interviews confirmed that cooking with a solar cooker is less flexible and related to certain weather conditions. The women have to adapt the cooking time according to the weather conditions.

> *I normally start cooking at 10 when I want to have lunch at midday. In the afternoon from 3 o'clock the sun is not enough […] (Woman using solar cooker, KASI project July 2008)*

Technology & Area

One major problem reported by several women is related to the mobility of the parabolic cooker. The parabolic concentrating cooker is bigger and heavier than the box cooker but like the box cooker, it must be moved to follow the sun in order to work efficiently. This can be quite demanding for women in wheelchairs and it is possible that they need to ask for assistance for moving and setting up the cooker. The use of the solar cookers also leads to the necessity of special precautions. Lina, a woman using a solar cooker reported that in order to use the cooker, she has to wear goggles and gloves. This is because of the strong reflection, which can hurt the eyes and lead to burns. Another informant reported a situation when she used the cooker without using goggles and her eyes were hurt. A further problem of the cooker is the storage; the cooker requires a lot of storage space.

> *The problem is the solar cooker is too big. So it is very difficult like myself to move to follow the sun. Again because it is big you need a big space to store it. If you left it outside it can be stolen so you have to take it inside. (Interview Urassa, July 2008)*

The high required amount of space can also lead to limitations in the cooker's functioning if not enough sunny area is available. One woman from the KASI project reported that the trees in her garden produce shadows, which makes it difficult for her to collect enough sun with the cooker for cooking. Another woman reported that she has enough space in the garden to store the cooker, but that she has to be careful with the storage of the cooker. If she sets up the cooker the wrong way, sun rays can be reflected to the roof of the house, which could ignite.

One problem that all informants mentioned, and which seems to be the overall problem with the cooker, is the limited usability of the parabolic cooker during the rain season and on cloudy days, especially in areas close to Kilimanjaro. One woman living in Machame, close to Kilimanjaro, reported the problems using the cooker during the rain season.

> *The rain season is the biggest problem, you can not use the solar cooker at all during this time because at Kilimanjaro it means when it is raining there is no sun at all and even after the rain season there are some days which are cloudy (Woman using solar cooker KASI, July 2008)*

Besides the rain season, she reports that the area is characterized by many cloudy days due to the close proximity to the mountain.

The donation of solar cookers

A further problem that has not been considered so far is the issue of donating solar cookers. The solar cooker project by KASI is special in comparison to the two other projects presented earlier in that its focus is on spinally injured women. The other projects did not focus on a special group of women. Also, the solar cookers are donated in the KASI project while the solar cookers in the other two projects had to be completely or partly purchased by the users. The act of donation leads to people perceiving solar cooking in a new light. When I asked the solar cooker users if any of the neighbours are using solar cookers or if there are willing to use or even buy a solar cooker, the informants usually replied that the neighbours were interested in the solar cookers, but that they did not use it. I was wondering if the reason for this is the purchase price or the lack of availability of the cookers, but the women's answered surprised me. They reported that the neighbours never asked about the possibility of buying a cooker because they assumed that since the solar cookers are a donation from KASI and are supposed to make cooking easier for spinally injured women that it is not available for the

broader community. This limits a wider implementation or awareness regarding the solar cookers.

Although it is acknowledged that the aim of the project was primarily to make cooking easier for the spinally injured women, Solar Cooking has to be perceived as a method of cooking that is not limited only to women with special needs but that rather is a possible method of cooking for everyone, including the general public.

6.5 Comparison of the solar cooking projects

So far, the chapter has given an overview of three different solar cooking projects in Tanzania, including their achievements and the factors influencing these achievements. It is difficult to compare the projects since they vary in the goal of the project, the solar cooking technology chosen, as well as thee target group. However, one aim of this study is to identify factors which limit or enable solar cooking projects in different areas in Tanzania.

In all three projects, problems with the use of solar cookers *(technology)* during the rain season *(area*) were mentioned. Also, the two projects which require the purchase of a solar cooker showed that there are problems with the cookers' *economic affordability*. Solar cookers are too expensive for the majority of the population. Regarding the influence of *social cultural values* in all three projects, women reported that they can prepare the same food that they prepared with firewood or charcoal. The only limitation mentioned was that some types of food are easier to prepare than others. Joyce Liundi from the solar cooker project in Masasi reported problems convincing people to switch from the traditional way of preparing food with a three stone to using a solar cooker. *Sustainability* was assumed to be an important factor in order to maintain an initiated solar cooking project and to increase the number of users. The project by Solar Africa Network showed that the attempt to introduce Solar Cooking as a business to women increased the project's sustainability.

The projects confirm that a lack of *information* flow influences the spread of Solar Cooking. In Masasi, the promotion of Solar Cooking is mainly based in Masasi town due to the long distances between villages. This limits the information of Solar Cooking to Masasi town. A lack of *infrastructure* further limits the spread of Solar Cooking. In Masasi, for example, solar cooker motivators mainly travelled from one to another by bike. Long distances and poorly developed roads make transport of the cookers a huge challenge. Table 3 summarizes the results. It comprises the seven dimensions and the degree of influence on the particular projects.

Table 3 Solar cooking projects in relation to the predetermined factors

Name of the project			
Dimension	**Sun oven project Masasi (Solar box cooker)**	**Moto Solar Africa Network (Parabolic cooker)**	**KASI solar cooking project (Parabolic cooker)**
Economic Affordability	- Cookers are difficult to afford, even though there is a pay by instalment programme	- Price around US$150. No local production, importing makes cooker expensive	+ No problems, since the cookers were donated
Social/ Cultural Values	+No changes in traditional type of food + Local production - In some cases difficult to change people	+ No changes in traditional type of food	+/- Demand is high but limited amount of cookers , no changes in traditional type of food
Information	+ Within Masasi town solar cooking idea is spreading - Limited to Masasi town	+ Information is spreading (beginning use of radio advertisement)	+ Women know about the cookers due to information flow within KASI
Infrastructure	- Difficult to reach people outside the town, long distances no proper roads	*No data obtained*	*No data obtained*
Technology	+ Easier to cook + Improves food taste - Limited use in rain season, slow cooking	- Limited use in rain season	- Difficulties moving cooker, use of special equipment - No use during rain season
Sustainability	- Motivators no longer employed	+ Solar Cooking is introduced as business	- Not enough financing
Area	+ Many sunny days per year - Rain season	+ Many sunny days per year - Rain season	+ Moshi is suitable (except for rain season) - Villages close to Kilimanjaro many cloudy days per year

6.6 Recommendations of the solar cooker users

Another aspect of the interviews conducted with the solar cooker users from the three projects is the recommendations made to improve the solar cooking movement. These recommendations can be classified according to the seven dimensions and comprise mainly of improvements to the technology and economic affordability of the cookers. In Masasi, the informants varied in their recommendations. One woman recommended improving the performance of the sun oven so that the cooking time would be reduced. Another woman was more sceptical towards an improvement to the cooker itself. In her eyes, an improvement of the cooker is associated with higher purchase prices, which would make it even more difficult for people to afford a solar cooker.

> *Improvement of the cooker means more money. If they can not afford this one, how can they afford an improved one? This is ok, if they can afford it. If this could be made cheaper […] (Interview woman using solar cooker, Masasi)*

The women of the KASI solar cooking project had some recommendations regarding the solar cooking technology. One woman reported about problems with the strips of the parabola. She noted that these strips were coming off her cooker because they are too thin and therefore not strong enough. She recommends replacing them with stronger ones. Another woman reported about problems regarding the heat storage of parabolic cooker. She recommends developing a way of storing energy in order to enable cooking even when the sun is gone[24].

6.7 The influence of the identified factors on the solar cooking decision process

The study showed that the factors assumed in the theoretical approach have an influence on the solar cooking projects, and depending on their occurrence, may have a positive or negative impact. However, it has not been discussed thus far how these factors influence the innovation decision process of an individual. In CHAPTER 4, a model of the Innovation Decision- process was introduced. The theory assumes that the seven different factors influence the model in different stages.

Figure 21 shows at which stages the defined factors have an impact on the innovation diffusion process. The influence of each of these factors on the decision process will be explained below.

[24] The problem with the heat storage has not been mentioned in this thesis at this point and will be discussed more detail in Chapter 8.

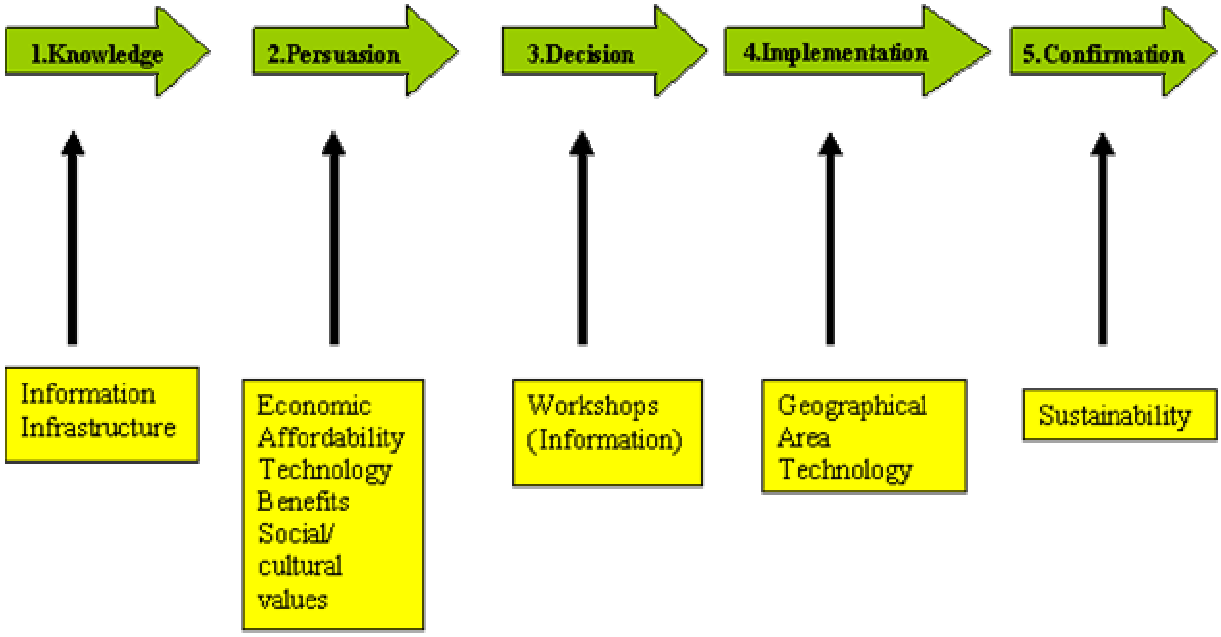

Figure 21 Model of Innovation- Decision Process & the factor's influence

Source: Adapted from Rogers (2003)

1. Knowledge

Knowledge is defined as the exposition of an innovation's existence and understanding to an individual (or another decision- making unit) (Rogers, 2003). It was said that three different types of knowledge exist: awareness-knowledge, how-to knowledge and principles knowledge. The interviews with projects leaders and users of solar cookers showed that the lack of a social network can have a negative impact on the creation of all these three types of knowledge among the intended users. The lack of these social networks are often due to a lack of infrastructure and project sustainability. In Masasi, for example, it was reported that people outside of Masasi town are difficult to reach due to a lack of infrastructure and the limited flow of information regarding Solar Cooking in this region. A lack of infrastructure and poor information flow leads to a lack of knowledge regarding the existence of solar cookers among the people outside Masasi. One of the informants in Masasi had guests from villages outside of Masasi town when I conducted the interview. I was able to talk to one of these visitors and ask about their knowledge concerning Solar Cooking. He reported that this was his first time to see such a solar cooker and that he is interested in it, but that this technology is not promoted in his village. On the other hand, the demonstrations of Solar Cooking in public places in Moshi led to an increase of the knowledge of Solar Cooking among the people.

It can be concluded that the three projects had different strategies in spreading knowledge to intended users. In Masasi, solar cooking *demonstrations* are given in public places to make people aware of Solar Cooking. In Zanzibar, the *radio* was used as media to make women aware of the existence of the solar cooking project. In Moshi, members of KASI WOCO were invited by the YWCA to join a *workshop* that informed about Solar Cooking and its way of functioning.

2. Persuasion

The persuasion stage was defined as the phase where the individual forms a favourable or unfavourable attitude towards an innovation (Rogers, 2003). The interviews with the informants from the solar cooking project in which the cookers were not donated showed that high costs are a major limiting factor in developing a favourable attitude towards Solar Cooking. In addition, difficulties with the use of the solar cookers led to the development of an unfavourable attitude towards Solar Cooking. Women of the KASI project reported that the fact that the cooker is bigger and heavier than a three stone fire makes it more difficult for the women to move the cooker towards the sun.

Additionally, if a solar cooker does not match existing social and cultural values, this can lead to the emergence of an unfavourable attitude towards it. The section showed that the women of all three projects reported that they can prepare the same food they prepared with fuelwood. It can be assumed that this has a positive effect towards developing a favourable attitude regarding Solar Cooking. In addition to the mentioned factors, several assumed benefits associated with the use solar cookers such as, for example, easier cooking, financial savings and improved health leads to the forming a positive attitude towards the solar cookers to those who hear about solar cookers.

3. Decision

The decision stage describes the process in which an individual participates in activities leading to a choice to adopt or reject and innovation (Rogers, 2003). One way to cope with the inherent uncertainty about an innovation's functioning and consequences is to try the new technology. The project in Masasi had public solar cooking demonstrations organised in order to provide people with information about Solar Cooking. In these demonstrations, potential users are taught about the functioning of the solar cookers and at the same time they are shown at the presentation that the cookers work. Also, for interested purchasers of solar cookers, an additional introduction can be provided to explain the functioning of the cooker.

The project by Solar Africa Network in Zanzibar and the KASI solar cooking project had an organised workshop where interested women could receive information about how to use a solar cooker before they decided about using/ purchasing a cooker or not.

4. Implementation

Implementation takes place when an individual begins to use an innovation (Rogers, 2003). The implementation stage is related to the actual use of a solar cooker. Though a household may decide to buy a cooker, it does not guarantee that the cooker is effectively used afterwards. Ahmad (2001) reports a case of Solar Cooking in Gujarat, India, where many families received a solar cooker and though many positive factors of Solar Cooking were present in this region, most of these families stored their cookers under beds or in storerooms. When I asked the informants how often they are using the solar cooker, the answer was always related to the weather situation.

> *When there is sun, I use it daily and especially to prepare food for my children because I have another business where I sell Swahili buns so I make these on the firewood […] During the rain season I don't use the cooker at all. (Woman using solar cooker, KASI project July 2008)*

The answers from the interviews showed that solar cooking implementation is limited. Solar cookers are only used during sunny days, when weather conditions allow due to the cooker's incapacity of saving energy for rainy or cloudy periods.

5. Confirmation

Rogers (2003) describes the confirmation stage as a phase where the individual has already made its decision about the innovation but seeks reinforcement for the decision already made, and may reserve this decision if it is exposed to conflicting messages about the innovation. The sustainability of a solar cooking project is an important factor in this phase. This means that organisations introducing solar cooking technologies have to be present as a counselling institution for solar cooker users and non-users. The permanent existence and addressability of the project can also eventually cause people who initially remained unconvinced or sceptical to decide to try using a solar cooker.

Also, the permanent presence of a solar cooking project with its developers and project coordinators can help solar cooker users confirm their choice through acting as a counselling organization. If the users are faced with any problems with the solar cooker, they can contact the counselling organization for help. In Moshi, for example, one woman reported that she had problems to use the parabolic concentrating solar cooker since the reflective strips

forming the parabola became loose. She fixed this problem by herself, but a counselling presence from the project would be a more appropriate alternative for these types of problems.

6.8 Conclusion

The section aimed to investigate how different predetermined factors influence the success or failure of solar cooking projects. In the theoretical framework, seven basic dimensions were assumed. These dimensions can function, depending on their degree of occurrence, as a hindrance or enabler of solar cooking projects. Three different solar cooking projects were presented and analysed with regards to the seven predetermined dimensions. Table 3 presented the seven dimensions and their degree of influence on the particular projects. In addition to the dimensions listed in the table, a further dimension related to the issue of donation and disability was identified during the fieldwork. The fact that solar cookers were donated to women of the KASI project caused other people to perceive Solar Cooking as a privilege to make cooking easier for disabled people and that is not designed for use by the general public. Furthermore, the chapter analysed how the seven predetermined factors influence the innovation decision model according to Rogers (2003). The chapter showed that the seven factors influence the decision process in different stages and that the direction of influence depends on the factor's occurrence.

CHAPTER 7: THE IMPACT OF SOLAR COOKING ON PEOPLE´S LIVES

7.1 Introduction

The following part of this study is related to the impact of Solar Cooking on people's lives. CHAPTER 4 showed that the Capability Approach according to Amartya Sen frames the theoretical background for this analysis. Besides analysing the impacts of Solar Cooking on people's lives, this chapter aims to discuss in what way Amartya Sen´s Capability Approach is generally appropriate to assess and conceptualize the impact of Solar Cooking on people's lives in Tanzania.

Recent studies on the impact of Solar Cooking on people's lives showed appreciable time and fuel savings as well as increased energy security through the use of solar cookers. The most intensive comparative field study about Solar Cooking was initiated by the Department of Minerals and Energy (DME) and the GTZ in South Africa between 1996 and 2004, which aimed to elucidate the application potential of solar cookers in South Africa and to identify the extent to which target groups can be expected to accept the new cooking option (Wentzel & Pouris, 2007). In the same study, the potential development impact of solar cookers for the intended user was investigated. It was indicated that Solar Cooking has the potential to improve people's quality of life and that it brings clean household energy to the places where it is most needed. It was also assumed that Solar Cooking can create local jobs and protect the environment (GTZ, 1999).

7.2 Sen´s Capability Approach in the context of Solar Cooking

Sen´s Capability Approach essentially states that researchers should focus on the real freedoms that people have. This means looking at what people are capable of doing instead of only focusing on what they consume or their income (Robeyns, 2003). As previously presented and discussed in this thesis, the majority of Tanzania's population depends on biomass as their primary energy supply and though the consumption of modern energy is extremely low in poor households, the expenditures for energy is relatively high. It was shown that in Tanzania, the average low income household spends around 35 percent of its income for energy (UNDP & GTZ, 2005). It was also said that it is mainly women who carry the burden of using biomass for fuel because in many places in Africa, it is they who are responsible for collecting firewood, which subsequently becomes rare and leads to the travelling of even longer distances for the women to collect the firewood (Laiser & Bura, 1999).

The argument from the side of the Capability Approach is that high expenditures for energy and the enormous burden of women carrying firewood for long distances limit people[25] in their freedom of living the life they want to live, to do what they want to do and to be the person they want to be. In CHAPTER 4, three conversion factors were presented which are considered to have an influence on the conversion from characteristics of a solar cooker (as for example an easier, healthier cooking and saving of fuelwood) to an achieved functioning. The following part of this section will identify and discuss the three different conversion factors in the context of Solar Cooking.

7.2.1 Social conversion factors

Norms or values of a social culture can influence the decision of using a solar cooker. Others people's behaviour can have an influence on people's interest of Solar Cooking. In all three solar cooking projects, the informants reported that people appreciated the use of solar cookers. In an interview with a woman from the KASI committee, it was reported that neighbours and friends are interested in solar cookers.

> *They wanted to see if it (solar cooker) can really cook and I cooked food and served food for them, they wanted to taste the food, many people came around to see it…Even a secondary school borrowed it to teach their students solar cooking. (Interview woman using solar cooker, KASI project, July 2008)*

In addition, existing gender relations can play an important role for the conversion of the solar cooker's characteristics to its achieved functionings. The project by Solar Africa Network on Zanzibar provided me with surprisingly results. My assumption was here that women would have problems joining the projects because of existing gender relations which perceive the men as the breadwinner. However, the interviews with the women showed that they are not facing any problems regarding the acceptance of their work by their husbands. Suzanne, one of the women of the co- operative reported that her husband likes that she joined the project. Normally the responsibility to buy food etc. is under her husband but sometimes he has no money and then he asks his wife for some money and she is happy to be able to contribute. In addition, Suzanne reports that she does not have do ask her husband anymore when she wants to spend money for private things. She can just use the money she earned. According to a study by Neidel (2006/07), the men even help the women in their work in different ways as for instance sewing, separating the fibres or giving inspiration to the work of the women.

[25] Particularly women

In comparison, in Masasi, a woman reported that she could not use a solar cooker since the cooking takes too long, which means that the food would not be finished when her husband is home from work. She argued that this could lead to a divorce for her. These two examples show how existing social values and gender relations can influence the conversion of the characteristics of a solar cooker into a functioning in positive and negative ways.

7.2.2 Personal conversion factors

Personal conversion factors were assumed to be sex, skills or disability, which influence how a person can convert the characteristics of a good into a functioning. In the case of Solar Cooking, this means in what way the participants can take advantage of the potential benefits of a solar cooker.

All three solar cooking projects I visited showed that a workshop was necessary in order to teach the potential users how to use a solar cooker. These workshops varied among the projects in their duration and intensity, depending on the type of solar cooker being applied and the personal adaptation. Liundi, the coordinator of the project in Masasi, reported that the workshop normally took place for one day but it also depended on the person and his or her ability to understand the system. In comparison, the workshop for women of the KASI solar cooker project took place in cooperation with a seminar about conserving forests and the need of alternative energy at the YWCA (Young Women Christian Association of Tanzania). This workshop seemed to be more intensive due to the advanced technology which was applied and the special situation of the women. During the study it became obvious for me that a solar cooking workshop is an essential precondition in order to make people familiar with the technology. The acquisition of the necessary skills to use a solar cooker leads to the achievement of the characteristics of the Solar Cooking which are an easier and healthier cooking.

7.2.3 Environmental conversion factors

For Solar Cooking, environmental conversion factors can play an important. It has been stated that if the geographical location is not appropriate for the use of solar cookers, or if the solar cookers are not available in a specific area, the solar cooker will be of limited help for people in that area. The limited use of a solar cooker due to the geographical location, besides the normal problems experienced during the rain season, became especially obvious during an interview with a participant of the KASI women's committee solar cooking project, living in Machame. Machame is located close to Kilimanjaro and therefore is covered with clouds many days of the year. This makes cooking with the sun difficult for the informant and

therefore Solar Cooking is of limited use. Additionally, Liundi, reported problems related to big distances between the villages which make it difficult to reach people and limits the availability of solar cookers in Masasi town.

Beyond the negative impacts of environmental factors, the lack of availability or the high price of firewood and charcoal can contribute to an increased use of Solar Cooking in all three areas. People are more willing to switch to a cheaper source of energy due to the high prices of fuels. This means that environmental conversion factors in the projects can be considered as contributing or limiting the characteristics of Solar Cooking into an achieved functioning, depending on how they occur.

7.2.4 The Capability Set

After having identified the different conversion factors in the projects, the question is still in which way Solar Cooking enables people to live the lives they want to live. In order to analyse whether Solar Cooking leads to more freedom in people's life, a set of capabilities was defined in forehand. The study investigates in which way these capabilities were expanded through Solar Cooking.

The qualitative interviews with the participants and coordinators of the different solar cooking projects were a major tool in identifying an increase of the predetermined set of capabilities. As introduced and discussed in CHAPTER 4 the set of capabilities comprises the following dimensions:

- Time autonomy
- Physical health
- Social relations
- Political participation
- Income generating activities
- Education & knowledge
- Leisure activities

The following analysis will show how the interviews provided data regarding an expansion of this defined set of capabilities.

7.2.4.1 Time autonomy

The strongest expansion took place within the factor "Time autonomy." In all three projects, women reported that Solar Cooking increases their time autonomy. When I asked if the

women have more time than before, the reply was always "yes". The following quotes by different women of the three projects confirm this conclusion.

> *It is easier with this sun oven because you can wash your clothes while the food is preparing. I have more time and use this for washing clothes, cleaning the house. (Woman using solar cooker, Masasi, July 2008)*
>
> *Once when you started cooking with the solar cooker you can do other things during cooking you do not have to sit there just come back occasionally to see if the sun moved if there are shadows. (Woman using solar cooker KASI project Moshi, July 2008)*
>
> *A solar cooker takes more time but is easier because you do not have to find fuelwood, so it is better to use the cooker because in the same time I can do other activities like for the project, while I am cooking, the food is getting finished slowly, then I make basket for the projects. (Woman using solar cooker, Solar Africa Network Zanzibar, June 2008)*

An interesting fact here is that the time surplus is not related to the reduction of time normally spent for collecting fuelwood, rather, the gain of time women have while the food is cooking. One reason for this could be that except for the women's initiative on Zanzibar, none of the solar cooking project participants reported that she has to collect the firewood. When I asked the women how they obtain the firewood or charcoal, the answer was that they buy the firewood or charcoal at the local markets instead of collecting it. This argument stands against the assumption which was claimed in CHAPTER 2 that women in Africa have the burden of collecting firewood. This is probably the situation for many women in Africa, including Tanzania, but as the interviews show, this cannot be generalized for the whole population in Africa.

However, the women have more time on the one side, but on the other side, this surplus of time is spent tied to the area immediately near the cooker. The women reported that they do not have to watch the food all the time but on the other hand they cannot leave the house area for a long time, since it is necessary to move the solar cooker towards the sun periodically.

7.2.4.2 Physical health

In order to be able to assess whether people's health improved, medical research would be necessary, including the performance of medical tests on a group of women using solar cookers for a specific period of time. This study does not provide any efforts in this direction. Nevertheless we can conclude that there is an impact of Solar Cooking based on the people's perception of their own health.

One of the questions in the interview guides asked for the reasons why people decided to use a solar cooker. In all three projects, women reported that one reason for using a solar cooker is that it is a way of preparing food in a healthy way since it does not produced any smoke which can lead to dangerous lung diseases.

> *[…]Because of smoke, the solar cooker is safe from disease from eyes and lounges […] (Woman using solar cooker, Masasi July 2008)*

Now, what is interesting to find out is how the women know about these health hazards associated with wood-fire cooking. When I asked the women how they knew about the health advantages when cooking with a solar cooker in comparison to cooking with normal firewood or charcoal, the answer was often the same. Many women replied that the NGOs that were in charge of the solar cooking project reported them about this.

> *Because of environmental reasons and diseases caused by smoke […] Joyce told me about the diseases caused by smoke after cooking we saw the differences between fire wood and solar cooking (Woman using solar cooker, Masasi July 2008)*

The fact that the NGOs told the women about the negative aspects related to the use of firewood led to a change in the perception of their own health. The women perceive their lives as healthier since they have been using a solar cooker. It is not possible to conclude concretely with this study if there is a real health improvement but it can be concluded that there has been an improvement of the women's perception of their health.

7.2.4.3 Income generating activities

Besides a gain of time and an improvement of the perception of people's physical health, an increase in income generating activities could be identified. Income generating activities allow people to work in the labour market.

Interviews with the informants showed that due to the time autonomy women gain through Solar Cooking, the opportunity to take part in the labour market was increased in many cases. In Masasi, a woman reported that the use of a solar cooker enables her to do her business of weaving baskets while the food is cooking. Another woman of the KASI project close to Kilimanjaro reported that she is able to sell *"Mandasi,"* a kind of bread which is typical in Tanzania, while the food is cooking.

This made me conclude that the actual time gained by women through using solar cookers increased their time availability for income generating activities in several locations. In

addition, the approach of implementing Solar Cooking by Solar Africa Network in Zanzibar was already directed to the issue of creating income generating opportunities for women in its concept phase. The solar cookers here were implemented with the primary reason of allowing for the production of baskets while cooking. These baskets can then be sold to tourists, thus proving to be a positive side effect of having a solar cooker.

Besides having more time for income generating activities, the informants reported of increased fuel savings during the summer months when they use the solar cooker. These fuelwood savings during the summer months and the gain of time for income generating activities leads to an increase of income. The question is now: What are the women actually doing with the increased income? Do they, for example spend it on education for their children? Or do they save it for the rainy season, when they have to use more fuelwood again? In the interviews it was difficult to ask this question. The standard reaction to the question "*What are you doing with the money you are saving?"* was first a big smile and a reticent laughter of side of the women. I have to acknowledge that this question was not an easy task for me, as a woman coming from one of the wealthiest countries in the world, since it deals with private issues. Even within Europe people would be hesitant to answer this question. I could notice that it was difficult for the women to admit that they have financial savings since they do not want others to know about it. However, the women gave me some answers and these showed me that the income was used differently by each individual. Women of the KASI project reported that they used the money for medication, food or their business while in Masasi, a woman reported that she used the money for her children.

> *There is saving but I can not put the money in the bank, I use it for other things for my children for example for clothes and food. (Woman using solar cooker Masasi, July 2008)*

> *[…] I save money and put the same money into something else for example to increase the stock into my business and you know it finds something else to be done. (Woman using solar cooker KASI project, July 2008)*

The quotations by the different women show that there are savings due to the use of solar cookers but that they do not last in the long term. The women spend the money on their current most important basic needs. In one case there is a necessity to buy food for the family, while in another the money is put in the stock of a business to ensure its sustainability.

7.2.4.4 Social relations

In the interviews, no comments were made regarding an increase of social relations through Solar Cooking. However, a report by Urassa (2003) about Solar Cooking argues that the workshop for introducing the solar cooker in Moshi contributed significantly to an increase of social networks and social support. In the report, it was written that participants enjoyed the time spent together in the workshop since for some participants, it was their first time out of their home and meet other disabled people. People even suggested that there should be more workshops on handicrafts or cooking various types of food, for example.

7.2.4.5 Other capabilities

The chapter so far could identify different improvements in people's lives due to the use of solar cookers. However, the capability set conceptualized in the theoretical framework includes more capabilities than those explained thus far. It was shown that an essential change in people's lives is the gain of time. In all of these projects, it was also shown that the women often use this gain of time for income generating activities. Moreover, according to a report by Urassa (2003) an increase of social relations was reported in the project in Moshi. Another question to be asked still is if this time gain can also contribute to an increase in the women's political participation or an increase in their education?

The interesting result of the comparative interviews of this study is that the majority of informants reported that they are using their increased time availability for domestic work such as cleaning or washing. Besides doing domestic work different informants reported that they are using the time for their business. The informants never reported that the time was used to meet friends, to watch TV or to participate in local political activities.

But why is there no evidence that the informants become more politically active, meet more friends, or participate in more social activities since they began using a solar cooker? Does it mean that the fact that someone is using a solar cooker cannot change his or her life in this important dimension? There are different explanations for why this study does not include any data related to an increase in political participation or social relations. One explanation might be that the time gained by the women is spent restricted to the cooking surrounding. As mentioned before, the informants reported that they have more time during cooking because they do not have to watch the food constantly, but in the same way, they cannot leave the house area in this time since the cooking process cannot take place completely without supervision. This leads to a surplus of time, but on the other hand this time is still spent tied to the cooking surrounding. However, besides the time gained from supervising the food during

cooking, women have gained more time after cooking as well. When preparing food with normal firewood or charcoal, the women reported that their presence was constantly required. The cooking process is shorter than with a solar cooker, but more time intensive due to the required supervision. This means that after one hour of cooking, the housework has still to be done, while the same meal might take three to five hours (depending on the kind of food, the weather conditions and the technology) using a solar cooker, but in this time, the housework can be done and women are free of domestic work after the meal. Theoretically, this time could be used for other activities as the capabilities mentioned above.

A second explanation is related to the Capability Approach itself and the difficulty of measuring the defined capabilities. According to Robeyns (2003), capabilities are people's potential functionings. This means that capabilities are possible opportunities we can choose in our life if we want to, but which we do not have to choose. The problem is now how to prove that these capabilities were increased if it was not confirmed in the interviews? Can it not be possible that women have time to be, for instance, politically active but that the interviewed women just did not choose to be so? How can we measure the freedom of being able to choose a certain capability if we do not transform it into an achieved functioning? In addition, the methodology which was chosen can be seen as having certain impacts on the results of this study. The method of questioning in this study influenced the answers of the informants. During my research, I decided not to ask questions directed linked up to constructs such as political participation or social relations. I decided to ask the informants open questions about what they are doing with their time increase in order to not direct them in a certain direction. Could it be possible that more direct questions regarding these capabilities would have led to other answers?

A fourth explanation is related to the high demand of this study to claim that Solar Cooking can increase people's political participation. It can be criticised that owning and using a solar cooker can increase people's political activities. Thomas (2002) claims that political participation is influenced by many factors such as local perceptions of gender, race and religion. These different potential explanations lead to the fact that we cannot exclude the possibility of an increase in the capabilities but neither can we disprove an expansion of these in this study.

7.3 Conclusion

The results of this study lead to a different picture than the assumptions previously made in the theoretical framework. It was shown that an increase of the defined capabilities took place to a certain level through the use of solar cookers which is, according to the theoretical assumption, equal to a development. On the other hand, it was presented that it was not possible to document an increase in all these capabilities. The qualitative interviews documented that enormous time savings due to Solar Cooking were reported by several informants of different projects. In many cases, these time savings then led to an increase of income generating activities or more time for domestic work. The interviews also showed that the perception of the informant's physical health changed positively.

It can be concluded that there is an impact of Solar Cooking on people's lives. The virtue of having more time through Solar Cooking and the individual perception of being healthier has an impact of the predefined capability set. Time autonomy leads to an improved quality of time since life becomes less stressful. Also, the savings of time due to the use of solar cookers gives people more time for different income generating activities that they otherwise would have done at another time or spent less time on. Furthermore, Solar Cooking itself can become new source of income as it was seen on Zanzibar.

CHAPTER 8: PERSPECTIVES ON SOLAR COOKING

8.1 Introduction

The study so far has given an overview of different solar cooking projects in Tanzania. In order to gain a broader view on Solar Cooking, the following chapter presents different perspectives of several actors in the field of Solar Cooking. My interest in these interviews was general directed to the three following questions:

- What are the problems related to Solar Cooking?
- How can Solar Cooking be improved?
- Does Solar Cooking 'have a future'?

In this way I conducted interviews with three researchers in the field of solar energy. The first research interview was conducted with Dr. Mushtaq Osman, who is currently working in the field of food processing at the University of Dar es Salaam. The second interview was conducted with Professor Boaventura Chongo Cuamba, who is researching renewable energies and is developing a small scale solar concentrating system with heat storage funded by the Norwegian programme for Development, Research and Education (NUFU) at the Eduardo Modlane University of Maputo. The third research interview was conducted with Professor Jørgen Løvseth from the Institute of Physics at NTNU in Trondheim, who has been working for the NUFU project and who is a partner of Professor Boanventura Chongo Cuamba. In addition, the section includes interviews conducted with Estomih N. Sawe, the executive Director of TaTEDO (Tanzania Traditional Energy Development and Environment Organisation), and Vitalis K. Kimario from TETRA (Trans Regional Environment Technology Organisation) and an interview with a local engineer from Nandra Engineering in Moshi.

8.1.1 What are the problems related to Solar Cooking?

One issue all three researchers agreed on was that there are problems with solar cookers but the researchers pointed out different types of problems.

In the interview with Dr. Osman,[26] he especially emphasized the problem related to the *affordability* of the solar cookers due to unsustainable implementation by NGOs. Additionally, he mentions problems related to the *design* of solar cookers, followed by disadvantages regarding the technology.

[26]The interview was conducted at the University of Dar es Salaam (28.07.2008)

Osman argues that solar cookers are still too expensive for people and therefore not widely accepted. He claims that the acceptance of solar cookers can only be increased and spread successfully in the population if the cookers are offered to an affordable price.

> *Life is expensive. People do not have the same capacities like in Europe so whatever is easily achievable; they would like to go for it. Solar cooking is acceptable only if it is affordable. (Interview Osman, July 2008)*

In addition, Osman argues that there is a *lack of communication* among different organisations working with renewable energies, and that these organisations *do not have a serious long term commitment*, which often leads to a collapse of the projects instead of a successful long-term implementation.

> *Nobody is addressing the issues completely. There is a government commitment but there is no serious drive to really address the issue of alternative energy, especially solar energy. People just take it as an opportunity, people promote it half way and they leave it and whoever comes next does not start at that point, he starts ten steps backwards again. (Interview Osman, July 2008)*

Besides the problems regarding the unsustainable strategy of introducing Solar Cooking to the population, Osman mentions problems related to the *technology* of the solar cooker, with focus on the parabolic concentrating solar cooker. He claims that the size of the parabolic concentrating solar cooker presents a major limitation for users. Many intended users do not have the space to set up such a cooker outside or even to store it. Also, due to the high reflection of the cooker, there is a risk of blindness from the reflector glare for the user.

Beyond the disadvantages related to the design of the parabolic cooker, Osman emphasizes the problem of Solar Cooking during the rainy season.

> *Everything with solar becomes difficult in the rain season. With cloud cover it takes longer time than in other places where you can use it, the temperatures are so low that whatever you gain from the solar energy is lost because of the cold environment. In some places it is not possible, in some places you can. (Interview Osman, July 2008)*

When I asked Osman if he considers the social acceptance of solar cookers as a major limiting factor, his answer was an empathic "no." According to his statements, the major problem of Solar Cooking is the affordability of the solar cookers while all other problems can be ranked behind.

Sawe shares the same view as Osman, that the high purchase prices are a major reason for the low solar cooker use rate rather than social acceptance.

> *[…]So maybe for the case of the solar cookers I think the problem has been the prices for the equipment but not the acceptance because solar technology in general has been accepted in rural areas because it is the most appropriate technology. […] (Interview TaTEDO, July 2008)*

Vitalis Kimario[27] from TETRA undermines that the high prices of solar cookers limits the broader implementation of Solar Cooking. Kimario is working with the implementation of environmentally friendly technologies in Moshi. He had been working with solar cookers, primarily the box cooker and the parabolic cooker. Due to a low request of solar cookers, the focus of TETRA is more shifted to other projects including solar lighting. In Kimario´s view, Solar Cooking is not successful because of its price, particularly the aluminium sheets used for the reflectors, that must be imported, rendering them expensive.

On the other hand, a completely different view regarding economic affordability comes from an interview with a local engineer in Moshi. The engineer is producing and selling two types of solar cookers in his workshop: the panel and the parabolic reflecting solar cooker. The price for a parabolic concentrating solar cooker is around 280.000 TSZ (US$ 210). The engineer reports sales of approximately one unit per year. The low demand is not surprising in a country with an average income of US$ 300 per year and with 35 percent of the population still living below the poverty line (IMF, 2009).

However, the local engineer presented another type of oven he is producing in his workshop and which he is selling much more successfully. This type of cooker is an improved stove which uses firewood or charcoal for cooking but with higher efficiency than the traditional three-stone fire. It also has a chimney, which sucks the smoke to the outside through a pipe in order to avoid indoor air pollution. The cooker is built into a small kitchen unit and comparable to the design of a European kitchen stove. The price for such a stove is around 850.000 TSZ (636 US$), which is about three times more than the solar cooker. Surprisingly the engineer sells almost 30 of these stove units per year. This example shows that there are people who are able to afford the prices for a solar cooker. The question is if the Tanzanian people are truly the intended target group or if it is simply rich Europeans searching for a good alternative for cooking at their cabins in the woods. However, the kitchen system must have definite advantages over the solar cooker since people are buying the improved stove instead of a solar cooker. Perhaps it is the reliability of the improved kitchen system, in that it can be used to prepare food no matter the weather conditions. Or perhaps it is because it reflects the more traditional, cultural methods of cooking? Since the stove can be used at any

[27] The interview took place in the office of TETRA (19.07.2008)

time during the day, people can prepare food whenever they want and not only when the outdoor conditions are right. It is also possible to cook inside the house.

Boaventura Chongo Cuamba[28], argues that the main problem of Solar Cooking is related to the social acceptance and the technology itself.

> *We have tested the cookers in a community apart of all these measurements, and our report says that people do not adopt the solar cookers. Our experience is that people were using the cookers when we were there. (Interview Cuamba, August 2008)*

Cuamba emphasizes that Solar Cooking has the disadvantage of limiting people in their cooking time since they have to cook during a particular time period during the day, which is between 10 am and 2 pm, depending also on the type of food they prepare. Another technical disadvantage is the fact that solar cookers are not able to *store heat*, which means that they only function when the sun is present.

However, Cuamba claims that Solar Cooking is a good alternative for specific types of meals. He suggests beans as an appropriate meal for cooking with a solar cooker. The argument is here that beans take a long time for cooking, so using a solar cooker here would give people the freedom to do other work, such as agricultural or domestic work, while the food is cooking. Furthermore, he emphasizes *geographical location* as one major factor influencing the success of solar cooking projects. Solar Cooking is only an alternative for arid areas with low amounts of precipitation.

Professor Jørgen Løvseth [29] at NTNU in Trondheim emphasised the technological disadvantages of the solar cookers. The fact that solar cookers are not able to store heat is seen by him as the major problem of Solar Cooking.

8.1.2 How can Solar Cooking be improved?

Besides investigating the current problems facing Solar Cooking from the perspective of researchers, I wanted to find out if there is a way to improve Solar Cooking in order to overcome these problems. The interviews showed again that the researchers vary in their suggestions of improvement.

Dr. Osman, who mainly sees the prohibitive prices of Solar Cooking as a limitation of a successful implementation recommends that NGOs should decide on a *clear way* to follow, if

[28] The interview took place at the Eduardo Mondlane University in Maputo (13.08.2008)
[29] The interview was conducted at the NTNU in Trondheim (04.11.2008)

they want to make solar cookers available for the intended users. According to Osman, solar cookers can only be successfully implemented if they are introduced in a *holistic approach*. This means that organisations have to think more about what kind of technology they introduce, how they will introduce it and how they will sustain the project in the long-term. He argues that many organisations are starting solar cooking projects without considering these factors, which often leads to the collapse of these projects after the NGO leaves the country. One way of he suggested of making Solar Cooking more sustainable is to adopt the principals of Solar Cooking for other solar applications.

> *For solar cooking the main thing that it is just for solar cooking and that is it. But it could be a business that similar principles could be adopted for solar drying. So you extend the application of the principle to something else because where solar cooking is practical, solar drying is practical. (Interview Osman, July 2008)*

In order to make people more aware of Solar Cooking, Osman recommends NGOs to look at ways how they can increase training to achieve a wider audience. He recommends starting a television commercial, since the TV presents a key tool for spreading information in Tanzania.

> *[…] One point is an audio visiual programme through TV [..] It spreads everywhere through Tanzania. People have TVs and mobile phones more than they have furniture in their houses. People want to have a TV, even if they do not have a TV they can have access to a TV in a nearby place where they show and pay a small fee. So with the audio vision transmission you can reach a bigger portion. (Interview Osman, July 2008)*

In addition, he suggests that Solar Cooking should come in as a business to people so that they benefit from it. In this way, he does not see the donation of solar cookers as a solution; rather, that they should be promoted as capital in order to make them more attractive for people.

> *The affordability thing has to be together with the people, donating things is welcome but is not and end solution by itself. They should be put in and say "we are promoting solar cookers" you can get a loan from so and so…the repayment is so…do you want it? Go for it" So you provide it as capital to the people and they regenerate it (Interview Osman, July 2008)*

In order to increase the sustainability of solar cooking projects in Tanzania, TATEDO presents one institution which is dealing with this issue. TaTEDO is a national development organization based in Dar es Salaam which follows the vision of poverty free and self-reliant communities in Tanzania with access to sustainable modern energy services (TaTEDO, 2009). One of the major activities of TaTEDO is the promotion of access to modern energy services.

In an interview with the executive director Estomih N. Sawe,[30] it was reported that TaTEDO follows different ways of promoting Solar Cooking: demonstrations in public places, exhibitions at special events in Dar es Salaam, the use of print media, clothing, radio and television, although media was the most common method of promotion. Additionally, TaTEDO seeks to develop networks and partnerships with local, national and international organisations in the field of energy. TaTEDO aims to connect solar cooker companies and clients.

Regarding Osman`s criticism related to the technology, he advises to develop a parabolic concentrating solar cooker which is more compact so that people do not require much space for setting up and storing the cooker. Cuamba recommends improving the performance of the cookers and improving the technology such that it is able to store heat. This presents also his current challenge. In Maputo, he is developing a small scale concentrating system with heat storage for communities and which can be used to cook in a kitchen, similar to a normal oven. The prototype of this system is not tested yet and price is still a problem with this system. Cuamba claims that even though the material is locally available, poor people cannot afford it. The assumption behind this project is that the level of income in Africa will increase given some time, which would make it possible for them to afford this kind of solar cooking system.

> *The material is available here, like pipes etc. They are produced in big amounst and [are] therefore cheap but poor people they cannot afford. So what we think slowly as the level of the people is going higher and higher they can afford to buy this type of system. So this may have some future. In this case it is not much we have to import. The pipes and antennas we have here. This can be fabricated in a normal workshop. (Interview Cuamba, August 2008)*

The argument of Jørgen Løvseth is similar to Cuamba's, regarding the way of improving solar cookers. Jørgen Løvseth is actively working on developing a small scale concentrating system with heat storage because direct solar cooking applications are not able to store heat. He claims that a concentrating solar cooker system with heat storage could even overcome the problems of using solar cookers during the rainy season in arid areas, depending on how much heat the person uses, and the amount of insulation used in the storage component. Also, a backup may be provided for advanced systems. For air systems, the exhaust from a gas burner or another cleanly burning oven could be sucked into the rock storage in long overcast period. Løvseth mentions the problem related to the affordability of these cookers, but sees in the long run a future for this cooker.

[30] The interview took place in the main office of TaTEDO in Dar es Salaam (28.07.2008)

> *But Africa is getting richer so even the Africans will not use the present solar box cookers if they could get an electrical stove, so my aim was actually to start a bit ahead to be able to produce a system with storage, and with a performance similar to the electric ovens. (Interview Løvseth, November 2008)*

However, Jørgen Løvseth also argues that it could be possible to improve the technology of current existing solar cooker types. One major attempt could include a heat transfer mechanism and to change the parabolic concentrating solar cooker to a rotating system so that the cooker's position does not have to be adjusted that frequently.

> *Most of the solar cookers could easily be improved by a person with knowledge of heat transfer. […] In general if you produce a solar box cooker, you should actually try to get hold of a heat transfer specialist or a person with knowledge about solar technology in general, to improve your construction. It goes for insulation and it goes for quality of reflectors which I saw. […] The parabolic cooker that you have to adjust the position every 15 minutes, you could easily make this into a rotational system. (Interview Løvseth, November 2008)*

In Moshi, the women of the KASI solar cooking project presented a solution to the problem of maintaining heat after cooking. They used a so-called fireless cooker or retained- heat cooker. According to Don O'Neal (2007), retained heat cooking can be used to reduce the use of firewood. It can be used to keep food hot for a later meal and it is easily applied to food that cooks long time, such as beans. The food can be simmered over fire for some time and then placed into a fireless cooker to complete the cooking cycle (Don O'Neal, 2007). The key to the retained heat cooker is the insulation. *"The purpose of the insulation is to retain the heat of a boiling pot long enough for the contents to complete the cooking cycle without additional heat."* (Don O'Neal, 2007: 2). The insulation efficiency of the cooker depends on the materials which are used to keep the pot at a cooking temperature for an extended amount of time.

In Moshi, I was able to visit the Kilimanjaro Biogas and Solar Centre where Sperancea Gabone is working with the production and promotion of solar cookers at different schools in Moshi. During my visit, she showed me a fireless cooker. This fireless cooker was made of a basket which uses wool blankets and pillows as insulation. The food is normally cooked in a black pot in a solar cooker. After cooking is completed, the pot is placed in the middle of the insulated basket and then covered with wool blankets and/or pillows. Figure 22 presents a fireless cooker such as those used in Moshi.

Figure 22 Fireless cooker, Moshi
Source: Pia Otte (2008)

This shows that there is a current solution to maintain the heat after cooking. However, a fireless cooker does not present an alternative for entirely cloudy days, where cooking with a solar cooker is not possible. In this case, the development of a small scale concentrating solar system with heat storage presents a suitable more reliable alternative since it is able to store the energy from sunny days, depending, of course, on how much energy is used for cooking.

The section so far showed several perspectives of Solar Cooking, including the problems and possible ways of improving the solar cookers. The interview showed that solar cookers are facing many problems today, varying from technical problems to difficulties regarding the social acceptance and sustainable implementation of the cookers. The researchers mentioned different approaches which should be considered in order to improve the cookers. The next section deals with the researchers' opinion regarding to what extent these improvements are realizable and what 'the future' of Solar Cooking is.

8.1.3 Does Solar Cooking have 'a future'?

Osman claims that there is 'a future' for Solar Cooking in arid areas that have high sun radiation. Besides the geographical considerations, he emphasizes the importance of introducing Solar Cooking to people as a business and not as a project to ensure the sustainability of the project and increased spread of the solar cooking concept.

Cuamba sees a future for Solar Cooking in terms of the concentrating solar energy system with heat storage. He also claims that the introduction of such a developed technology could also enhance the adoption of simpler Solar Cooking technologies as the box cooker for example.

Jørgen Løvseth believes in the future of the small scale concentrating system with heat storage, which he is working on at the moment. He does not see a future for direct solar cooking applications in the long run if they are not improved.

> *They (the solar box cookers) will have a future as long as we have women going around without capital and without background to do a paid work because they are cheaper. We can not compete in price as long as we have women who think it is ok to wait four hours- at least three hours- before the meal is cooked. But they should be improved I would say because normally there has been interest […] or maybe now it is coming in Tanzania. (Interview Løvseth, November 2008)*

In addition to the technological weaknesses of current solar cookers, Løvseth argues that a gap of a technological tradition in many African countries present a challenge in the further development of solar cooking technologies. He is also facing this problem in Mozambique. The Mozambican Civil War led to a closing of different graduate programmes, including physics, mathematics and chemistry up to 1990. Today, there is a high student enrolment at the Faculty of Science. However, the Faculty at EMU[31] is mainly made up by Mozambicans who earned their university degrees abroad, while Masters-level education programs in science and technology is just starting now (Løvseth, 2007). The existing technological gap in many African countries emerged due to an inadequate education system. In many cases there is a lack of books, school- houses and teachers which lead to insufficient access to education. The challenge is to overcome this lack of education and technological tradition in order to be able to transform developing countries to technologically advanced societies.

> *If the developing countries want to transform their societies into technologically advanced ones, it is necessary also to develop an educational system that can train a workforce able to cope with the challenges of the new society such as developing, maintaining and operating advanced equipment. A solar oven is just one of the ingredients that can make this transition possible in a sustainable way, without deforestation, resource depletion and further harm to the global climate. The importance of a good general and vocational school system is often overlooked – as well as the importance of tradition to the functioning for the society- change will take a long time to be sustainable. (Interview Løvseth, November 2008)*

In addition, Løvseth sees the role of developed countries in assisting the developing countries to make them capable for technology development. He describes technology development as costly and requiring considerable skill and experience, which has to a large extent provided by developed countries but preferably in cooperation with countries in the south.

[31] Eduardo Mondlane University

8.2 Conclusion

The views of Solar Cooking by NGOs and the users of solar cookers presented in the previous chapters represent one side of the solar cooking coin. In order to gain a broader perspective on Solar Cooking, researchers and other agencies involved in solar energy were interviewed. The problems associated with Solar Cooking mentioned are many and combine not only economic, cultural/social and technological reasons, but also communication problems between solar cooking agencies. The methods of improvement and the future prospects of Solar Cooking are as manifold as the problems. Osman argues that Solar Cooking has only a future in areas with enough sun in Tanzania. Also, Solar Cooking has to be introduced in a holistic approach which includes presenting Solar Cooking as a business from which people can benefit. Cuamba and Løvseth see only a future for Solar Cooking if the current problem of no heat storage can be solved. Claims were also made that Africa has to overcome the current existing technological gap in order to develop successful solar technologies.

One could ask now which is the most suitable approach to overcome the limited adoption of Solar Cooking. There is no easy answer. The different views of the informants showed that the problems of Solar Cooking are various, as well as the suggested solutions. There are several issues that prevent a broad application of solar cookers, ranging from the performance of the technology to a criticism regarding the project's approach to implement solar cookers. There is not one single solution for solving the problem of the limited adoption of Solar Cooking. Instead, there is a need of a holistic approach which considers the multifaceted problems and elaborates an improved solution based on this view.

CHAPTER 9: CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

The purpose of this study was to analyse three different solar cooking projects in Tanzania with respect to their adoption and impacts on people's lives. The specific objectives of the study included the following questions:

- What limits or enables the success of Solar Cooking?
- Why do people decide to use or not use solar cookers?
- What can be done to increase the adoption of Solar Cooking?

Also, the study investigated the impacts of Solar Cooking on people's lives and the ways in which it contributes to development. In particular, this included the answer to the following question:

- Does Solar Cooking lead to development?

To answer these questions, interviews were conducted with solar cooker users, coordinators of the three solar cooking projects, researchers in the field of solar energy, and other agencies involved in Solar Cooking. The following part reviews the four research questions and their findings.

What limits or enables the success of Solar Cooking?

In this study, seven different dimensions were identified as having an impact on the success of Solar Cooking. The seven dimensions are economic affordability, social and cultural values, information, infrastructure, technology, sustainability and the area, or locale, where the project takes place.

Problems related to technology were reported as a limiting factor for the successful implementation of Solar Cooking by solar cooker users of all three projects. In particular, the performance of the solar cookers during the rain season was singled out as a factor that limits the use of the solar cooker. Also, the parabolic and box cooker applied in the different project are characterised by different advantages and disadvantages. In all three projects, the participants appreciated the fact using a solar cooker does not require the use of fuelwood, which leads to financial savings. On the other hand, problems related to the enormous space of storage and the high reflectance of the cooker, were mentioned by users of the parabolic solar cooker. Users of the box cooker mentioned problems regarding the performance of the

cookers. The locally produced sun ovens can not compete with the performance of the original American produced sun oven. Besides, the two projects require the purchase of a solar cooker, showing that there are problems related to the economic affordability of the solar cookers. The project coordinators and the solar cooker users claim that there is a demand of people willing to use solar cookers, but the high prices seem to discourage them from adopting it.

Furthermore, in the analytical framework, social and cultural values are seen as factors which can influence the success of Solar Cooking. In the case of the three projects in Tanzania, the solar cooker seems to conform with traditional cooking habits. The informants reported that the use of solar cookers does not require any changes in the type of food they cook. Also, the increased cooking time in comparison to the use of fuelwood was not seen as a limiting factor for the use of solar cookers. (The second part of the conclusion will discuss the impact of increased cooking time in more detail).

As another factor, sustainability of the solar cooker project was defined as having an influence on the success of Solar Cooking. The study showed that a project that lacks sustainability can limit the success of Solar Cooking. The project in Moshi is characterised by a lack of solar cookers, which limit the wider application and success of Solar Cooking in society. On the other hand, the project by Solar Africa Network on Zanzibar proved that the approach of introducing Solar Cooking as a business to women makes it more sustainable and thus enables a successful implementation. Additionally, the local production of solar box cookers in Masasi is a first step to make solar cookers available to people in the long term. A well established information flow is considered to enable the success of Solar Cooking since it can convey relevant information to the members of a community/village/town/region. In Masasi, it was seen that the promotion of Solar Cooking is mainly constrained to Masasi town due to the lack of employed motivators who advertise the use of solar cookers in other villages.

As a last factor, infrastructure is considered to have an influence on the success of solar cooking projects. In Masasi, an existing lack of infrastructure limits the spread of Solar Cooking. The former motivators travelled mainly by bike to demonstrate the use of solar cookers. Long distances between the villages and poorly developed roads made the transportation of solar box cookers a challenge.

The section showed that the success or failure of Solar Cooking is also limited by the technology factor. The study showed that the approach of implementing a technology plays an important role as well. For example, problems related to the technology such as slow cooking rates, need for a large storage space, and limited use during rain season all influence the success of Solar Cooking. On the other hand, however, even a high efficiency, user friendly solar cooker technology will not succeed if the implementation is not sustainable. The method used by organisations to implement a solar cooker and sustain the project is an important factor which must be considered just as important as the technology itself for a successful implementation.

Why do people decide to use or not use solar cookers?

In order to identify the reasons for why people decide to use or not to use solar cookers, the Innovation- Decision Model by Rogers was introduced and discussed in relation to Solar Cooking. The model considers the decision of an individual for an innovation as a process over time which comprises five different stages or phases: the stage of knowledge, persuasion, decision, implementation and conformation. The study showed that the seven different factors identified in this study as having an impact on the success or failure of solar cooking projects influence the decision of an individual at different stages. Beginning at the first stage, it was shown that a necessary precondition for being able to decide about using a solar cooker is the existence of awareness of Solar Cooking among the intended users. A lack of infrastructure and a limited flow of information regarding Solar Cooking can prevent people from learning about Solar Cooking. Potential users also have to be aware of the benefits of Solar Cooking in order to form a positive attitude about Solar Cooking in the persuasion stage. In the study, the solar cooker users reported of several benefits which led to a positive attitude towards solar cookers. Some of these benefits included easier cooking, financial savings and improved health.

In the decision stage, different activities have to take place which enable or contribute the choice to adopt solar cookers. In this stage, workshops or public demonstrations on the use of solar cookers can contribute to a decision for Solar Cooking. To ensure a successful implementation of solar cookers, which includes frequent use of the solar cooker, the technology has to be improved such that it can also work efficiently in the rain season. As a last point, Rogers' model includes the confirmation stage in which an individual seeks reinforcement for their earlier decision. In this stage, the sustainability of the project plays a major role. Organisations introducing solar cooking technologies have to be present as a

counselling institution for solar cooker users in an area in order to offer help and assistance when questions or problems with the cooker arise, and to address the doubts of potential users who have not yet been convinced.

What can be done to increase the adoption of Solar Cooking?

To increase the adoption of solar cookers, several hindrances must be overcome. These hindrances are not only limited to the dimensions often mentioned in the literature, which are namely the high purchase prices and the inconsistence of solar cookers with people's traditional cooking habits.

The interview with a local engineer in Moshi in particular showed that there must be more factors at work than the high prices of solar cookers which cause non-adoption of Solar Cooking. The interviews with the researchers confirmed the picture that the adoption of Solar Cooking is influenced by several different factors. The researcher interviews presented a picture of many problems and suggested solutions related to or for Solar Cooking. One claims that the focus should be on sustainable implementation of the cookers and improving the affordability. Another suggests introducing Solar Cooking as a business venture to people. People have to see how they will benefit from using a solar cooker. A solar cooker must give them something that they are willing to use. Others focus on the improvement of the technology, which includes enabling the cookers to store heat and improving the system such that it allows cooking indoors. The vision is a small scale solar concentrating system with heat storage which will be similar to a normal kitchen unit.

The various views of the problem of solar cookers, ways of improvement and future perspectives show that there is not a single certain way to increase the adoption of solar cookers. For example, in order to overcome the problem that Solar Cooking is not affordable, one could argue that the donation of solar cookers could solve the problem, but unfortunately, it is not that easy. The situation is complex and the influences on Solar Cooking are multifaceted. The donation of solar cookers would be a solution in the short term for a certain group of people, but would not improve the overall situation of Solar Cooking. The KASI solar cooking project showed that the donation of solar cookers could help a group of women to improve their situation, but according to Urassa, the demand is much higher than the number of solar cookers available.

Does Solar Cooking lead to development?

One of the research objectives of this study was to identify in which way Solar Cooking leads to development. The definition of development in this study was based on the concept of the Capability Approach, which describes development as the freedom of living the life people want to live, and of doing things people want to do. This means that development is understood as an expansion of certain capabilities. In chapter 4, the Capability Approach Model according to Robeyns was introduced, applied and presented in relation to Solar Cooking. It was an aim of this study to identify certain dimensions of this model. The basic background of the model was that Solar Cooking is a good, which is of certain interest to people because of its different advantages (including, for instance, better health or financial savings).

In the model according to Robeyns, it was claimed that the conversion of a certain good to achieved functionings is influenced by different conversion factors. Social, personal and environmental conversion factors. The study could identify how these factors influence the conversion of certain characteristics of Solar Cooking into achieved functionings. It was presented that the existence of social conversion factors as, for example, gender relations, can influence the characteristics of a solar cooker to an achieved functioning. The different projects showed that the support from women's husbands at home can contribute to achieve the desired functioning. On the other hand, negatives attitudes of side of the husband, related to Solar Cooking, limits the conversion of the functionings. In addition, personal conversion factors play an important role. It was shown that potential solar cooker users have to learn how to use a solar cooker. This means that a workshop is necessary in order to teach the essential skills to people so that they can convert the desired functionings of Solar Cooking to achieved functionings. Last, but not least, it could be presented in this study that environmental conversion factor play an important role in terms of Solar Cooking. The rain season presents a major problem which limits the use of solar cookers and, consequently, the conversion of its funcionings. On the other hand, areas where biomass is rare, support the use of solar cookers and, in this way, its conversion to the achieved functionings of a, for example, healthier life with fuel savings.

The main focus of the model presents the capabilities. Capabilities were defined as the freedom of people to live the lives they want to live. In this study, a set of relevant capabilities was defined, including health, income generating activities, social relations, education and

knowledge, time autonomy and leisure activities. The study investigated the ways in which Solar Cooking contributes to an expansion of these capabilities.

The analysis could conclude that there is an improvement of women's perception of their own health since they have been using solar cookers. In addition, there is a considerable amount of time that is gained by the women. While the cooking time with a solar cooker is longer than that of charcoal or firewood cooking, there is an enormous time gain during the cooking process since the solar cooker does not require constant attention as firewood or charcoal does. It was realized during this study that the time gain is connected to the surroundings of the cooking area since the solar cooker has to be tracked with the sun. This let to the conclusion that the quality of gained time found in this study is different than the time gain assumed by solar cooking proponents who focus on the time saved by not collecting firewood. This type of time gain is related to a greater freedom of time while the food is cooking. The interesting question was to find out how the solar cooker users used their gain in time. It was investigated whether this time gain led to an increase political participation, social relations or education. The study could not prove an expansion of these capabilities. Chapter 7 discussed this issue and showed that there are different explanations for why this study does not include any data related to an increase of political participation, social relations, leisure activities or education. One explanation was that the new surplus of time is spent tied to the cooking area since the cooker has to be moved periodically. The women do not have to watch the food as frequently as with the use of firewood or charcoal, but nor can the solar cooking process take place completely without supervision. A second explanation is related to the Capability Approach itself and the difficulty of measuring the defined set of capabilities. Capabilities are defined as possible opportunities people can choose in their live, but which they do not have to choose. The problem is how to prove that social relations, political participation, education and leisure activities increased, if it was not confirmed by the informants in the interviews. Can it be possible that women have time to be, for instance, politically active but that the interviewed women just did not choose to be so?

A third explanation is that the methodology chosen can be regarded as having an impact on the results of this study. In CHAPTER 7 I explained that I decided not to ask questions directly related to topics such as political participation or social relations. I decided to ask the informants open-ended questions about what they are doing with their increase in time in order to avoid directing them to a certain answer. It cannot be excluded that a more direct question regarding these capabilities would have led to different answers.

A fourth explanation was shown is related to the high demand of this study to claim that only the change of a cooking device can increase for example people's political participation. These different explanations lead to the conclusion that this study can not exclude the possibility of an increase in the capabilities but neither can I disprove an expansion of these capabilities in this study. What can be proved in this study is that the time gain women experience through the use of a solar cooker is often used for domestic work or to pursue a business, which can be the production of baskets, the management or ownership of a small store, or the preparation of batik shawls. This increase in income generating activities leads to an increase of people's financial savings. However, the savings are small and often used for the fulfilment of certain needs, such as the payment of medication, clothes, food or the money invested into the business. Whether the money is enough to deposit in a bank account remains unknown. The women did not give any statement or evidence that the money is placed in a bank account.

However, I have to be careful to conclude that this is due to the fact that there are no savings. In chapter 7, I discussed how difficult it is for me, as a person coming from one of the wealthiest countries in the world, asking these women in Tanzania what they are doing with their money savings It is possible that the women have some savings in a bank, but that they did not want to admit it in front of me; maybe because of fear that others could find out or simply embarrassment.

9.2 The analytical framework revised

In Chapter 4, the analytical framework for this study was presented. This framework was used to investigate the factors influencing the decision process of an individual whether or not to adopt Solar Cooking.

Figure 23 presents the revised analytical framework. It combines the two theories, Innovation Decision Process and the Capability Approach. The figure shows that an increase of certain capabilities can only take place if an individual decides to use a solar cooker. The decision for Solar Cooking is influenced by seven factors which were explained earlier in this section. In Figure 23 we can see that the successful adoption of a solar cooker leads to a considerable positive change in people's perception of their own health. In addition, it leads to a gain of time and thus to increased freedom of time. Whether this gain of time leads to increased activities of political participation, social relations, education and leisure time remains unclear.

The figure does, however, show that the increased time through Solar Cooking enables women to pursue their business and/or do their domestic work during the cooking period. Thus, it can be concluded that the Capability Approach applied to Solar Cooking could show that Solar Cooking leads to a development in terms of a positive improvement of people's perception of health and an increased freedom of time.

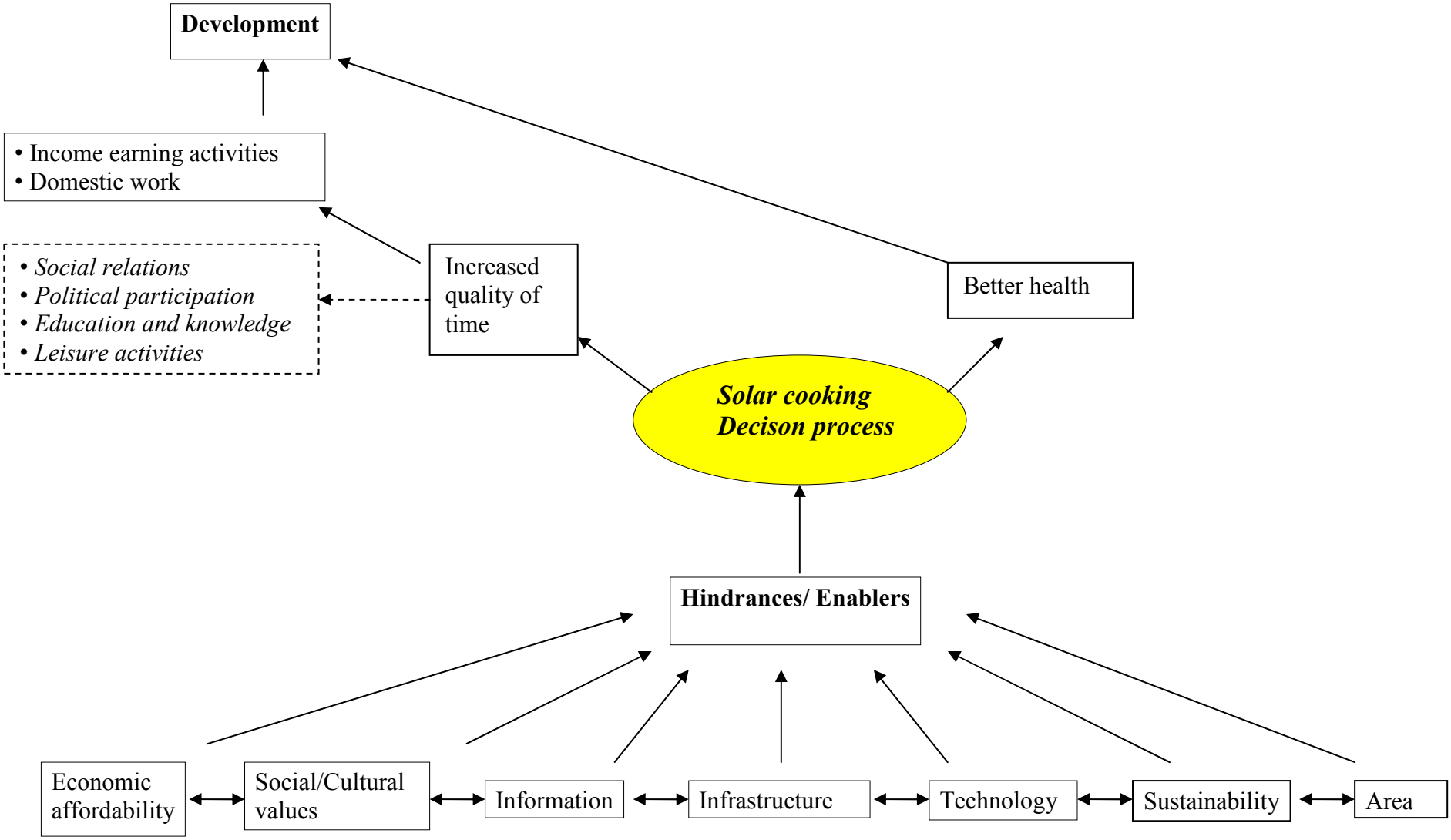

Figure 23 Analytical framework revised

9.3 Recommendations

The motivation of this study was the claim that decades of efforts to implement solar cookers have not helped to achieve the breakthrough of this technology (GTZ, 2007). This study investigated three different solar cooking projects and showed that solar cookers have been adopted to a certain degree in these projects. However, solar cookers seem to face several challenges. The interviews with solar cooker users showed that problems related to the performance, the storage and use of the technology limit the people using the cookers. Additionally, the solar cookers seem to be too expensive for these limitations. The interview with the engineer in Moshi showed that there are people who are able, and willing, to pay even higher prices for cooking devices other than a solar cooker, if they perceive certain benefits of these devices over a solar cooker.

Considering these hindrances, the question emerges whether solar cookers still present an adequate alternative of energy supply in Tanzania. My answer is both "yes" and "no." Solar cooking presents *one* alternative in finding an adequate alternative to fuelwood but is not the *only* solution. It can present an adequate alternative for Tanzania's rural dry areas where Solar Cooking fits into people's traditional way of cooking and where NGOs are present to make solar cookers affordable and available in a long term.

However, in order to improve the adoption of Solar Cooking, I agree with the suggestion that there is a need for a holistic approach. This approach includes the cooperation among different actors in the field of Solar Cooking, the donors, the developers of the technology, the NGOs promoting Solar Cooking and, particularly, the intended target group.

Also, the key requirement for increasing the success of Solar Cooking is particularly to strengthen the communication between solar cooking organisations. According to Mwandosya, et al. (1997), efforts to introduce wood energy conservation practices have been uncoordinated and carried out in a disjointed way. Mwandosya, et al. (1997) claims that there is the need for increased interaction between different initiatives to share information and experiences. A better network between solar cooking organisations could also reduce the cost and time for the implementation and distribution of solar cookers. Furthermore, an increased collaboration and communication among solar cooking initiatives can give future solar cooking projects the opportunity to learn from the experiences of current projects and try to modify and improve in areas where previous projects failed. In Tanzania, several projects can be found promoting the use of solar cooking. These projects all seem to work more or less

independently from each other. If these projects were connected in a network together with the donors, the developers and experienced solar cooker users, they could help to remove current constraints and problems for facilitating the broader adoption of Solar Cooking.

Finally, solar cooking promoters should pay more attention to people's voices in their projects. By people's voices, I mean solar cooker users as well as non- users. This study was based on interviews with solar cooker users and did not include the opinions of non-users. In order to gain a larger picture of why people are not using solar cookers, the consideration of non-users in the research process is indispensable. Also, in order to be able to improve the cookers, a consultation with the solar cooker users is necessary since they are the most familiar with the application of the technology and are more likely to have suggestions on how to improve the cookers. This means that the greater involvement of the general population's participation in the planning, dissemination and monitoring of solar cooking projects presents an important tool for the successful implementation of a solar cooking project.

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Appendices

Appendix I Alternative energy supplies for cooking

Improved biomass use

For many households in developing it is not possible to switch away from traditional biomass in a short term. Another way can be therefore to improve the way biomass is used for cooking to reduce its harmful effects. The improvement can be achieved through transformation of biomass into less polluting forms or through the use of improved stoves. Charcoal and agricultural residue briquettes present one form of efficient transformation of biomass. The briquettes have a higher energy content than fuelwood and reduce thus the amount of fuel needed. Another approach is the usage of improved stoves. These stoves are designed for low-income households and have a higher energy efficiency. The two main technical principles are an improved combustion and improved heat transfer to the pot (Kees, 2008). An increased combustion efficiency decreases harmful emissions which and reduce in this way the degree of indoor air pollution. In addition, an increased heat transfer leads to a higher efficiency of the stove. Less firewood is needed which reduce the cost and time spent for gathering firewood.

The idea of improved cooking stoves is not new. Already in the late 1970s and early 1980s programmes supported by developing country governments, donors, NGOs and others were introduced. The assumption was that people would adopt the technology quickly and that an initial intervention would lead to a self- sustaining programme (Barnes & Floor, 1996). The efforts were mainly focused on the dissemination and different factors as for example local customs, the economic setting, availability and prices of local biofuels were ignored. In addition, the energy efficiency of the improved stoves was overestimated. It was expected that improved stoves would decrease the wood consumption by 75 percent or more. According to Barnes & Floor (1996) a decrease of 25 percent is realistic. As a consequence of these wrong assumptions, many early programmes failed.

Nowadays there have been done many efforts to improve the efficiency of the stoves and the economic returns of successful programmes have been good in urban and rural areas. For example the money saved on purchased fuel in urban areas can pay off the investment in improved stoves in a few months. In rural areas fuel for cooking is often collected. Here the time spent gathering fuelwood is enormously reduced (Barnes & Floor, 1996). In addition to these two mentioned options, a changing behaviour plays an important role when reducing the

exposure to indoor pollution. For example drying fuel before using it, improves the combustion and lowers the smoke production. If young children are kept away from the hearth prevents them from the breathing in the health- damaging pollutants. These advices are not as effective as the mentioned solutions before but they have to be considered for different interventions (Rehfuess, 2006).

Modern cooking fuels

Modern cooking fuels are defined as those which have a high energy density, high combustion efficiency and high- heat transfer. It can be divided between gaseous and liquid modern cooking fuels. Biogas and LPG are commonly used gaseous fuels while kerosene and jatropha are liquid cooking fuels. In the long term modern cooking fuels can be an appropriate solution.

Kerosene

Kerosene is a petroleum- based fuel produced in oil refineries. Kerosene is mainly used in urban areas of Africa but its level varies across the countries. In Tanzania it is only used by 15 percent of urban households while in the neighbouring country Kenya it is used by 57 percent (Schlag & Zuzarte, 2008). Kerosene is dangerous to use because its toxicity and flammability. In addition it produces soot and other particulates when burned therefore it can not been seen as a “real” modern fuel but however it represents an improvement over other woodfuel.

Jatropha

Jatropha is a plant which is easy to establish and drought resistant. It is often used by farmers in rural villages to protect crops and, prevent erosion and to demarcate property. The plant can live up to 50 years and produce seeds up to three times per autumn (Eijck & Romijn 2008). Jatropha grows wild in entire Africa including Tanzania and similar oil crops can be found in Asia and Latin America (Eijck & Romijn 2008). The oil which is extracted from the seeds can be used for different applications. It can be used as a cooking fuel, for soap production and for medical purpose. In addition it could become important for producing bio diesel.

However current developed technologies for plant- oil stoves still face too many disadvantages for a successful implementation. Stoves which have been produced so far do not work properly and do not satisfy the users (Eijck & Romijn 2008). In addition, the emissions of the stove are dangerous which prevents jatropha to be an attractive alternative for cooking (Schlag & Zuzarte 2008). There is a need of improved stove systems which can reduce the emissions and thus make jatropha oil to an attractive alternative to traditional fuels.

Biogas

"Biogas is a clean cooking fuel that is produced through the anaerobic digestion of various organic wastes; the most commonly used feedstock is animal waste." (Schlag & Zuzarte 2008: 5) The digestion process produces a mixture of methane (60 %) and carbon dioxide gases (40%) [32] from which the carbon dioxide can be separated to increase the energy density of the gas. The result of this process is a clean fuel that produces no smoke or particulate matter on combustion. Biogas reaches a total energy efficiency of 60 percent which makes it to an attractive alternative to traditional cooking fuels. Biogas is a combustible gas and can be among other things used for cooking (Sudi & Ngowi, 1999). Biogas is especially applicable in rural areas and offers there a potential for sustainable development projects. In several countries efforts were made to introduce digesters to rural areas but unfortunately without much success. In Tanzania, biogas technology was first introduced by SIDO (Small Industries Development Organisation) in 1975 and in the 1980s a programme was developed which aimed to disseminate biogas technology but only 200 digesters were operating in 1991 (Rutamu 1999 citied in Schlag & Zuzarte 2008:5). It seems like that biogas projects have been much more successful in China and India where can approximately be found 1 millions and 2.9 million digesters (Bizzo et al. 2004 citied in Schlag & Zuzarte 2008:5).

Liquefied petroleum gas (LPG)

LPG presents a mixture of propane and butane gas. It is considered to be a clean fuel because it can be efficiently burned and has a low pollution rate. In addition, it is non- toxic and the specialized stove required for the combustion is simple and easy to use. LPG has a high energy efficiency of between 45 and 60 percent (Bailis 2004 citied in Schlag & Zuzarte 2008:5). In Africa it is used as a cooking fuel but its usage varies between the countries and is dependent on government policy. Senegal shows the greatest success in integrating LPG in household applications while in many Eastern African countries the market for LPG is almost non- existent.

Ethanol

Ethanol is produced by fermenting the sugars in various types of biomass feedstock. It can also be produced from starches if they were concerted into sugars. Ethanol can be burned directly in special stoves but even better is a further conversion to gelfuel which is an easy process and offers several advantages. Ethanol in liquid form can cause burns which can be prevented by the use of gelfuel. Today Ethanol is mainly used as an additive in transportation

[32] Sudi & Ngowi (1999)

fuels but it could also meet the needs of household cooking needs in Sub- Saharan Africa the future. It is mainly seen as an energy solution for the urban population because of its large output of ethanol distilleries. To this day ethanol is not widely available in Sub-Saharan Africa but several projects attempt to introduce it into different communities (Schlag & Zuzarte 2008).

Electricity

According to Schlag & Zuzarte (2008) electricity presents a clean and efficient source of energy but because of a poor developed grid in most developing countries just a few households have access to it. In addition, most of the electricity that is generated in Sub-Saharan Africa is used for industrial or commercial purposes. The use of electricity for cooking is for most of the people not realizable because of unaffordable. Figure 24 confirms this picture, except for Mauritius and the countries around South Africa in the Southern African Customs Union (SACU) the share of population with electricity access is very low while the ratio of fuelwood consumption out of the total energy is high.

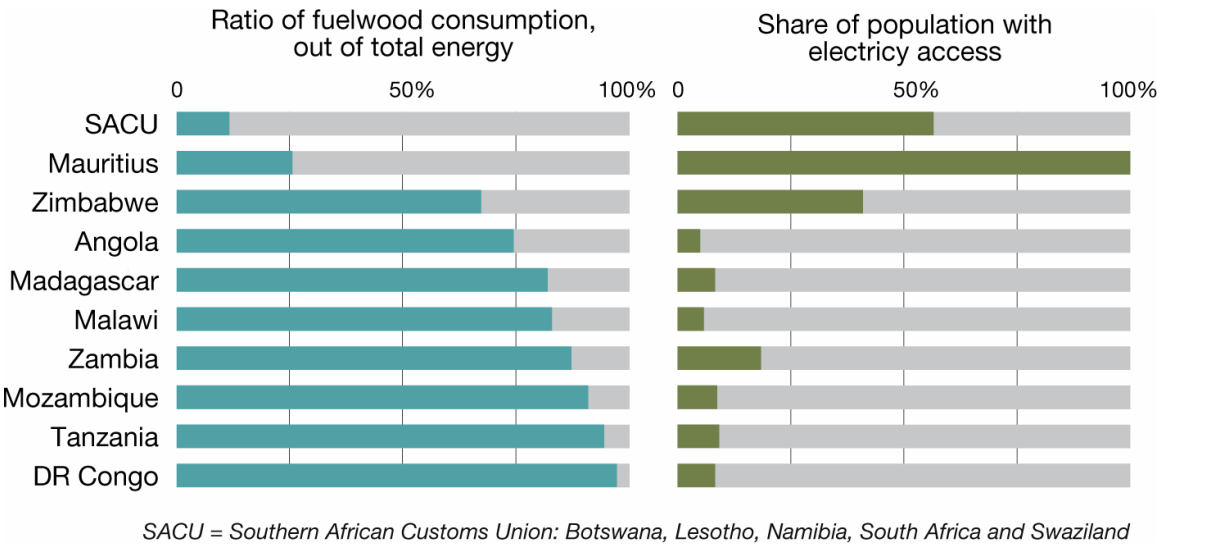

Figure 24 Electrification and traditional fuels in Sub- Saharan Africa

Source: UNEP & Grid Arendal (2008)

In addition, domestic use of electricity is almost exclusively concentrated in urban areas. For example the greatest access to electricity in Tanzania is in Dar es Salaam but also here less than 50 percent of all households are connected (Poverty and Human Development Report, 2007).

Appendix II- Table of countries with at least 1000 solar cookers

Nandwani (1996) presents a table which includes a list of countries which have at least 1.000 solar cookers. The list is based on a literature survey. The list is presented in Table 4.

India	340.028 (Garg,1995)
China	140.000 (Hongpeng, 1995)
Tibet	20.000 (Hongpeng 1995)
Pakistan (Afghan refugees)	10.000
Switzerland	6.000 (Sustainable Energy News, 1994)
United Nations of America	3.000
South Africa	2.720 (Solar Box Journal, 1994b)
Kenya	1.250
Ladakh, Mexico, Nicaragua, Costa Rica, Ecudador, Chile, Nepal	2.100
Total	525.000

Table 4 Number of solar cookers constructed and/or distributed in different countries

Source: Nandwani (1996)

Appendix III- Interview guides

Interview guide- solar cooker users

1. **Purpose and guidelines of the interview**

2. **Background of the informant**

   - How old are you?
   - What is your profession?
   - How long have you been living here?
   - Family background? (children, husband/wife, educational background)

3. **Solar cooking project**

   - Why did you participate in a solar cooker project?
   - How did you get to know about the project?
   - Did you get any training of how to use a solar cooker?
   - If yes, how long was the training?
   - Are you using solar cookers now? If not, why?

4. **Solar cooker itself**

   - When did you start using a solar cooker?
   - What kind of food do you prepare with a solar cooker?
   - Are there any problems related to the use of the solar cookers?
   - Do you need any assistance when using a solar cooker?

5. **Impact of solar cooker on daily life**

   - How much time did you spend for cooking before using the solar cookers? How much time do you spend now?
   - Do you have more time now?
   - If yes, how are you using the time? What are you doing while the food is cooking?
   - Is it easier to cook now?
   - Can you prepare the same food with a solar cooker as before?
   - When do you normally start cooking?
   - Are you using less fuelwoood/charcoal since you started solar cooking?
   - If yes, what are you doing with the savings?
   - Are there any other changes since you have started using a solar cooker?

6. **Acceptance& Participation**

   - Are many of your neighbours participating in the projects?
   - Do many of your neighbours use solar cookers?
   - What do you think could be the reason why people do not participate?

7. **Recommendations**

   - Anything you would like to mention?
   - Thank you!!

Interview guide- NGOs

Purpose and guidelines of the interview

Background of the NGO

- When did the NGO start?
- Origin of the NGO?
- Years of presence?
- Reasons of presence?
- Staff, nationality, background
- How many people are employed?
- Is there any cooperation with other NGOs?
- Any links with academical research?
- What about funding? Do you get any funding? Are there any links with international NGO's/ donors?

Project itself

- Could you describe the projects a little bit?
- Could you describe the solar cookers you are promoting?
- How are they working?
- Why this type of solar cooker?
- What is the main goal/aim of the work?
- How do you try to achieve these goals?
- What have you achieved so far?
- Who is participating in the projects?

Acceptance of the solar cookers

- What are the problems in the projects?
- How do you try to solve these problems?
- If there are problems with the acceptance of solar cookers, what do you think could be the reasons for this?
- How do you think you can get more people involved?

Future perspectives

- What are the future perspectives of the projects?
- Is there anything which should be changed in the future?
- Thank you!!

Interview guide – Researchers/experts

1. **Purpose and guidelines of the interview**

2. **Personal Background**

    - Profession?
    - What are you doing at the university?

3. **Research solar cooker**

    - How long have you been working with solar cookers?
    - What is your research exactly about?
    - What type of solar cooker are you working with?
    - Which type of solar cooker would you say is the most suitable?

4. **Solar cookers, their problems and way of improvement**

    - What are the problems related to Solar Cooking?
    - How can Solar Cooking be improved?

5. **Future of Solar Cooking**

    - Do you think Solar Cooking has a future? (Which type of solar cooker has a future?)
    - What has to be done that Solar Cooking has ‘a future’?
    - Is there anything that should be changed in the future?
    - Anything else you would like to mention?
    - Thank you!!