

**ASSESSMENT OF ENERGY EFFICIENT ROCKET STOVES
CONTRIBUTION ON DEFORESTATION CONTROL IN
TANZANIA, A CASE STUDY OF CHAMWINO DISTRICT IN
DODOMA REGION**

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TANZANIA, A CASE STUDY OF CHAMWINO DISTRICT IN
DODOMA REGION**

**By
Annamaria Cornelius Gerome**

**A Dissertation Submitted in Partial Fulfillment of the Requirements for Award
of the Degree of Master of Science in Environmental Management (MSc. EM) of
Mzumbe University**

2015

CERTIFICATION

We, the undersigned, certify that we have read and hereby recommend for acceptance by the Mzumbe University, a thesis/dissertation entitled **Assessment of Energy Efficient Rocket Stoves on deforestation control in Ikowa and Membe Wards in Chamwino District, Dodoma Tanzania** in partial/fulfillment of the requirements for award of the degree of Master of Science in Environmental Management (MSc. EM).

Major Supervisor

Internal Examiner

Accepted for the Board of the Institute of Development Studies

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DEAN/DIRECTOR, FACULTY/DIRECTORATE/SCHOOL/BOARD

DECLARATION

I, Annamaria Cornelius Gerome, declare that this thesis is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Signature.....

Date.....

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I am, however, solely responsible for any errors in the content of this research work

DEDICATION

This work is dedicated to my lovely parents Mr and Mrs Cornelius Gerome and all relatives and friends for their moral, psychological, and financial support for my education. Your presence has been of valuable contribution to my success.

ABREVIATIONS

APC	Aprovecho Research Center
CF	Conceptual Framework
CO ₂	Carbon dioxide
DEMO	District Environmental Management Officer
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FC	First Climate
FO	Forest Officer
FGD	Focus Group Discussion
JFM	Joint Forest Management
KCJ	Kenya Ceramic Jiko
MLNRT	Ministry of Lands, Natural Resources and Tourism
MNRT	Ministry of Natural Resources and Tourism
MTNRE	Ministry of Tourism, Natural Resources and Environment
NBS	National Bureau of Statistics
NEMC	National Environmental Management Council
NEP	National Environmental Policy
NFP	National Forest Policy
NFP	National Forest Programme
NGOs	Non-Governmental Organization
REDD	Reduced Emissions from Deforestation and Forest Degradation

SEAS	School of Education, Arts and Science
SPSS	Statistical Package for the Social Sciences
STT	Sunseed Technologies Tanzania
STTO	Sunseed Technologies Tanzania Officer
TAFORI	Tanzania Forest Research Institute
TATEDO	Tanzania Traditional Energy Development and Environment Organization
TFSA	Tanzania Forest Services Agency
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environmental Programme
URT	United Republic of Tanzania
USA	United States of America
USGS	United States Geological Survey
VLFRs	Village Land Forest Reserves
WB	World Bank
WEO	Ward Executive Officer
WEO	World Energy Outlook
WPR	World Population Review
WRI	World Resources Institute
WRS	World Reference System
ZFDP	Zanzibar Forestry Development Project

LIST OF ACRONYMS

Kms	Killometers
%	Percentage
Tshs	Tanzanian shillings

ABSTRACT

Deforestation is undeniable fact that it is a worldwide environmental concern. This study assessed contribution of energy efficient rocket stoves technology in deforestation control at household level in Chamwino District whereby it specifically examined adoption and adaptive use of energy efficient rocket stoves technology. It also explored the impact of energy efficient rocket stoves technology in rate of deforestation and identified challenges in adoption and use of energy efficient rocket stoves technology in the study area. The study involved 114 respondents including randomly selected 100 households and 14 purposely selected key informants such as WEO, VEO, DEMO, FO and STT Officers. The data were collected using structured questionnaires, interviews, focus group discussions, participant observation and documentary review. Quantitative data were analysed using descriptive statistics while qualitative data were analysed through content analysis based on emerging themes. Moreover, forest cover change was assessed using ERDAS IMAGINE 2014, ArcGIS 10.2.2, Google Earth and Microsoft Office Excel.

Findings showed that, even though the majority (60%) revealed the fact that rocket stoves are efficient in terms of firewood, adoption was only high initially due to promotion by STT project and perceived benefit, later as the project phased out, adoption decreased due to loss of hope and socioeconomic barriers. Even those who adopted the stoves, only few (27%) had adaptive use as the majority turned into use of traditional stoves because the majority (84%) faced challenges in use of the stoves. Among the challenges were easy breaking of the stove, costs of running the stove when broken and cutting of wood into small pieces. Moreover, it was revealed that the rate of deforestation is still increasing despite the introduced stoves. It was therefore concluded that rocket stoves have not helped in control of deforestation. Hence, it was recommended that, people should respond positively towards such projects so that forests are sustained for both present and future generations. Also, the implementers should continue to visit the areas and work on the existing challenges so as to ensure effective adoption as well as use of the stoves even after the phase is off.

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CHAPTER ONE

INTRODUCTION

This chapter provides background information for the study and conceptualizes the research problem. It also defines the research objectives, research questions and significance of the study.

1.1 Background to the Problem

Deforestation has recently become a major concern for many countries in the world. It is one of the most pressing land use problems. Chakravarty (2011) revealed that sufficient evidence exists that the whole world is facing an environmental crisis on account of heavy deforestation. World's forests are being consumed rapidly; more than 30 per cent of the world's forest is believed to have been deforested (Myneni, 2008). Despite the environmental and economic benefits provided by forests (Chakravarty, 2011), trees are cut down for paper and wood products, cooking fuel, commercial and industrial development, house building and furniture-making. Furthermore, trees are cut down to clear off land for road construction, growing crops and to develop pasture for grazing animals (*ibid*).

Deforestation has been practiced by humans for thousands of years chiefly as a result of clearing land (World Resources Institute (WRI) *et al.*, 1996). In Europe for example, the rate of clearance increased during the second half of the 19th century due to agricultural-expansion. Currently major worries concern the loss of tropical rainforest worldwide, whereby one fifth was destroyed between 1960 and 1990, and the loss in 1990s range from 55,630 km to 120,000 km each year. At this rate, all tropical forests may have gone in less than 80 years (*ibid*). Similarly, Chakravarty (2011) showed that the area of tropical rainforest is diminishing and the rate of tropical rain forest destruction is escalating worldwide, despite increased environmental activism and awareness. Africa is the most severely deforested continent. In the continent, forests are believed to have been cleared 29 times faster than they were being planted in the early 1980s (World Bank, 1992). This depletion is of great concern for environment and development in many developing countries.

Deforestation in Africa in particular revealed that unsustainable use of forests has resulted in severe environmental problems, especially land degradation which is manifested by soil erosion, desertification and general loss of productive potential in rural areas. Soil degradation has been the cause of stagnating or declining yields in parts of many countries especially on fragile lands from which the poorest farmers attempt to wrest a living (*ibid*). Deforestation has also affected water catchment areas and destroyed watersheds, affecting the quantity and quality of the water supplies they contain.

In Tanzania, forests and woodlands cover about 34 million hectares (URT, 1998). These forests have unique environmental and biodiversity values, and make available a wide range of products for subsistence use. The most predominant use of wood is in the form of firewood and charcoal by the majority of Tanzanians in both rural and urban areas. According to Malimbwi *et al.*, (2012), firewood is preferred in rural areas simply because it is obtainable for free of charge. Likewise charcoal is preferred in urban areas, because it is considered to be cheap and easy to transport, distribute and store. Furthermore, it is almost smokeless and has a higher energy value than firewood (*ibid*). This wood fuel collection becomes a serious threat to forests in densely populated areas. In rural areas, the impact of wood fuel collection may be offset by natural forest regeneration, but it can become a severe cause of forest degradation and eventual deforestation.

Government estimates that deforestation in Tanzania happens on a rate of 300,000 to 400,000 ha per annum (Ministry of Lands, Natural Resources and Tourism [MLNRT] 1989). In Eastern Usambara, for example, the Amani forest has been reduced by about 50% while in Western Usambara, an estimated average of about 7,000 ha of forest has been cleared annually between 1960 and 1980. Recent estimates suggest that well over 70% of the Usambara forests have been cleared since 1905. In Shinyanga Region, about 1.9 million ha of forest is estimated to have been lost between 1900 and 1984(NEMC, 1995). There is also encroachment on forest reserves for agriculture and other uses. In 1980, about 200 ha of Kilimanjaro Forest Reserve, a water catchment forest were encroached by farmers. The factors

that cause deforestation in Tanzania include expansion and clearance for small scale commercial agriculture, felling for domestic and agricultural fuelwood, charcoal, building poles and export, indiscriminate bush clearing and bush fire and overgrazing (Ministry of Tourism, Natural Resources and Environment (MTNRE), 1994). Increasing demand for fuel and the scarcity of alternative sources is also a major factor that causes a loss of some 575,000 ha annually through fuelwood extraction (Shechambo, 1995). Fuelwood supply to Dar es Salaam city alone has been depleting forests in the surrounding areas at a rate of 75,000 ha per annum. Consequently, today charcoal is brought from distances of up to 200 km inland (MTNRE, 1994).

The gradual disappearance of woodland in circular areas around towns has also been observed in Dodoma. This has caused environmental damage due to use of firewood and charcoal becoming more challenging for the arid and semi arid areas like Dodoma. This situation has influenced Sunseed Technologies Tanzania (STT) to introduce energy efficient stoves (Rocket Stoves) to a local community in the area so as to reduce the use of firewood, and at the same time reduce the workload of collecting firewood and improve the health and quality of life of the community members. Formerly, the community was using three-stone stoves which require much firewood. Therefore, there is a need of continuous efforts in enhancing measures to reduce the rate of deforestation in the study area by promoting sustainable use of the forest. Hence a study of assessing contribution of rocket stoves to deforestation control in Chamwino District.

1.2 Problem Statement

Loss of forest is an alarming problem in Tanzania experienced in many parts of the country. National Environmental Policy (1997) has addressed deforestation to be among the major environmental problems that require urgent attention (URT, 1997). This has also been revealed in a study of Malimbwi *et al.*, (2012) which showed that the country suffers an annual loss of 400,000 hectares of forests mainly due to domestic fuel demand. Moreover, high costs of alternative and much cleaner fuel sources, such as gas and electricity continue to drive the reliance of people on wood and charcoal for the 80 per cent of the population (Philemon, 2012). According to

URT (2008) collection of firewood and charcoal production are among the leading causes of deforestation which are degrading the woodland resources and/or converting them into non-forested lands. In Chamwino District, deforestation is also a problem, the causes of deforestation in this district are multiple and complex as elsewhere in Tanzania, but all are result of human development. If there are no efforts undertaken to act on the situation; the area may turn to barren land like some other parts of Dodoma Region. Recently, the government established the Tanzania Forest Services Agency (TFSA) to help in management of the nation's diminishing forest resources which have come under terrific pressure due to high demand of forest products. However, charcoal as well as firewood remains to be a challenge in conserving and managing forest resources in the country (Philemon, 2012); hence a need of real alternative like energy efficient rocket stoves as an effort to reduce the extent of deforestation in the study area.

Various studies have been conducted on use of different cooking stoves in different areas (Holmes, 2010; Kuria, 2011; and Makame, 2007). However, little has been done on assessing the use of the stoves (particularly rocket stoves) in relation to reduction of deforestation. Therefore, this study was an important step towards bridging this gap whereby it assessed the contribution of energy efficient rocket stoves on reduction of deforestation in Chamwino District specifically at Makoja and Ikowa villages in Ikowa ward, Membe and Mlimwa villages in Membe ward.

1.3 Objectives of the Study

1.3.1 General Objective

This study aimed to assess the contribution of energy efficient rocket stoves to deforestation control at household level.

1.3.2 Specific Objectives

- To examine the trend of adoption of energy efficient rocket stoves technology in the study area.
- To examine adaptive use of energy efficient rocket stoves in the study area

- To assess the impact of energy efficient rocket stoves technology in rate of deforestation in the study area.
- To identify challenges in use of energy efficient rocket stoves technology in the study area

1.4 Research Questions

- How is the trend of adoption of energy efficient rocket stoves technology in the study area?
- How is the level of adaptive use of the energy efficient rocket stoves in the study area?
- What is the impact of energy efficient rocket stoves technology in rate of deforestation in the study area?
- What are the challenges in use of energy efficient rocket stoves in the study area?

1.5 Scope of the Study

This study was conducted in Dodoma Region, Chamwino District Council, specifically at Makoja and Ikowa villages in Ikowa ward, Membe and Mlimwa villages in Membe ward. The study explicitly focused on the role of energy efficient rocket stoves as a technology to lessen the problem of deforestation in the study area.

1.6 Significance of the Study

This study was expected to come up with the answer concerning contribution of efficient rocket stove as a strategy towards reducing the rate of deforestation. The study specifically intended to show the reality on adoption, adaptive use, and impacts of the stoves on deforestation as well as the challenges in use of the stoves. Findings from this study were intended to influence the government support to the stoves users especially on the challenges they had faced on use of this technology as a strategy towards reduction of deforestation. Also the study intended to influence other non-state actors who are interested to work on the similar issue of improved stoves or other sources of energy which aims at reducing the rate of deforestation. Moreover,

this study is intended to be useful source of data to other researchers with interest to related studies.

1.7 Ethical consideration

The moral principle governing conduct of this study based on the following:

Firstly, the researcher was honest in all logical communications with community, as well as key informants. Also researcher was very honestly in reporting the data and methods used.

Secondly, objectivity was a consideration of a researcher in the study so as to avoid bias in cross-sectional design, data analysis, data interpretation as well as personnel decisions. Personal and financial interests that could affect research were disclosed.

Lastly, openness was considered by the researcher, whereby the researcher had to introduce herself in all the offices she had to visit first by showing a letter permit for data collection from the university and what the study intended to do in the area. After that, the researcher had to choose some research assistants who could help during data collection in the study area. Data were then collected as soon as the researcher got permit from the District Authority, STT office and Ward as well as Village leaders from the study area.

1.8 Limitations of the study

In assessing the efficiency of rocket stoves in deforestation control in the study area, the study faced the following limitations;

Firstly, money constrains, the study required more than three research assistants due to its vast geographical area and therefore it required more funds to motivate them. Despite this limitation, data collection was successful since the research assistants used their physical resources such as bikes to minimize transport cost.

Secondly, remoteness of some of the areas in the study area was a challenge however data were collected successfully since the researcher was flexible as she had to use motorbike so as the get there.

Thirdly, the researcher failed to get secondary data from TAFORI and DEMO which could show actual loss or increase in the forest so as to come with conclusion. Despite this limitation, the study was successful since the researcher had to look for technical assistance whereby forest cover change was assessed using images from United States Geological Survey (USGS) and analysed by ERDAS IMAGINE 2014, ArcGIS 10.2.2, Google Earth and Microsoft Office Excel.

Fourthly, sometimes respondents were not available at their home places, despite this limitation; the data were collected since the researcher had to go back at respondents houses again.

Lastly, language was a barrier as many rural people were not conversant with English language and yet the questionnaire was set in English thus it required the researcher to use either Kiswahili or an interpreter during the interviews.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter includes review of various literatures related to contribution of energy efficient rocket stoves in deforestation control. It includes theoretical part and review of empirical studies. Eventually, the conceptual framework will be established to show the variables and the relationship between them.

2.1 Conceptual Definitions

Conceptualisation is the process whereby these concepts are given theoretical meaning. The process typically involves defining the concepts abstractly in theoretical terms (Msabila and Nalila, 2013).

2.1.1 The rocket stove

Rocket stove is an efficient cooking stove using small diameter wood fuel which is burned in a simple high-temperature combustion chamber containing a vertical chimney and a secondary air supply which ensures almost complete combustion prior to the flames reaching the cooking surface (World Energy Outlook, 2006).

2.1.2 The Three-Stones stove

The three stone stoves is the traditional method of cooking. It is the cheapest stove to produce, requiring only three suitable stones of the same height on which a cooking pot can be balanced over a fire. The Three stone stoves are comprised of three rocks or bricks holding the pot above an open fire. The three traditional three-stone are often 90% efficient at turning wood into energy, only 10 to 40% of released energy actually reaches the pot this make them consume so much wood for cooking daily compared to the rocket stoves (IJSLE, Vol 7, No.2, pp.49-68, 2012).

2.1.3 Forest

According to Myneni (2008), forest is a complex ecosystem consisting mainly of trees that buffer the earth and support many of life forms. The trees help create a special environment which, in turn, affects the kinds of animals and plants that can exist in the forest. Trees are important components of the environment. They clean the air, cool it on hot days, conserve heat at night, and act as excellent sound absorbers. Food and Agriculture Organization (FAO) (2014), has defined forest as land with tree crown cover (or equivalent stocking level) of more than 10% and area of more than 0.5 hectare. The trees should be able to reach a minimum height of 5m at maturity level. Forests are further subdivided into plantations and natural forests. Natural forests are forests composed mainly of indigenous trees not deliberately planted. Plantations are forest stands established by planting or seeding, or both, in the process of afforestation or reforestation. Forests can be broadly classified into types such as the taiga (consisting of pines, spruce, etc.), the mixed temperate forests (with both coniferous and deciduous trees), the temperate forests, the sub tropical forests, the tropical forests, and the equatorial rainforests (*ibid*).

Adedire (2002) defines forests as lands with a lot of trees which provide wood for lumber and paper, buildings, materials and fuel, and are an important source of foreign exchange. Forests help maintain soil quality, limit erosion, stabilize hillsides, modulate seasonal flooding, and protect waterways and marine resources from accelerated siltation. In addition, many millions of people living in and near the forests depend directly on them for food, medicine and other basic needs.

2.1.4 Deforestation

Is a situation occurring driven by a rapidly rising demand for forest products. This includes charcoal as an energy source for urban centers such as Dar es Salaam, where charcoal provides the overwhelming majority of household energy supplies. It also includes the globalised trade in timber from forests, which has expanded to encompass a greater number of tree species over the past ten years (REDD, 2009). According to Timberlake (1985), in Kabanza (2013), deforestation means different things to different people. For some it means the total clearing of trees, for others it is

any activity which disrupts the natural ecology of the virgin forest. In this regard, change can range from irregular slash and burn cultivation followed by partial regeneration, to complete clear-felling over large areas. Basically, this confusion is a matter of terminology, but it has created a lot of problems in trying to compare different estimates on the extent and rates of deforestation.

2.2 Theoretical Literature Review

This part involves the systematic identification, location and analysis of documents containing information related to the research problem being investigated (Msabila and Nalila, 2013).

2.2.1 Deforestation as a worldwide problem

Thirty per cent of the world's land area, about four billion hectares is currently covered by forest. Worldwide, more than 1.6 billion people almost a quarter of the global population depend on forests for at least part of their livelihoods, including for fuelwood, foodstuffs and medicinal plants (Chakravarty *et al.*, 2011). According to Adedire (2002), forest resources provide wood for lumber and paper, buildings materials and fuel. Wood has been a primary energy source for people ever since people have populated this planet; up to today, firewood satisfies most of the developing world's domestic energy needs.

Although the survival of forest ecosystems is essential to sustainable development, yet they are threatened by increasing human demands. The high pressure on forest resources has resulted in worldwide deforestation. Estimates showed that 10 to 25 million ha are being lost each year. Losses of forest are as old as human beings, but during the past few decades, deforestation rates have increased dramatically (Adedire, 2002). Forests worldwide have decreased from an estimated 6.2 billion ha to approximately 4.3 billion ha (Lanly, 1982). Also a study by Adedire, (2002), reported that, at a regional level, South America suffered the largest net loss of forests in the decade 2010 – about 4m ha (equivalent to 0.46 per cent of total forest cover) per year followed by Africa, which lost about 3.4m ha (0.50 per cent) per year. Northern and Central American forest areas remained more or less stable, while

European forests expanded, though at a slower rate than in the previous decade (0.7m ha per year (+0.07 per cent). The most dramatic change was in Asia, which, overall, reversed a net forest loss of about 0.6m ha per year in 1990–2000 to see a net gain of more than 2.2m ha per year (+0.37 per cent), South and Southeast Asian countries continued to experience high net rates of forest loss.

Africa is suffering from deforestation at twice the world rate (UNEP Report, 2004). A study by FAO (2005) in Soini and Coe (2011) reported that the annual loss of forest in Africa alone was estimated to be 5.1 million hectares between the year 1981 to 1990. Focusing on Tanzania, between 2000 and 2005, the country had the third largest net loss of forest area in Africa and the sixth largest in the world. The relative high decline of forests in developing countries in comparison to developed countries is contradictory and highly problematic, because of developing countries' higher dependency on forests. In developing countries in Africa, Asia and Latin America, most rural and urban people still rely on trees and other forest vegetation to meet their basic energy needs (Makame, 2007).

2.2.2 Causes of deforestation

Various authors have thoroughly discussed the major causes of deforestation. Adedire (2002), reported rapid population growth as one among the causes which increases the pressure on forests. Population growth has been highest in developing countries, as a result of lower average educational level among both men and women and lack of access to contraceptive methods (Gregory, Campbell and Cheng, 2007). In Africa, the population grew from 589.2 million people in 1987 to 871.8 million 2000 (Adedire, 2002). In Tanzania, the annual growth rate is estimated around 3%. In 2012 the official census recorded almost 45 million people living in the country (Wold Population Review, 2014). As a result, deforestation problems remain most severe in developing countries, resulting in both qualitative and quantitative decline. According to Barnes *et al.*, (1993) and Lombard (1995), the increased pressure on forest resources does not only result from population growth, but also from decreased access to kerosene for cooking after the oil shocks of the 1970s. First Climate Report (2006) declares that, Uganda currently loses about 2% of its forest cover annually,

fuel wood use being the second driver after land-clearing. Around 95% of Ugandan households use wood fuel (firewood and charcoal) as a primary energy source for cooking. Urban dwellers use predominantly metal charcoal stoves while in rural areas, households still mostly burn firewood in traditional three-stone fire places, which increases demand for wood resulting in putting Uganda's forests under tremendous pressure. Similar situation has been reported in Tanzania by Soini and Coe (2011) that deforestation is greatly caused by collection of firewood for domestic goals; fuels from trees like firewood and charcoal meet most of Tanzania's cooking energy needs. Firewood is collected mostly from unregulated common land. In addition to cutting trees for firewood, other primary drivers of deforestation include logging for domestic use and export, and agricultural conversion.

Moreover, the rapid decrease in forest resources is accounted to the rise of the agricultural society (Adedire, 2002). The rise of agricultural society was accompanied by intensive cutting of trees in order to generate fields to grow crops. Subsistence agriculturalist, livestock raisers, fuelwood collectors and people who set fires to facilitate clearing or gathering activities, remain the main agents of deforestation and forest degradation (*ibid*). Clearing activities include breaking new agricultural land in order to satisfy food requirements of expanding populations (Birgegard, 1991). The same view is shared by Johnson and Cabarie (1993) who state that agricultural expansion, partly caused by population growth and migration, is one of the major causes of deforestation. Adedire (2002) cites other causes of tropical deforestation, such as urban and industrial expansion, intensive logging for veneer, saw timber and for chip wood and exploitation for charcoal and firewood.

Therefore the drivers of deforestation are complex and interconnected. Duncan and Rob (2013) concluded that in Latin America commercial agriculture, including livestock were the most important direct driver of deforestation, contributing around two-thirds of total deforestation. In Africa and sub-tropical Asia, commercial agriculture and subsistence agriculture accounted for around one-third of deforestation each. Mining and infrastructure development both played larger roles in Africa and Asia than in Latin America, mining accounting for about 10 per cent of

deforestation in Africa and infrastructure for about 10 per cent in Africa and Asia. Timber and logging activities accounted for more than 70 per cent in Latin America and Asia, whereas fuelwood collection and charcoal production were the main drivers for Africa.

Moreover, Lambin *et al.*, (2003) in Kabanza *et al.*, (2013), argue that, underlying, or indirect, drivers constitute an interaction between demographic, economic, technological, policy/institutional and cultural/socio-political changes. Despite the various causes, the need for wood-derived energy remains the first cause of deforestation in developing countries (Adedire, 2002). The need for wood-derived energy has always been high in developing countries: an estimated of 90% of people in developing countries depend solely on wood for fuel (Adedire, 2002), most of this wood is used for cooking. However, McCarthy and Tacconi (2011), argue that, different studies of deforestation have generally attempted to incorporate measures of wealth, population growth, urbanisation, and economic incentives. In addition, many studies have attempted to include governance in their make-up, developing indicators of good and bad governance to explain deforestation rates. These include measures of political stability and corruption, the latter also being used in some models as the major explanatory variable. It is argued that, the causes of deforestations cannot be generalised at a global level and, in consequence, the solutions need to be, to a certain extent, country specific.

2.2.3 Consequences of deforestation

Deforestation has many negative consequences. Its impacts are felt on various levels. A first level that is affected by deforestation is the environment in general. Deforestation reduces the protective function of the forest and causes the ecosystem to lose its ability to hold nutrients (Adedire, 2002). Furthermore, deforestation worldwide is linked to “[...] severe flooding, sedimentation, water shortages, decreased hydroelectric production, landslides, and productivity losses in such coastal ecosystems as mangrove forests and coral reefs”, “[...] declines in rainfall, increased surface temperatures, and the alteration of local hydrology” and “increasing atmospheric concentration of carbon dioxide” (Adedire, 2002). The rise

in carbon dioxide has severe effects on the global climate; it changes natural ecosystems and biodiversity and as such influences the current patterns of agricultural production (Adedire, 2002). Adedire (2002) warns for the severe consequences of global warming, strengthened by deforestation: “Global warming brought about through the so-called ‘greenhouse effect’ will result in major climatic changes, which are expected to cause thermal expansion of oceans, melting of glaciers in cold regions and hence an increase in ocean levels. The consequences of global warming are expected to include massive flooding of the low coastal regions of the world, changes in food chains and a general disruption in agricultural production”.

Deforestation also affects human beings, both directly and indirectly. People, especially women and children, are directly affected because they tend to spend more time close to the fire. Around 1.5million people die each year due to exposure to the smoke (Jetter and Kariher, 2009). Furthermore, women and children are directly affected because decreasing forests lead to higher prices to buy and longer walking distances to collect wood. As the country’s population increases wood resources increasingly come under pressure, resulting in dwindling and degrading forests, higher prices and longer distances to find wood-fuel for domestic use. Collecting firewood is hard work and takes up a lot of time and effort. It is usually the responsibility of women and children. For a woman who spends many hours a week walking to collect wood fuel, a reduction in the amount of wood she needs to prepare the daily food for her family will allow her to save valuable time and effort. In cases where firewood is purchased, it can lead to cash savings (Mwale, 2012). Deforestation also affects people indirectly, through climate changes. Adedire (2002) states that increased soil erosion by wind and rain, a general increase in aridity and dust in an area, a lowering of the water table and silting of dams and irrigation systems reduce the quality of life of local people. Shortages of fuelwood, a reduced availability of fodder for livestock and a lack of emergency food reserves are direct economic impacts of deforestation felt by local people in developing countries (Adedire, 2002).

2.2.4 Deforestation in Tanzania

Tanzania experiences high rates of deforestation and forest degradation, creating negative externalities at both local and global levels (FAO, 2011). Measures to mitigate the problem have accordingly been suggested from both the Tanzanian government and others. Focusing merely on central command and control of forest use, the Tanzanian government has in the last 20 years increasingly decentralised the responsibility to the community level (URT 2012). Furthermore, foreign donors in collaboration with NGOs have introduced a third measure; rewarding forest users for reducing their CO₂ emissions by decreasing forest use (Angelsen *et al.*, 2012 in URT, 2012). The measures aim to increase the propensity of the forest users to incorporate the negative externalities of their actions in their decision making process. As such, forest management is also management of behaviour.

Tanzania, like many other African countries, relies heavily on biomass energy (firewood, charcoal and farm residues) mainly for domestic cooking and heating and for operating small scale rural industries. Biomass fuels, mainly firewood and charcoal, have remained the main source of energy in Tanzania, accounting for over 90 per cent of the total energy used in the country over the past five decades, with limited alternatives for upward fuel switch to commercial energy sources like electricity and petroleum products due to low income by the majority of the people (MEM, 2003; MNRT, 2001). In spite of the high contribution of biomass fuels to the energy balance in Tanzania, energy development priorities have concentrated on commercial energy sources namely: electricity and petroleum (MEM, 2004). However, over 90% of the Tanzanian population has failed to access the commercial energy sources due to their low income and the prohibitive cost of this energy. Barely one per cent of rural Tanzanians are currently connected to the national grid (*ibid*). Lack of concrete programmes to enhance sustainable supply of biomass energy for the majority of the Tanzanian population relying on biomass fuels has resulted in a rapid decline of biomass fuels supply associated with environmental degradation, a situation that could lead to a critical energy crisis in Tanzania if allowed to continue (MEM, 2003).

Just like the mainland of Tanzania, Zanzibar faces an extensive gap between supply and demand of firewood. According to Williams (1996), approximately 3,600ha of trees had to be planted by mid-1990 to answer the scarcity of wood on the island, in order to prevent the need to import firewood from the Mainland wood. Current tree planting efforts on Zanzibar are far behind the desired magnitude and considering the land scarcity in the islands it is unlikely that the balance can be achieved by tree planting alone. Therefore, an intensive fuelwood-saving program and use of alternatives to fuelwood have been recommended. The development and diffusion of improved cooking stoves under projects and programs throughout developing countries began in the early 1980s and was largely justified as a “demand side” solution to the fuelwood crisis (Barnes, 1994). In Zanzibar the move toward the development and dissemination of improved cooking stoves started in the late 1980s, under Zanzibar Forestry Development Project Phase Two (ZFDP). The project initiated and started to implement the production and dissemination of fuel saving cooking stoves. However, the feedback for this program is not promising. This study conducted in urban Zanzibar aimed at examining the extent of fuelwood consumption and to investigate the rate of adoption of improved charcoal stoves and its impact on rural forests.

The major effects of deforestation in Tanzania have been deterioration of ecological systems with resulting negative impacts on soil fertility, water flows and biological diversity (NEMC 1995; Misana and Nyaki 1993, in Kabanza, 2013). Soil erosion has become a serious problem in many parts of the country, particularly in the central region. Sheet and gully erosion were widespread, rendering most of the land unproductive. Deforestation has also affected water catchment areas and the quantity and quality of water supplies they contain. There is extensive evidence of reduced dry season river flows and drying up of springs and seepages. There is also increased sedimentation of rivers and dams and frequency of flash floods. Major floods and landslides occurred in Lushoto in 1993 and they have been attributed to deforestation in the Western Usambara following the degazettement of forest reserves around Mlalo in the 1960s (NEMC, 1995). Ground water supplies have also been depleted because of reduced infiltration of rainfall into the soil caused by deforestation. The

lack of and poor quality water have, in most cases, been associated with incidences of many waterborne diseases such as typhoid, diarrhoea and cholera.

Deforestation has also led to acute shortages of fuelwood in many parts of the country. Women in rural areas are forced to walk long distances up to 7 km or more with heavy burden of wood. Until the late 1970s women were able to collect firewood within a radius of one to two kilometres from their villages (Kilahama 1988, in Kabanza, 2013). By the 1980s, however, women particularly in semi-arid areas were walking ten kilometres or more looking for firewood. Regions which are experiencing fuelwood deficits include Mwanza, Shinyanga, Mbeya, Mara and Arusha.

Furthermore, there has been loss of wildlife habitat and biodiversity as a result of fragmentation and loss of critical ecosystem linkages and over-exploitation of the natural habitats. The depletion of forest resources in Tanzania is of great concern for environment and development. It is affecting not only the economy of the country, through negative effects on agriculture but also the health of the people. It is undermining the potential for sustainable development. Therefore, efforts need to be made to reverse the trend (*ibid*).

2.2.5 General overview of improved stoves

From the mid 1970,s attention shifted to designing and promoting stoves which were claimed to be fuel efficient. A number of these stoves were made from fired clay and constructed by skilled potters in the space of a few hours (First Climate Report, 2006).

According to First Climate (2006) a potential adopter of a new/improved stove is likely to be interested in a stove which is simple to use, fits in with traditional cooking practices, has a low cost (either in monetary terms or construction time), easy to maintain, has a low fuel cost and produces low levels of smoke if used in an enclosed space. A summary of such features are given for stoves promoted as being both, smokeless and fuel efficient. Nearly all the stoves promoted as being both fuel

efficient and smokeless, constructed from mud (unfired clay). Most of these stoves have dampers (to control the heat output of the burning fuel).

According to international institutions such as the World Bank and the U.N. Food and Agriculture Organisation (2005) the food and fuel need of the rapidly growing population in developing countries has resulted in deforestation. Thus in 1985, the Forestry Department of the United Nations Food and Agriculture Organisation reported that, fuelwood supplies have been rapidly depleted and the cutting of firewood has in turn been a major cause of excessive deforestation. Consequently, the rural poor in developing countries are experiencing a shortage of firewood. Strategies to cope with the shortage of firewood and deforestation are concerned with increasing the supply of firewood and/or decreasing the demand for firewood. One demand orientated strategy has been to promote new cooking stoves in the rural sector of developing countries (*ibid*).

Most of people's cooking energy needs are met by fuels from trees like firewood and charcoal. As any country's population increases there is growing pressure on wood resources resulting in dwindling and degrading forests, higher prices and longer distances to find wood-fuel for domestic use (Nyirenda *et al.*, 2012). Collecting fuel is hard work and takes up a lot of time and effort. It is usually the responsibility of women and children. For a woman that spends many hours every week walking to collect wood fuel, a reduction in the amount of wood she needs to prepare the daily food for her family will allow her to save valuable time and effort. In cases where firewood is purchased, it can lead to cash savings (*ibid*).

Improved stoves, such as the Chitetezo Mbaula, Rocket, Esperanza and others are being promoted in order to improve the quality of life for the people that rely on firewood as their main source of fuel. These stoves have improved design features appropriate to burn firewood efficiently. First Climate (2006) argues that, most cook stoves combine three main design features for improved fuel efficiency. Firstly, the improved cook stoves achieve higher combustion efficiency. Secondly, better stove insulation boosts this effect and improves general heat retention to minimize loss of

unused heat. Lastly, heat loss is reduced further by optimizing heat transfer between the stove and the pot.

When used correctly, this leads to greatly reduced firewood requirements and amount of smoke in the kitchen (Nyirenda *et al.*, 2012). Due to their safer design with the fire contained in a fire-chamber, these stoves can also help to avoid accidental burns, thus the name ‘protecting stoves locally produced from local clay. The widespread adoption of these stoves is likely to have any significant impact on deforestation as gathering cooking fuel especially in rural areas is among the primary cause of deforestation (*ibid*).

2.2.6 The role of rocket stoves in reduction of deforestation

Rocket stove have the following important characteristics, they are well insulated, allowing less heat to escape, which means less firewood is used to produce the same amount of heat as the traditional 3-stone fire, because the fire is hotter and food cooks more quickly, each stove has a chimney which removes indoor smoke and reduces the risk of eye and respiratory illnesses. Further, children and adults are at much less risk from burns than from an open fire, they contain two holes for pots, rather than the single-pot 3-stone fire, so that meals take less time to cook, again reducing the amount of firewood needed, approximately half the amount used with a traditional fire, each day (World Energy Outlook, 2006).

The Rocket Stove, originally developed at the Aprovecho Research Center, relies on insulation for heat retention in cooking. Improving heat transfer efficiency to the pot through this solution facilitates a significant reduction in fuel consumed. Additionally, improving fuel combustion efficiency reduces smoke and toxic emissions (IJSLE, Vol 7, No.2, pp.49-68, 2012). Fuel use and emissions are reduced by forty to fifty per cent according to laboratory and field testing of Rocket Stoves by Aprovecho Research Center and Shengzhou Stove Manufacturer (*ibid*). The Rocket Stove consists of two main sections: the Lower Stove and the Upper Stove. The Lower Stove contains the Fuel Inlet where unburned fuel is placed along with an Air Inlet that allows air circulation through the stove. The Combustion Chamber is a

vertical section that carries heat to the pot, which rests in a pot stabilizer in the Upper Stove. (IJSLE, Vol 7, No.2, pp.49-68, 2012). Some rocket stoves have a metal skirt around the sides of the pot for improved heat transfer from the hot combustion gases to the pot (EPA, 2009 in IJSLE, 2012). It is estimated that half the world's human population depends on burning wood, charcoal, coal, crop residues, other biomass and animal dung for cooking, boiling and heating (Jetter and Kariher, 2009). The continuous increasing population, the escalating cost of stove and gas cookers coupled with the scarcity of kerosene and cooking gas, caused many villagers in developing countries to rely on wood-derived energy for their domestic cooking (Adedire, 2002:36). This heightened demand severely pressures forests all over the world, which led to a higher concern for environmental issues. This concern led project developers to implement the production of fuel saving cooking stoves.

Before the introduction of the rocket stove, most Tanzanian villagers relied on three-stone open fires. These three-stone stoves however use a lot of firewood. Therefore, the Rocket Stove was implemented, “[...] which is a more efficient insulated wood-burning stove”, “[...] is fuel-efficient, has low smoke emissions [...] and can be constructed and maintained using local and affordable resources” (Chastonay *et al.*, 2012: 51). Improved stoves, such as the rocket stove, are being promoted in order to improve the quality of life for the people that rely on firewood as their main source of fuel. These stoves have improved design features appropriate to burn firewood efficiently. When used correctly, this leads to greatly reduced firewood requirements and amount of smoke in the kitchen. Due to its safer design with the fire contained in a fire-chamber, the rocket stove can also help to avoid accidental burns, thus the name ‘protecting stove’.

The rocket stove was originally developed at the Aprovecho Research centre and relies on “[...] insulation for heat retention in cooking. Improving heat transfer efficiency to the pot through this solution facilitates a significant reduction in fuel consumed” (Chastonay *et al.*, 2012). The rocket stove has additional benefits, such as an improved fuel combustion efficiency, which reduces smoke and toxic emissions (Chastonay *et al.*, 2012). The rocket stove has a simple structure: it consists of two

sections, namely the lower stove and the upper stove. Chastonay *et al.*, (2012) clearly explains the functions of both stoves: “The lower stove contains the fuel inlet where unburned fuel is placed along with an Air Inlet that allows air circulation through the stove. The Combustion Chamber is a vertical section that carries heat to the pot, which rests in a pot stabilizer in the Upper Stove. The total area of the inlets and outlets should be approximately equal so that air can flow smoothly through the fire”.

The rocket stove has been applied in numerous African countries, such as Uganda, Lesotho, Mozambique, Malawi, Zambia, South-Africa and Tanzania (Chastonay *et al.*, 2012). It is assumed that these stoves save a lot of firewood and cook quickly. Web pages of projects promoting them typically claim 30% to 80% savings in firewood consumption – without producing the data supporting the claim. In its brochure “Reducing deforestation with improved cook stoves,” First Climate (2006), states that the improved cook stove achieves fuel savings of 35% and 50% compared to conventional metal stoves. Furthermore, these stoves are said to be much healthier, since the cleaner burning stoves generate less smoke and fewer carbon monoxide. There are some studies that have compared the traditional three-stone fire with a particular improved stove. Some stoves are thoroughly tested or designed on thorough scientific understanding, but others have inadequacies in describing the study methods and data collection. There are practically no useful studies that would have attempted to compare different models of improved stoves (Soini and Coe, 2011).

However, most literature lists many benefits of the improved stoves. (First Climate, 2006) states that “[...] the improved wood cook stoves save almost 60% compared to common appliances. An average family can cut their charcoal use by some 300 kilograms per year.”The lower need for firewood eases the pressure on forest resources in Tanzania, which yields benefits like slowing soil erosion, the destruction of natural habitats and loss of biodiversity (First Climate, 2006). Thirdly, the stoves reduce air pollution and the emission of harmful substances, which cause respiratory infections and respiratory, cardiovascular and ocular diseases (First Climate, 2006).

As stated in the above, women and children are disproportionately affected, as they spend 3-7 hours per day preparing food and because they tend to spend more time close to the cook stoves (Jetter and Kariher, 2009). Reducing the amount of firewood needed, fourthly, frees more time for productive activities, such as the education of children, economic or agricultural tasks. Lastly, projects that implement improved cooking stoves promote locally manufactured technology, which improves technological self-reliance and allows for self-sustaining development. The benefits of the improved rocket stove are many. The question remains however whether villagers actually make use of the stoves. Therefore, this study will focus on the adaptive use of rocket stoves in Tanzania and their contribution on deforestation control.

2.2.7 Policies and Regulations related to Deforestation

In Tanzania, there are different regulations as well as policies which have been established so as to address the problem of deforestation; below are the general overview of these policies and regulations.

2.2.7.1 National Environmental Policy (1997)

Tanzania has promulgated the National Environmental Management Policy (NEP) of 1997 and other sector specific policies, which provide the policy guidance on how its environment and natural resources will be sustainably managed. There is in place a solid institutional framework mandated among institutions to coordinate the implementation of policies and enforce laws that have been enacted by the Parliament for the conservation and management of the environment and natural resources. The role of NEP, 1997 can be summarized to include the following:

- i. Developing consensual agreement at all levels for the challenge of making trade-offs and the right choices between immediate economic benefits to meet short term and urgent development needs, and long term sustainability benefits.
- ii. Developing a unifying set of principles and objectives for integrated multi-sectoral approaches necessary in addressing the totality of the environment.

iii. Fostering Government-wide commitment to the integration of environmental concerns in the sectoral policies, strategies and investment decisions, and to the development and use of relevant policy instruments which can do the most to achieve this objective.

iv. Creating the context for planning and coordinating at a multi-sectoral level, to ensure a more systematic approach, focus and consistency, for the ever-increasing variety of players and intensity of environmental activities.

One of the major thrusts of NEP is that it provides for the need to develop ways for encouraging a holistic multi-sectoral approach to environmental management by integrating environmental concerns in sectoral policies, strategies and decisions. In that way it creates the context for cross-sectoral planning and coordination (NEP, 1997). NEP articulates the concept of shared responsibility and distinct accountability for environmental management so as to inculcate collective responsibility in environmental management without blurring specific mandates and responsibilities that have been assigned to each institution. The NEP is a framework policy and covers environmental mandates assigned to other sectors. Paragraphs 45 to 60 of the Policy provides on sectoral policies covering agriculture, livestock, water and sanitation, health, transport, energy, mining, human settlement, industry, tourism, wildlife, forestry and fisheries. This position is also reciprocated and reflected in sectoral policies by including paragraphs on environment management in general and specifically on the requirement to undertake EIA (Environmental Impact Assessment) (REDD+, 2013).

The NEP in its analysis of the state of the environment in Tanzania identified six major problems that require urgent attention, these are; Land degradation; Lack of accessible, good quality water for both urban and rural inhabitants; Environmental pollution; Loss of wildlife habitats and biodiversity; Deterioration of aquatic systems and Deforestation. In finding solutions to tackle these challenges, the NEP outlines its overall objectives as follows:-

- i. To ensure sustainability, security and equitable use of resources for meeting the basic needs of the present and future generations without degrading the environment or risking health or safety.
- ii. To prevent and control degradation of land, water, vegetation, and air which constitute life support systems.
- iii. To conserve and enhance our natural and man-made heritage, including the biological diversity of the unique ecosystems of Tanzania.
- iv. To improve the condition and productivity of degraded areas including rural and urban settlements in order that all Tanzanians and aesthetically pleasing surroundings.
- v. To raise public awareness and understanding of the essential linkages between environment and development, and to promote individual and community participation in environmental action.
- vi. To promote international cooperation on the environmental agenda, and expand our participation and contribution to relevant bilateral, sub-regional, regional, and global organizations and programs, including implementation of Treaties.

Challenges and problems identified in the NEP as well as the overall objectives have informed the enactment of the Environmental Management Act, 2004 (REDD+, 2013).

2.2.7.2 National Forest Policy (1998)

The first National Forest Policy in Tanganyika was promulgated in 1953. The policy emphasised among other things the need to protect forest resources and managing them in the most productive way to meet present and future needs. The policy envisaged shared responsibilities, but there were no legal provisions to enforce such envisioned responsibilities (REDD+, 2013). The Forest Legislation of 1957 was not effective beyond the government controlled forest estate because it was not explicit on how to monitor forest development in areas outside state ownership. The consequence has been massive deforestation in the forests on general (public) lands (57% of total forest area).

Thus for over four decades, Tanzania has been implementing the Forest Policy of 1953, until in 1998 when a new policy was approved by the government. The overall goal of the National Forest Policy (1998), is to enhance the contribution of the forest sector to the sustainable development of Tanzania and the conservation and management of her natural resources for the benefit of present and future generations (REDD+, 2013). The objectives of the forest sector on the basis of the overall goal are as follows:-

- i. Ensured sustainable supply of forest products and services by maintaining sufficient forest area under effective management.
- ii. Increased employment and foreign exchange earnings through sustainable forest-based industrial development and trade.
- iii. Ensured ecosystem stability through conservation of forest biodiversity, water catchments and soil fertility.
- iv. Enhanced national capacity to manage and develop the forest sector in collaboration with other stakeholder.

The Policy encourages community and private sector involvement in forest management through establishment of Village Land Forest Reserves (VLFRs), individual, group and community forests over which they have full rights of ownership and management and Joint Forest Management (JFM) through joint management agreements with government where communities have user rights and management responsibilities. All these aim at enhancing conservation of forests by reducing illegal use of the resources (REDD+, 2013).

According to (REDD+) 2013 the forest Policy explicitly makes reference to linkage with other sectors. These include agriculture, livestock, mining, energy, wildlife, beekeeping, environment and land. Policy failures in some of these sectors have contributed to the deforestation and degradation of forest resources. This has been due to inadequate sectoral coordination and harmonization of policies. Similarly, both the current National Forest Policy of 1998 and its subsequent National Forestry Programme of 2001 recognizes and promotes sustainable forest management and utilization. This is demonstrated by the three policy objectives which put emphasis

on: i) improved forest quality through sustainable management practices, ii) improved livelihoods through increased forest revenues and secure supply of subsistence forest products, and iii) improved forest governance at village and district levels through effective and accountable natural resource management institutions (*ibid*).

2.2.8 Sunseed Tanzania Technologies

Sunseed Tanzania comprises a UK registered NGO and a Tanzanian registered NGO. Their work is integrated and implemented through a field team of three (two Tanzanian and an expatriate) based in Dodoma and working alongside the Dodoma region, districts and villages as well (www.sunseed.org). Domestic Energy Project is one among the three projects of the organization; others are Institutional Energy Project and Mycorrhiza Project. Sunseed promotes the Rocket stove that is safer and greener than the traditional three-stone fire. The improved fuel efficient stoves promoted by Sunseed Tanzania save between 40-50% of the firewood used with the traditional cooking method, representing an annual saving, for each household, of approximately 1 tonne of firewood (and reducing CO₂ emissions by over a tonne). The stove technology promoted by Sunseed Tanzania involves locally available materials (mud and dried grass) (*ibid*).

Sunseed Tanzania's local team works through local government structures and in partnership with village leaders and communities. The team takes three years to build confidence and generate enthusiasm for the stove project. The team uses its expert knowledge to introduce rocket stoves and establish a change in cooking culture. Sunseed Tanzania works with a village for three years. However, communities can still seek advice, if it is needed, from Sunseed after the team has formally stopped working in a village (www.sunseed.org).

2.2.9 Theories related to the study

This part involves theoretical perspective. It can be simply a theory, but it can also be more general, a basic approach to understand something related to the study being conducted (Msabila and Nalila, 2013).

2.2.9.1 “Theory of change”

Theory of change is an on-going process of reflection to explore change, how it happens and what it means in a particular context, sector, and/or group of people (Jameel, 2014). If people are willing to change their ways in terms of the use of forest resources, then the rate of deforestation can be reduced. A theory of change is the articulation of the underlying beliefs and assumptions that guide a service delivery strategy and are believed to be critical for producing change and improvement. Theory of change represents beliefs about what is needed by the target population and what strategies will enable them to meet those needs (INSP, 2005). They establish a context for considering the connection between a system’s mission, strategies and actual outcomes, while creating links between who is being served, the strategies or activities that are being implemented, and the desired outcomes. A theory of change has two broad components. The first component of a theory of change involves conceptualizing and operationalizing the three core frames of the theory. These frames define:

- **Populations:** who you are serving.
- **Strategies:** what strategies you believe will accomplish desired outcomes.
- **Outcomes:** what you intend to accomplish.

The second component of a theory of change involves building an understanding of the relationships among the three core elements and expressing those relationships clearly. The theory of change is defined by the three core elements and the relationship that exists between them.

According to this study and its relation to the theory of change, there is what we want to accomplish as far as deforestation is concerned that is reducing the rate of deforestation, so the three core frames of this study is the population in the study area, the strategy is the use of rocket stoves and the outcome will be either increase or decrease in rate of deforestation. Yet, this change is influenced by different challenges in various categories.

❖ **Life style**

Is the typical way of life of an individual, group or culture. The term refers to a combination of determining intangible or tangible factors. Tangible factors relate specifically to demographic variables, i.e. an individual's demographic profile, whereas intangible factors concern the psychological aspects of an individual such as personal values, preferences, and outlooks (Jameel, 2014).

❖ **Poverty**

Is the state of one who lacks a certain amount of material possessions or money (*ibid*). Refers to the deprivation of basic human needs, which commonly includes food, water, sanitation, clothing, shelter, health care and education.

❖ **Population dynamics**

Population dynamics is how populations change over time. The composition of the population, including the age of the population, the birth and death rates, and the amount of immigration and emigration are all components of population dynamics (*ibid*).

❖ **Institution stability**

A weak institution is an institution in decline. An institution is commonly defined as a stable, durable, and valued arrangement that prescribes and prohibits specific behavior for specific situations. An institution can take various forms (think of a respected custom, a long-standing law, or a widely admired organization). When its influence wanes, and it is no longer taken for granted but formally still persists, we speak of a weak institution.

❖ **Limited financial resources**

The money available for spending in the form of cash. Those who lack adequate financial resources are unable to seek a better lifestyle and improve their quality of life.

❖ **Lack of traditional knowledge on forests management**

Refer to knowledge systems embedded in the cultural traditions of regional, indigenous, or local communities. Traditional knowledge includes types of

knowledge about traditional technologies of subsistence (e.g. tools and techniques for hunting or agriculture). These kinds of knowledge are crucial for the subsistence and survival and are generally based on accumulations of empirical observation and interaction with the environment.

❖ **Lack of monitoring and enforcement**

Lack of monitoring and enforcement broadly refers to situation in which there is no follow-up about a certain situation existing and by which some members of society act unorganized towards a situation within that particular society. Though the efforts are always focusing on environmental sustainability, as far as the environment is concerned, without change of people's behavior, environmental sustainability cannot be achieved. According to this study, people should change so as to overcome the problem of deforestation. This change should focus on the alternative sources of energy instead of depending totally on forests. However the change can be influenced by above mentioned challenges which can be used as factors to be studied in the study area as a way of identifying improvement measures for promoting the use of the technology in reducing the problem of deforestation.

2.3 Empirical Literature Review

Various other studies related to assessing rocket stoves in relation to deforestation in Tanzania and other countries have been conducted by various researchers as follows:

According to the study done by Makame (2007), School of Education, Arts and Sciences (SEAS) on Adoption of Improved Stoves and Deforestation in Zanzibar with the aim of understanding the extent of fuel wood consumption for cooking and the adoption of improved charcoal stoves as a policy option toward reducing the consumption of fuel wood in urban sectors, the results of the analysis suggested that the majority of people still cook using traditional stoves which consume a great deal of wood to the extent of deteriorating forest resources. Since conventional fuels remain remote for the majority, improved charcoal stoves are perceived as a real option for reducing consumption of wood fuel in urban area and thus arresting the rate of deforestation. However, this can only be realized if the improved charcoal

stoves are widely adopted within social systems. Adoption itself results from a series of individual or any unit of adoption to begin using the new stoves. Poor quality of the improved stoves, costs, information and education about the stoves are major factors for the failure to adopt improved charcoal stoves in urban Zanzibar (*ibid*). For example Rogers (1983), in Makame (2007), assumed that economic motivation is the main thrust for adopting an innovation, especially if the idea is expensive in both the initial and running costs. Again, an individual who is not exposed to mass media and peer groups' interaction will adopt an innovation later than those who are exposed.

Furthermore, the level of education has its implication on the adoption of innovation. Sharada and Knight (2000), in Makame (2007), in their study of adoption and diffusion of agricultural innovation in Ethiopia, found that most of the adopters have been in school. Second, stove attributes, according to the theory of perceived attributes by Rogers (1995), in Makame (2007) enables adopters of innovation to judge and base their perceptions in view of five characteristics of innovation: trialability, observability, relative advantage, complexity, and compatibility. Third, management support, this factor influences the other preceding determinants toward adoption. Undoubtedly, successful adoption of an innovation in the social system has to be probed with the management support to clarify the importance of the innovation in question to the people's wealth and their environment. Through programs and projects the policy's objectives can easily translate the meaning of an innovation, and thus keep pace with its diffusion and adoption in the social system.

Furthermore, high rate of adoption will depend to the extent to which members of social systems perceived the innovation (improved charcoal stoves) as useful to all aspects of their life and how user friendly it is (cheap to buy and run, less smoke, speed in cooking) (Makame, 2007). Lastly, adoption is a kind of social change, defined as the process by which alteration occurs in the structure and function of a social system. When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs. Such changes can happen in other ways too. Poor or better management of forest resources for the case of improved charcoal stoves is a change. Thus, successful adoption of improved

charcoal stoves in urban Zanzibar is expected to have significant implication on the rural forest resources, resulting in tremendous reduction of fuel wood consumption in urban sectors. On the other hand, failure to adoption (decision to reject) leads to negative impact on the forest resources. This means there will be no reduction in wood consumptions and thus, accelerate deforestation (*ibid*). From the study, the need to revive improved charcoal stoves programs and exploration of alternative sources of energy have been recommended in order to reduce the pressure over forest resources induced by the great demand for fuel wood in urban Zanzibar.

Another study conducted by Njogu (2011), on Adoption of Energy-Efficient Woodstoves and Contribution to Resource Conservation in Nakuru, Kenya found that, the most commonly used form of fuel by households in Nakuru Country was woodfuel. Charcoal was mostly used in the urban areas (85.5%), while in the rural areas firewood was mostly used (69%). The other forms of fuel used by households in the study area were kerosene (7%) and electricity (1.1%). Crop residue was not always used in the County since it was mostly a seasonal type of fuel, with about 42% of respondents using it sometimes in the rural areas.

Most of the respondents in the urban division of Lanet in Nakuru County had acquired the improved charcoal cookstove (93.5%) as compared to the rural parts of County (81%). Majority of those who had acquired the cookstoves commonly known as *Kenya ceramic jiko* (KCJ) also often used it in their daily cooking activities though its use was more common in the urban (84%) than the rural areas (51%) (*ibid*). The adoption of the firewood cookstoves (e.g *Kuni mbili* and *Upesi jiko*) was found to be very low with only 9.18% of rural and 1.08% of the urban households having acquired it. The difference in adoption of the improved firewood stove was significantly higher in rural as compared to urban households. Adoption of fireless cookers was very low in both Lanet (8.06%) and Dundori areas (1.53%). Costs were one of the major factors contributing to low adoption as well as lack of information relating to the technology. Some of the factors identified that could influence adoption of woodfuel conservation technologies were income of the household, level of education of the heads of the household, number of dependants, cost of fuelwood

stoves, cost of the KCJ and the cost of fireless cooker. It was also found that majority of the respondents in the rural areas (67%) had never heard of a fireless cooker. This could be a factor that influenced its adoption (Njogu, 2011).

From the study it was found that a majority of the respondents (89%) in the study area recognizes that there had been weather changes. Majority of the respondents were in agreement that cutting down trees could negatively affect the weather, majority of the respondents perceived the use of charcoal as a better option for natural environmental conservation as compared to use of firewood. This implied that those respondents who used charcoal did not think that it has greater negative impacts on the natural environment as compared to firewood especially when considering the charcoal making process and thus would encourage switching to charcoal as a better option yet this might not be the solution (*ibid*).

According to Holmes (2010), on her study on Potential Effects of Improved Cookstoves Use and Barrier to Acceptance, A case study Measkron, Tanzania. The two objectives of this thesis were to determine the rate of reduction in fuelwood consumption obtained by the adoption of improved cook stoves compares to the traditional three-stone method and identify barriers to broader cook stove acceptance, the study found that, women who lived in the central part of Measkron were familiar with the improved cookstove, awareness about the stoves was pre-established, but cost was a significant barrier for many. Word-of-mouth was the primary mode of knowledge transmission about the stoves. Women told each other about the stoves and/or directly experienced the benefits, which greatly contributed to the acceptance and use of the stoves. Women living outside the central radius of Measkron, in the hillsides, were less accepting of this new technology and viewed it as an intrusion to the customary traditional method of cooking. However, there was the occasional woman who lived in the outskirts of town that heard about the stoves and showed actual interest in owning one (*ibid*).

According to Holmes (2010), some women were able to save money or acquired money from their husbands or neighbors to buy a stove, but most women who didn't have a stove and wanted one, claimed that they couldn't afford it. Because of the

reduction in fuelwood consumption, there is an expected reduction in fuelwood collection. During follow up visits time and time again, participants enthusiastically reported high levels of satisfaction with the features of the improved cookstoves. Overall, participants expressed interest and satisfaction with the immediate benefits received by stove use. The main advantages of the stoves compiled from follow-up survey results include the following: All participants experienced a 50% reduction in overall fuelwood consumption (equates to less fuelwood collection trips/ fuelwood purchased), Reduction in time spent on cooking meals, Reduction in smoke levels as explained to the cohort, part of the motivation for this case study was to lessen deforestation in Measkron Village by reducing fuelwood consumption. In order to understand the perceived role improved cook stoves play in this rural Tanzanian village, discussions on deforestation of Measkron were tracked. Out of 26 participants, four commented and perceived to understand the link between fuelwood dependence, and how improved cook stoves can decrease local deforestation (Holmes, 2010).

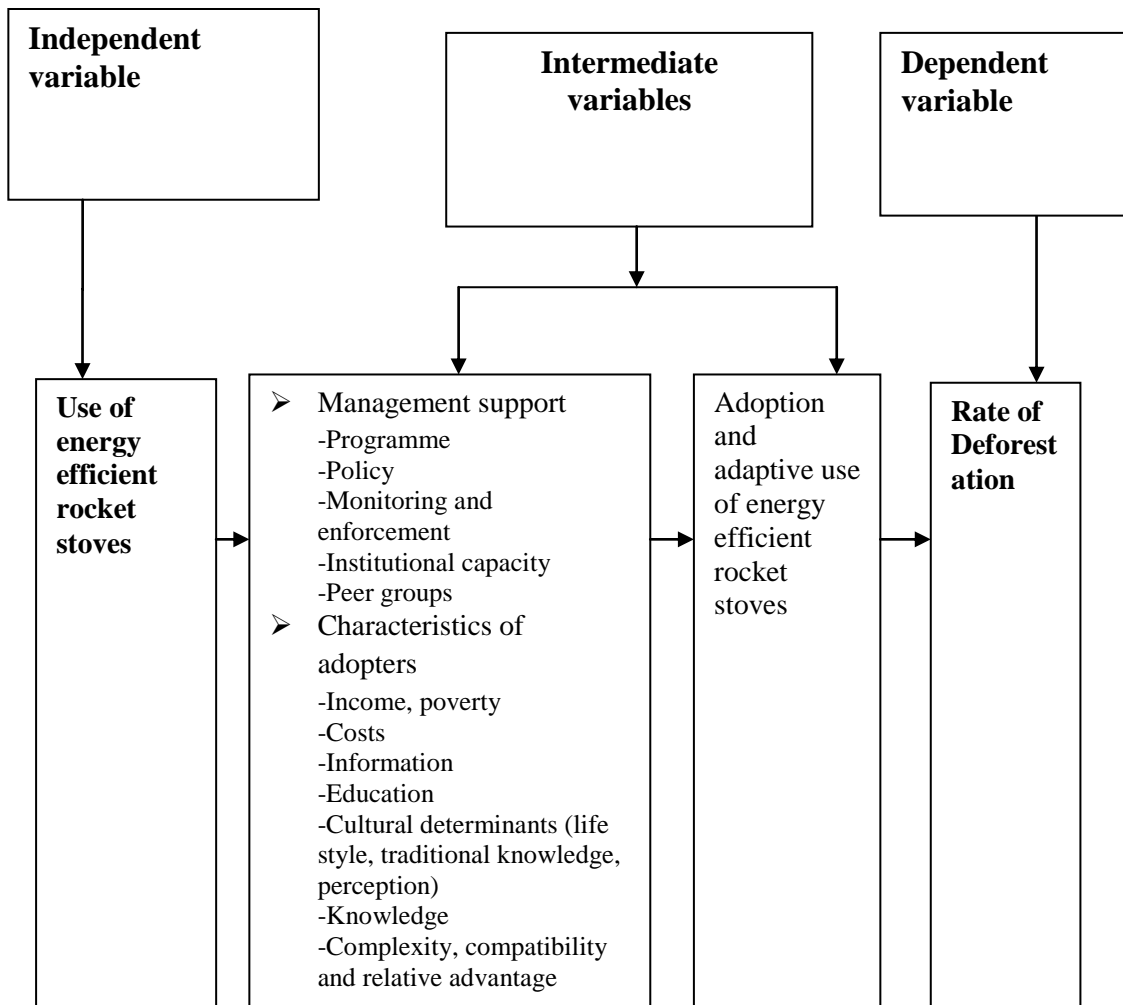
2.4 Synthesis and research gap in the literature reviewed

Different studies by other researchers that have been reviewed each focused on adoption of the improved stoves in relation to the wood consumption. However, all of them didn't focus on either the impact of the stoves on exactly increase or decrease in deforestation rate. Therefore this study aims at bridging the gaps in other studies that have been reviewed by finding out if the rocket stoves have contributed to the deforestation control in the study area, and the challenges in use of rocket stoves in the study area. Also, the reviewed empirical studies show that the rate of deforestation can either increase or decrease due to different factors. Though most of the studies show that failure in adoption of these improved stoves is due to knowledge transition, cost of stove, cultural determinants, education, information, rural poverty also on the other side is the programme as well as policy objectives which can be used as the variables in conceptualizing the conceptual framework and show the relation between them.

2.5 Conceptual Framework

Conceptual Framework refers to a set of broad ideas and principles taken from relevant fields of enquiry and used to structure a subsequent presentation (Reichel and Raney, 1987 in Msabila and Nalila, 2013). Conceptual framework consists of concepts or constructs that are placed within a logical and sequential design (*ibid*). In this study, this framework involved independent variables (use of energy efficient rocket stoves), intermediate variables (Management support, characteristics of adopters and adoption and adaptive use of energy efficient rocket stoves) and dependent variable was the rate of deforestation. In addition, the variables under independent, intermediate and dependent are operating in one direction that is from independent variables to dependent variables. Figure 2.1 below shows conceptual framework of the study.

Figure 2.1 Conceptual framework



Source: Researcher, 2014

As presented in Figure 2.1 above, the use of improved stoves (i.e. energy efficient rocket stoves) by the people depended on the management support (such as Programme, Policy, Monitoring and enforcement, Institutional capacity and Peer groups) and Characteristics of adopters (such as Income-poverty, Costs, Information, Education, Cultural determinants (life style, traditional knowledge, perception), knowledge, complexity, compatibility and relative advantage. These factors have influence on adoption and adaptive use of the improved stove depending on negativity or positivity of the influence. For instance, economic motivation has influence on the use of energy efficient stoves because if one is well enough

economically he will be able to afford the stove especially in its initial as well as the running cost compared to the one who is not well economically. Also for the case of information too those people who were well exposed to peer groups as well as other media were getting enough information about the stoves and be able to use them compared to those who did not get or did not have information about the stoves and the last example is knowledge, people with knowledge about the stoves also are easy to adopt these kind of stoves compared to those without knowledge, because if one has enough knowledge can be able to even repair the stove if it has some problems without consulting a specialist compared to the one without knowledge.

Moreover, adoption and adaptive use had implication on contribution of improved stoves to deforestation control (rate of deforestation). If there was high adoption and adaptive use, it was expected that the contribution of the improved stoves to the deforestation control would be high (i.e. rate of deforestation would decrease). On the other hand, if there was low adoption and adaptive use, there would be negative impact to deforestation control.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

Research methodology is a science of studying how research is done scientifically. It involves various steps that are generally adopted by a researcher in studying the research problem along with the logic behind the environment (Kothari, 2004). In this study, research methodology will consist of study area, research design, study population, sampling and sampling techniques, data collection, data analysis and presentation.

3.1 Research design

The research design is a chosen plan for achieving a particular study or research. It stands for advance planning of the methods to be adopted for collecting the relevant data and the techniques to be used in their analysis. In other words, it constitutes the blueprint for the collection, measurement and analysis of data (Kothari, 2004). Research design, in fact has a great bearing on the firm foundation of the entire structure of the research work (*ibid*). The research used in this study was cross-sectional design that enabled the researcher to do an in-depth examination of the study population and be able to collect data from a relative large number of cases at a point in one time.

3.2 Study area

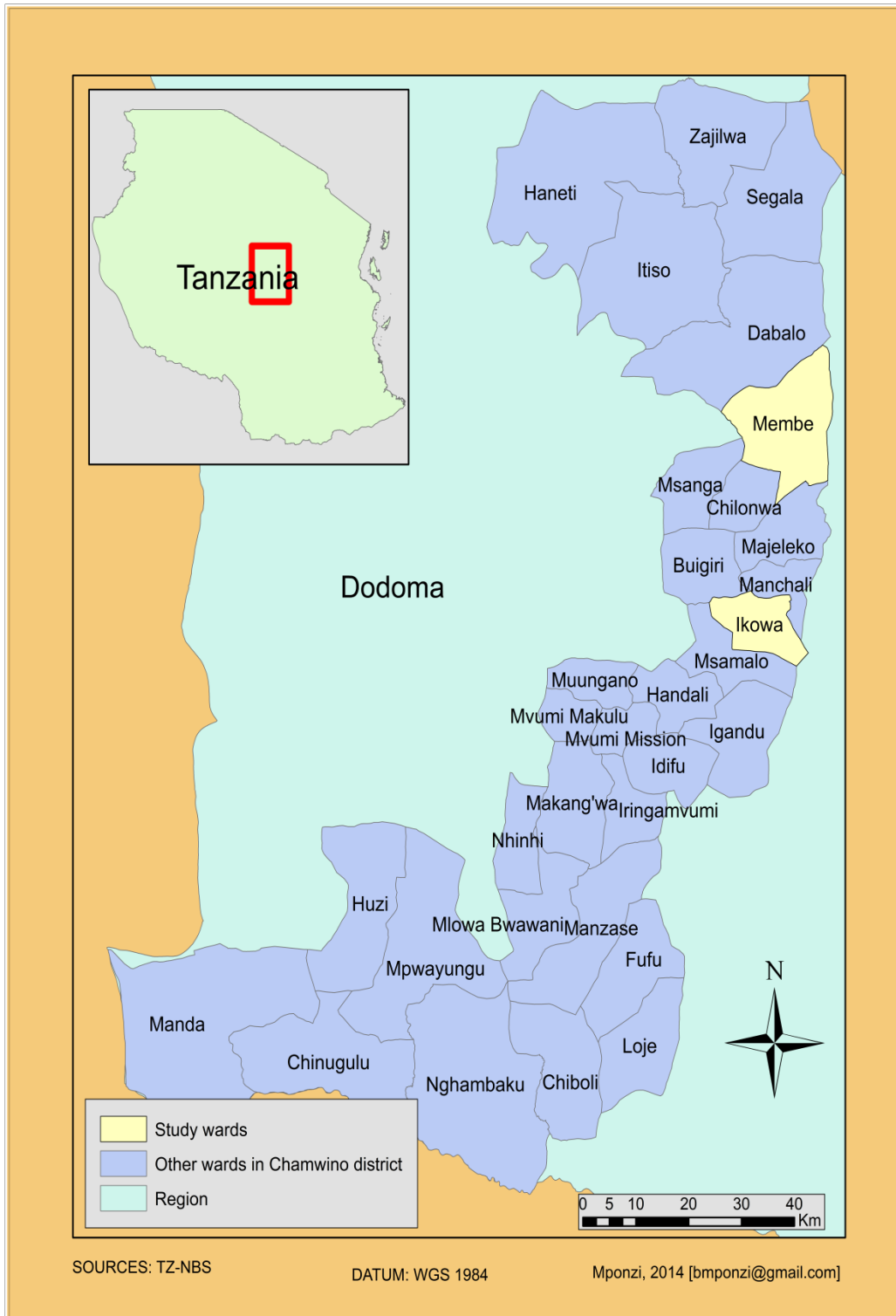
This study was conducted in Chamwino District Council which is one of the districts in Dodoma Region originated from the traditional Dodoma Rural District. The District has a total area of 8,056 square kilometers and it is located in the central plateau of Tanzania which extends between latitude 40° and 80° South and longitude 35° and 37° East. The district has five divisions, thirty two wards, and seventy eight villages. The district borders Dodoma Municipal on the West, Kondoa District on the North, Kongwa and Kiteto Districts on the East, Mpwapwa District and Iringa rural

on the Southwest, and Bahi District on South East. The 2012 National Population and Housing Census showed that the district had the population of 330,543 people, among them females were 171,661 and males were 158,882. However currently regional and district projections show that Chamwino district has a population of 340,129 where by females are estimated to be 175,601 and 164,528 are males. The Population density is 42 people per km (URT, 2010).

The district is sporadically semi arid with a dry savannah type of climate, which is characterized by long dry season starting late April to early December, and a short single wet season starting from December to mid April. The average annual rainfall is 500mm and about 85% of this falls in the four months between December and March. The rainfall in the district is relatively low and unpredictable in frequency, amount and distribution particularly in January when most of the crops are generally sown (URT, 2010). The main economic activities performed by the Chamwino community are agriculture, livestock keeping and fishing. Despite the fact that rainfall is unreliable, maize, beans, groundnuts and grapes are main products grown in the District.

The study was conducted specifically in Ikowa and Membe wards specifically in their respectively villages. Preference to these wards was due to the fact that the problem of deforestation is high and the efficient rocket stoves technology was introduced and implemented in some villages in the respective wards. Moreover, the selected two villages (Makoja and Ikowa) represented the villages where natural forest is located between them and the project was implemented; one village (Membe) with natural forest within the village and the project was implemented; and the other village (Mlimwa) represented the villages where SST project was not implemented.

Figure 3.1 Map of Chamwino District showing the study area



3.3 Sampling and sampling techniques

Sampling is the process of obtaining information about an entire population by examining only part of it (Kothari, 2004) while sampling techniques are the methods used in drawing samples from a population usually in such a manner that the sample will facilitate determination of some hypothesis concerning the population (*ibid*).

3.3.1 Sampling frame and sampling unit

The study population of this study consisted of the respondents from the two selected wards such as Ikowa and Membe. The study involved Wards, Villages and STT officials as well as officials in the district level. The sampling unit was households which were strictly the rocket stove users from three villages (i.e. one village from one ward and two villages from the other ward in which there are forests and the technology have been implemented) and non-users of the stoves from one village which is close to the forest but the technology has not been implemented. It also involved District Environmental Management Officer (DEMO), Ward Executive Officers (WEO), Village Executive Officers (VEO), Forest Officers (FOs) and STT officers (STTOs).

3.3.2 Sampling techniques

This study involved both probability and non probability sampling techniques. The probability sampling that was used is such as simple random sampling while non probability sampling involved purposive sampling technique.

3.3.2.1 Simple random sampling

Simple random sampling is a technique that every possible combination of subjects in the population to be studied has an equal chance of being selected (Kothari, 2004). This technique was used to select households, that is, stove users and non stove users to be included in the study. This technique was appropriate in the study because it is free from classification error, also the sample were free from Bias (*ibid*).

3.3.2.2 Purposive sampling

Purposive sampling is technique which involves deliberate selection of a particular unit of the universe for constituting a sample, which represents a universe (Kothari, 2004). Preference to this technique was due to the fact that it is cheap and quick to choose a sample and the results obtained from analysis of a deliberately chosen sample are tolerably reliable (*ibid*). This technique was used to select key informants such as VEOs, WEOs, DEMO, FOs and STTOs. These officials were very important as far as the study was concerned because they were able to provide more information according to their positions.

3.3.3 Sample size

The formula by Yamane (1967) was used for calculating the sample size of a research. The study population at Ikowa and Membe wards was estimated to be **10,636** (URT, 2012). The sample size was then;

$$n = N / 1 + N (e)^2 \quad \text{where } n = \text{sample size, } N = \text{population size}$$

$e =$ level of precision

$$n = 10,636 / 1 + 10,636(0.1)^2 \quad \text{where } N=10,636, e=\text{constant}=0.1$$

$$n=10,636/1+106.36$$

$$n=10,636/107.36$$

$$n=99.0685$$

The sample size of the study was 100 respondents (25 households for each village) and 14 key informants making a total sample size of 114 respondents. The distribution of sample size is as shown in Table 3.1 below.

Table 3.1 Distribution of sample size

S/N	Category of respondent	Number of respondents
1.	Stoves users (villages 1)	25
	Stoves users (villages 2)	25
	Stoves users (villages 3)	25
2.	Non-stove users(village 4)	25
3.	WEO	2
4.	VEO	4
5.	DEMO	1
6.	FO	4
7.	STT officers	3
	Total	114

Source: Formulated by Researcher, 2014

3.4 Sources of data

Both primary and secondary data were used in the study. Primary data were obtained directly from the field. These data were obtained from the respondents directly in the study area from the two selected wards and their villages. On the other hand, secondary data were obtained from different sources both published and unpublished documents and relevant literatures such as reports, journals, pamphlets, newspapers, and internet sources. These secondary data included adoption and adaptive use of the rocket stoves in the area where the technology has been implemented, trends of deforestation in selected villages, impact of the rocket stoves on deforestation as well as the challenges associated with use of the stoves.

3.5 Data collection methods

Primary data were collected through questionnaires, in depth interviews, focused group discussions (FGDs) and observation. On the other hand, secondary data were collected through documentary review, from National Bureau of Statistics and United States Geological Survey.

3.5.1 Questionnaires

The questionnaire to be used must be prepared very carefully so that it may prove to be effective in collecting the relevant information (Kothari, 2004). In this study questionnaires were distributed to 100 respondents including stove users (**Appendix Ia**) and non-stove users (**Appendix Ib**) in each village. This technique was preferred because it is free from bias of the interviewer and the answers are in own language of the respondent and the respondent have adequate time to give well thought out answers (Mukul and Deepa, 2011).

3.5.2 Interview

The interview method of collecting data involved presentation of oral-verbal stimuli and reply in terms of oral-verbal responses. This method can be used through personal interviews or telephone interviews (Kothari, 2004). This study employed personal interviews where by the interviewer asked questions in a face-to-face contact to WEO and VEO (**Appendix II**), STT Officers (**Appendix III**), FOs and DEMO (**Appendix IV**). In depth interview was used to gather enough information in noted form concerning the impact of rocket stoves on the rate of deforestation. The interview was preferred because it is very flexible as the interviewer has the freedom to formulate questions as they come to mind around the issue being investigated; it also enables to get more information in greater depth (Mukul and Deepa, 2011). Therefore interview was used to different officials in order to get their experience and views about deforestation as well as impact of the rocket and traditional stoves on deforestation rate.

3.5.3 Focused Group Discussion

This method was used to obtain information from small groups initiated by Sunseed to promote use of stoves in the study area. One group from each village where the stoves have been introduced was involved where each group consisted of five villagers. Selection of members of the groups considered women, men as well as youth who were asked various questions ranging from their knowledge about deforestation, impacts of rocket stoves on deforestation, adoption and adaptive use of rocket stoves as well as challenges associated with use of rocket stoves. After discussions these villagers were asked individually to write shortly on their views about the study, particularly with the intention of expressing what they couldn't say in groups due to fear. The guiding questions which were used to FGDs are presented in **Appendix V**.

3.5.4 Observation

This method involves obtaining information which relates to what is currently happening and is not complicated by either the past behaviour or future intentions or attitudes of respondents (Kothari, 2004). In this study, participant as well as non-participant observation was used to observe the use of rocket stoves as compared to traditional stoves and deforestation. Observed parameters are as presented in observation checklist (**Appendix VI**).

3.5.5 Documentary Review

Various documents were reviewed in the Sunseed Trust Tanzania's Offices, villages and ward offices. Also the review involved different sources both published and unpublished documents and relevant literatures such as reports, journals, pamphlets, newspapers, and internet sources. The reviewed issues included records on the trend of deforestation in the villages, adoption and adaptive use of rocket stoves, impacts as well as challenges of the rocket stoves in the study area in relation to deforestation.

3.6 Data Analysis

According to Kothari (2004), data analysis is a process, which implies editing, coding, classification and tabulation of collected data. Both quantitative and qualitative analyses of data were used in this study. Quantitative data gathered through the household survey were analysed by means of descriptive statistical methods in which cross tabulation between variables was done by the use of characteristics of the stove users (age, sex, education and sources of income) to compare two different variables as shown in Table 3.2 below.

Table 3.2 Grouped data of respondents

S/N	AGE	SEX	EDUCATION	SOURCES OF INCOME
1.				
2.				
3.				
4.				

On the other hand, qualitative data consist of words and observations, not numbers, as with all data, analysis and interpretation are required to bring order and understanding (Ellen and Marcus, 2003). Qualitative data collected from the respondents from all villages were analysed through content analysis in which the researcher had to adapt to own extension of evaluation considering patterns/common themes emerging around specific item in the data. The collected data were re-read and right impressions which were useful were written down and organized according to groups of respondents from households, focus group discussions and key informants. After this had been completed, analysis was done using SPSS.

Moreover, to know the extent of forest cover change, assessment was done using LANDSAT 7 thematic mapper plus (ETM+) images for the year 2002 and 2009 and LANDSAT 8 images for the year 2015. LANDSAT images were downloaded from the United States Geological Survey (USGS) then were geo-referenced using World Reference System 2(WRS 2) with Path 168 and Row 064. Software used were

ERDAS IMAGINE 2014, ArcGIS 10.2.2, Google Earth and Microsoft Office Excel. All images were band stacked first in ERDAS IMAGINE 2014 then they were cross checked by linking them to Google Earth functionality found in ERDAS IMAGINE 2014. Since the interest was on forest cover change, supervised image classification using maximum likelihood classifier was used to classify the images into two classes (forest and non-forest). The classified images were then loaded into ArcGIS 10.2.2 together with vector files for both wards and their respective study forests. All images were then converted from raster to vector format for easy processing. The resulting vectors were then dissolved by land cover type (forest and non-forest). The study's forests vector shape file was used to get the resulting forest and non-forests vectors for both study forests. From the derived study's forest vector shape file, area in kilometers, for both forests and non-forests area were computed using "Calculate Geometry" in ArcGIS. The results were then exported to Ms-office Excel for further summaries and presentation. Lastly, data were presented in the form of charts, graphs and tables.

CHAPTER FOUR

FINDINGS, ANALYSIS AND DISCUSSIONS

4.1 Introduction

This chapter presents the research findings, analysis and discussions of the results obtained through questionnaires, interviews, observation, Focus Group Discussions (FGD) and documents. The findings are presented in line with specific objectives which were: to examine adoption of energy efficient rocket stoves technology; to examine adaptive use of energy efficient rocket stoves; to assess the impact of energy efficient rocket stoves technology in reducing rate of deforestation; and to identify challenges in use of energy efficient rocket stoves technology in the study area. Such analysis will provide the basis for recommendations of ways and means that can help rural community to use sustainably clean energy sources that are environmental friendly and be able to promote their use through proposing ways to resolve the challenges that they face when using such kind of technology.

4.2 Demographic and Socio-economic Characteristics of the Study Respondents

This part provides the summary of the studied population characteristics. In any community, demographic and socio-economic characteristics play an important role in analyzing the population livelihood development. Generally this part provides information about the number of respondents in a study area, sex, age, marital status, education level, and main livelihood activities.

4.2.1 Number of Respondents by sex

A total number of respondents in both wards were 114 whereby 100 respondents came from household level in which 75 were from the 3 villages (25 respondents from each village) where the rocket stoves project was implemented and 25 were from the village in which the project was not implemented. The remaining 14 were key informants whose findings were compared with the information gathered from the communities. Also, the analysis based on two groups that is respondents from 3

villages where the project was implemented and respondents from one village where the project was not implemented so that the groups could be compared to know the impact of rocket stoves technology. The study showed that, out of 75 respondents who were stove users, 73 (97.3%) were females while 2 (2.7%) were males. On the other hand, out of 25 respondents from the village where the project was not implemented 17(68%) were females while 8(32%) were males as presented in Table 4.1 below.

Table 4.1 Distribution of respondents by sex

Villages	Sex		Total
	Female	Male	
With project (Membe, Ikowa and Makoja)	73	2	75
Without project(Mlimwa)	17	8	25
Total	90	10	100

Source: Field Data, 2015

Results revealed that a greater number of women had a greater representation in expression of the information concerning the adoption, adaptive use, impact as well as challenges of rocket stoves livelihood and other related issues in the study area than men. This finding reflects that, females are more concerned with kitchen issues and mostly in firewood collection compared to men. On the other hand, all men who were involved in the discussion concerning rocket stoves and their contribution on deforestation control were interested with the topic so they decided to respond themselves and let their wives do other activities. HEDON (2014) supports that, women are the ones who mostly collect firewood and are also community and environmental leaders who can raise awareness about the importance of adopting more sustainable forms of energy as they can have livelihoods in the energy sector and unlock barriers to adoption.

4.2.2 Age of respondents

Five age groups were considered in this study such as respondents in age group between 21-30 years, 31-40 years, 41-50 years, 51-60 and 61-70 years. Table 4.2 presents the distribution of respondents by age. Results showed that, in the villages where the rocket stoves' project was implemented, about 18.7% of respondents were aged between 21 to 30 years, 46.7% were aged between 31 to 40 years, 26.7% aged between 41 to 50 years, 4.0% aged between 51 to 60, and 4.0% in the age category of 61-70 years. However, in the village where rocket stoves were not implemented, there were no respondents in the age range 51-70 years, 7(28%) were in the age of 21-30, 12(48%) were in the age of 31-40 and 6(24%) were in the age of 41-50. Table 4.2 below shows distribution of respondents by age.

Table 4.2 Distribution of respondents by age

Groups by age	With project	Without project	Total
21-30	14	7	21
31-40	35	12	47
41-50	20	6	26
51-60	3	0	3
61-70	3	0	3
Total	75	25	100

Source: Field Data, 2015

The findings revealed that the majority of respondents who were involved in discussions concerning efficiency energy rocket stove contribution on deforestation control were aged between 31-40 years. On the other hand, only few respondents were aged between 51-60 and 61-70 years. This helped the researcher to get more useful information since it is the working group where people are mature enough and have more experience in resource management and livelihood activities. It was also found that, rocket stoves are complicated in cleaning, in lighting up as well as cutting firewood in small pieces. This might be the reason for failure of old aged group to

afford the use of rocket stoves as they are not strong enough compared to the working age group. This is supported by the study of Njogu, (2011) who said that most of the adopters of the Kenya Ceramic Jiko (KCJ) were in this age of 26-33 and they were in the age of working group thus they could be flexible in adopting the stoves. It was observed that, even in most of the activities this age group was the one involved in many activities. This can be because they are still strong and can be able to perform many activities at a time compared to those who were too young or too old.

4.2.3 Marital status of respondents

This study found that, in villages where the project was implemented, 3(4.0%) respondents said they were not married, 1(1.3%) said she was in relationship, 69(84.0%) said they were married and the remained 8(10.7%) said they were divorced. Likewise, in the village where rocket stoves were not implemented, 2(8%) respondents were not married, 20(80%) were married and only 3(12%) were divorced. Table 4.3 below shows distribution of respondents based on marital status.

Table 4.3 Marital status of Respondents

Marital status	With project	Without project	Total
Not married	3	2	5
In a relationship	1	0	1
Married	63	20	83
Divorced	8	3	11
Total	75	25	100

Source: Field Data, 2015

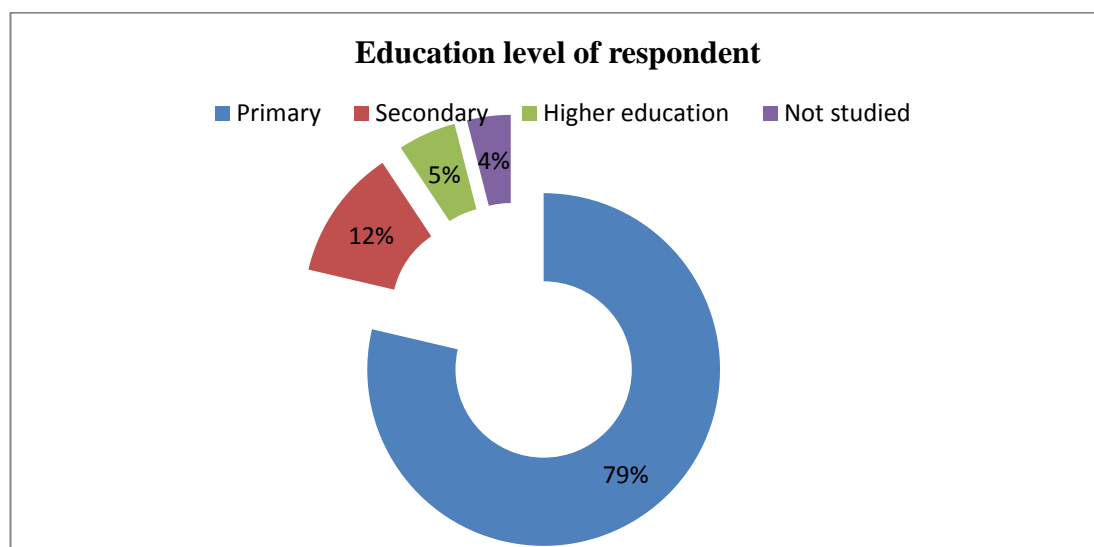
Findings indicate that most of the respondents were married while there were only few who were either only in a relationship or not married. This shows that marital status of the respondents can influence acquisition and use of a technology because there is usually a need for consultation before a decision is made within the house

unlike in the case of female headed household where a woman makes decision on her own. It was also observed that most of the married adopters of the stoves were at least trying to use the rocket stoves compared to those who were not married as could sometime cook or not cook.

4.2.4 Education level of Respondents

Education is one of the long term strategies that may be used to improve livelihoods and proper utilization of resources hence reduce the impacts of rural energy sources on forests (TATEDO, 2009). As presented in Figure 4.1 and 4.2 below, this study found that, in the villages where the rocket stoves were introduced, 3(4%) respondents didn't attend school, 59(79%) respondents completed primary education, 9(12%) respondents completed secondary education and 4(5%) respondents completed higher education as presented in Figure 4.1.

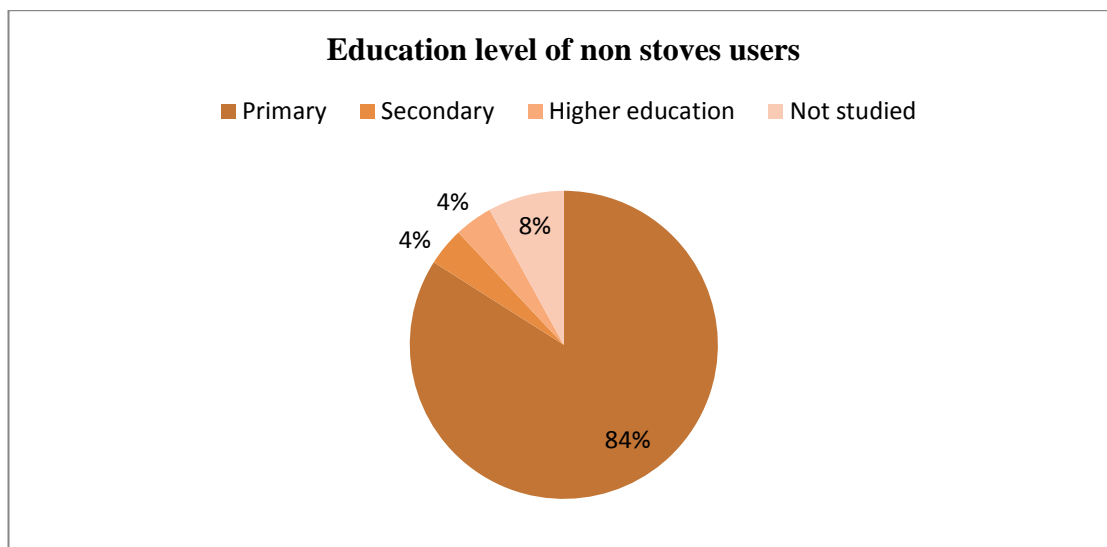
Figure 4.1 Educational Level of rocket stove users



Source: Field Data, 2015

Likewise, in the village where the rocket stoves were not introduced, 2(8%) had not attended school, 21(84%) completed primary school, 1(4%) completed secondary education and 1(4%) person completed higher education as presented in Figure 4.2.

Figure 4.2 Education Level of Respondents where rocket stoves were not implemented



Source: Field Data, 2015

Findings of this study agrees with those of Karanja (1999) who found out that many of the non adopters of energy technology were those with no education while majority of the adopters had been either through primary school(79%), secondary (12%) and (5%) higher education. This indicates that, majority adopters of rocket stoves have at least completed primary education, secondary and higher education as well. Mayetta (2004) reported that illiteracy is one of the causes of resource disturbance; and increase in education of the community tends to increase peoples' awareness of the importance of sustainable natural resource utilization. This is also supported by the report of Chen *et al* (2011) which argues that highly educated populations tend to be more involved in environmentally sustainable production as they are more exposed to education. It is always said that, most of the time people who are educated are the ones who always respond positively towards a certain issue.

4.2.5 Main livelihood activities in the study area

Livelihood activities are means of making a living; main livelihood activities involve activities which are carried out repeatedly and they are the respondent's sources of income (Karanja, 1999). The study found that there were different livelihood

activities in the study area. However, the majority 65(86.7%) were farmers, while 6(8%) were engaged in business, 2(2.7%) were livestock keepers and 2(2.7%) were engaged in other activities in the villages where rocket stoves were implemented. Most of the non-stoves users were farmers that is 23 (92%) were farmers, 1 (4%) was doing business and only 1(4%) was others as it is shown in the Table 4.4 below.

Table 4.4 Main livelihoods activities of respondents in the study area

Activities	With project	Without project	Total
Farmers	65	23	88
Livestockkeepers	2	0	2
Business	6	1	7
Others	2	1	3
Total	75	25	100

Sources: Field Data, 2015

These findings indicate that, majority of the respondents were farmers and thus farming is the main livelihood activity in the study area. Farming activities are seasonal so the farmers in the study area were low income earners. Therefore they were main adopters of rocket stoves compared to other respondents who depended on other livelihood activities. Those who were doing business and other works were able to afford other kind of stoves such as energy sources like kerosene and charcoal stoves for cooking at home that is why they were few in number. This was similarly revealed in the study of Holmes (2010) which reported that farmers were main adopters of the stoves because majority of the rural people depends on agriculture and most of them are low income earners compared to those doing business and other activities; those who are doing business can be able to use other sources of energy for cooking. It was also observed that, most of non-farmers were able to use other sources of energy at their houses for cooking since they earned more money compared to farmers in the study area.

4.3 Adoption of rocket stove in the study area

Adoption is a kind of social change, defined as a process by which alteration occurs in the structure and function of a social system when new ideas are invented, diffused and adopted or rejected leading to certain social change (Makame, 2007). This study assessed adoption of rocket stoves in the villages where the rocket stoves were introduced in comparison to the village where the stoves were not introduced. Figure 4.3 below shows one of the rocket stoves used in the study area.

Figure 4.3 Rocket stove



Source: Field Data, 2015

4.3.1 Number of adopters of rocket stoves

This study found that in the villages where rocket stoves were implemented, all respondents were adopters and they were randomly selected from a large number of adopters of rocket stoves who were purposively selected from three villages. It is also the same with respondents from the village where rocket stoves were not implemented, whereby, all 25(100%) respondents said that, they owned traditional three stones stoves at their homes for cooking and other heating activities as shown in Table 4.5 below.

Table 4.5 Rocket and traditional stoves users in the study area

Villages	Rocket stoves respondents	Traditional stoves respondents	Total
With project (Membe, Ikowa and Makoja)	75	0	75
Without project (Mlimwa)	0	25	25
Total	75	25	100

Source: Field Data, 2015

Moreover, the study found that there is diffusion of information about rocket stove technology from the village where the stoves were introduced to the village where the stoves were not introduced. It was found that, among 25 non-stove users in the village where the stoves were not introduced, 15(60%) were aware while 10(40%) were not aware on what rocket stoves were. This was revealed from non-users who said to be aware as they heard about rocket stoves from the people in the nearby village, and that the stoves are very good in terms of using firewood. However, some of non-users of rocket stoves said that they knew what rocket stoves were, but only 3(2%) have ever used them at their homes for cooking in many years back and not recently and 22(88%) said they have never used such kind of stoves in their houses. It implies that although people had information in their area, adoption was low because the project was not introduced and implemented in the area and thus there was no promotion of the stoves to the area as such people were not given any education on the advantages of the stoves in regards to forest conservation. In addition, if the peer groups in the nearby village could try to promote the stoves, then this could be able to allow easy diffusion of rocket stoves in the nearby village thereby reducing the amount of wood which is cut down for firewood in the study area. But since it was impossible, it implies people in the village continue relying completely on firewood which increases the rate of deforestation.

4.3.2 Trend of adoption of rocket stoves in the study area

Trend is the general direction in which something is developing or changing (Liana, 2011). In the study area, the trend of adoption of rocket stoves was assessed since the

invention of the technology in the study area. In the study area, the rocket stoves were introduced in the year 2006 by Sunseed Tanzania Trust (STT), and the project ended in the year 2011. As it is presented in Table 4.6 below, the study found that 10(13.3%) respondents adopted rocket stoves in the year 2007, 34(45.3%) respondents adopted the stoves in 2008, 7(9.3%) adopted the stoves in 2009, 5(6.75%) adopted in 2010, 8(10.7%) adopted in 2011, 7(9.3%) adopted in 2012 and 4(5.3%) adopted the stoves in the year 2013.

Table 4.6 Adoption of stoves yearly in the study area

Year	Frequency	Percent (%)
2007	10	13.3
2008	34	45.3
2009	7	9.3
2010	5	6.7
2011	8	10.7
2012	7	9.3
2013	4	5.3
Total	75	100.0

Source: field Data, 2015

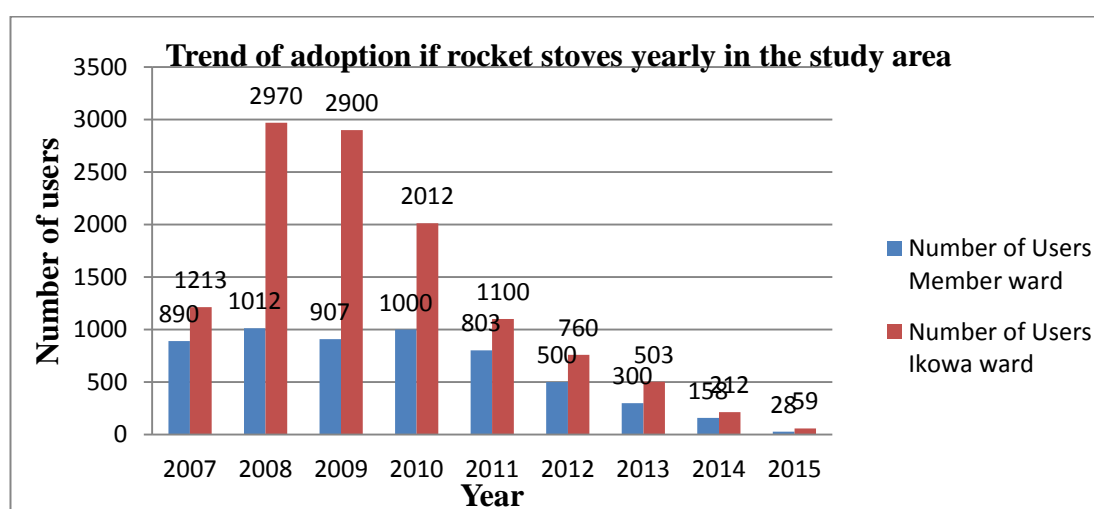
The findings show that, there was initially an increase in adoption of rocket stoves after they have introduced in the study area i.e. from 10 in the year 2007 to 34 in the year 2008. However, later on, there was a decrease in adoption of the stoves to a large extent. Similar trend was also observed from the wards records in the study area. The records showed that initially there was an increase in number of adopters but later on there was a decrease number of adopters of the rocket stoves as indicated in Table 4.7 and Figure 4.4 below.

Table 4.7 Number of users of rocket stoves in Membe and Ikowa Ward

Year	Number of users	
	Membe ward (Membe village)	Ikowa ward (Ikowa and Makoja village)
2007	890	1213
2008	1012	2970
2009	907	2900
2010	1000	2012
2011	803	1100
2012	500	760
2013	300	503
2014	158	212
2015	28	59

Sources: Ward offices, 2015

Figure 4.4 Graph showing trend of adoption yearly in the study area



Source: Ward offices, 2015

Moreover, even based on demographic and socioeconomic characteristic that is age, marital status, education and occupation of the respondents, the data showed initial increase in number of adopters but later a decreasing trend yearly as presented in Table 4.8 below.

Table 4.8 Cross tabulation between demographic/socioeconomic characteristics of respondents and adoption of rocket stoves

	Since when have you started using rocket stoves							Total
	2007	2008	2009	2010	2011	2012	2013	
Age								
21-30	1	8	2	1	1	0	1	14
31-40	8	13	1	4	4	4	1	35
41-50	0	10	4	0	3	1	2	20
51-60	1	1	0	0	0	1	0	3
61-70	0	2	0	0	0	1	0	3
Marital status								
Not married	1	1	0	0	1	0	0	3
In a relationship	0	1	0	0	0	0	0	1
Married	8	28	5	5	6	7	4	63
Divorced	1	4	2	0	1	0	0	8
Education								
Primary	7	28	5	4	5	6	4	59
Secondary	2	3	2	0	1	1	0	9
Higher education	0	2	0	1	1	0	0	4
Not studied	1	1	0	0	1	0	0	3
Occupation								
Farmer	10	30	3	5	6	7	4	65
Livestockkeeper	0	1	0	0	1	0	0	2
Business	0	2	4	0	0	0	0	6
Others	0	1	0	0	1	0	0	2

Source: Field Data, 2015

Generally, there was initially increasing trend in adoption because STT was still promoting the stoves highly which made easy diffusion of the technology to the community. However, later, there was decrease trend due to the fact that the project phased out. Also most of the people were discouraged due to different challenges encountered in use of the stoves for instance, the community said that the stoves were easily breaking up, were not movable so when people migrated to other areas they had to leave the stove at its original place and most of the stove builders could not agree to build the stoves at a half cost as half of the cost had to be paid by STT. This was supported by STT officers who revealed that adoption of the stoves in the study area was very high in the beginning since people saw there was a white lady with them so many people were attracted to adopt with expectation that they would be given loans and aids later. However, as the project was going to phase out, the adoption decreased as people saw that there was nothing given out. Similarly, a study of Makame (2010) revealed that, in the beginning people are more attracted with kind of new technology because there is high promotion from the implementers.

4.3.3 Implications of adoption of rocket stoves to deforestation in the study area

Based on the number and trend of adoption of rocket stoves as presented in subsections 4.3.1 and 4.3.2, it indicates the problem of sustainability of use of the rocket stoves in the study area. The decreasing trend of adoption indicates that most of the people were switching to traditional stoves and increase number of users of traditional stove in the study area. This implies, the need for firewood was increasing as the traditional stoves consume a lot of firewood compared to rocket stoves. Hence, it caused an increasing problem of deforestation in the study area. This also implies that, more people were going back in use of traditional stoves which require a lot of firewood and hence the rate of cutting down trees for firewood increased. Similar findings were revealed in the study of Makame (2010) which reported that, a decrease in adoption of any improved stoves in a certain area always results into high exploitation of natural vegetation.

4.4 Adaptive use of rocket stoves in the study area

Adaptive use is making full use of a new technology as the best course of action available or the uptake of wood fuel energy saving technologies by households (Njogu, 2011). This study has assessed adaptive use of rocket stoves since it has implications on deforestation in the study area. The adaptive use was assessed based on use of rocket stoves in relation to other types of stoves, frequency of use of rocket stoves, and factors affecting adaptive use.

4.4.1 Availability of rocket stoves in relation to other stoves to households in the study area

This study assessed the types of stoves owned by community in the study area which included users and non- users of the rocket stoves. This was intended to know the use of other stoves and whether there was a possibility of use of other stoves by rocket stove users. The study found that, in the village where rocket stoves were not introduced, among 25 non-rocket stove users, 22 (88%) respondents were always using traditional three stones stoves while only 3 (12%) were sometimes using charcoal stoves. Furthermore, the respondents revealed that, they were all using traditional stoves because the traditional ones were the only ones available, the only kind of stoves which was easy to afford, and easy to use. This study showed that, 90% of these respondents said to prefer traditional three stone stoves because they were used to the stoves while 10% said that the stoves have no cost that it is obtained for free whereby one can collect three big stones and make a stove. Figure 4.5 shows a traditional three stones stove used by one of the respondent in the study area.

Figure 4.5 Traditional three stones stove



Source: Field Data, 2015

The study also found that among 75 rocket stove users, 63(84%) respondents also owned traditional three stones stoves while 12(16%) respondents owned only rocket stoves. This shows that even the people who owned rocket stoves also use traditional three stone stoves. This might be due to the fact that STT don't have a policy that force people to only use the rocket stoves. In the study of Njogu (2011), it was recommended that if the people were adopting the improved cooking stoves (ICS), they were not allowed to use other kinds of stoves. Moreover, those who were using traditional stoves despite of having rocket stoves said that, they use traditional ones because they are easy to light up, they are movable and they don't need to cut the firewood into small pieces which is like wasting of time. Figure 4.6 below, shows a woman who was found cooking by traditional stove in the study area.

Figure 4.6 A woman cooking by using traditional three stones stove

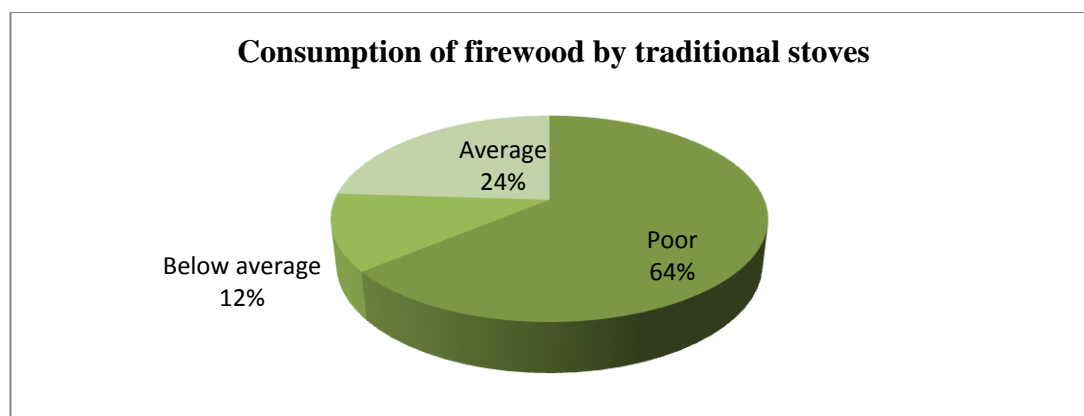


Source: Field data, 2015

Findings showed that there was high use of traditional stoves compared to rocket stoves as even those owned rocket stoves, the majorities were also using traditional stoves. This indicates high demand of firewood as the traditional stoves are poor in use of firewood compared to improved stoves. For instance, when all the respondents were asked on how the traditional stoves are in the use of firewood, 64% said poor, 12% said below average and 24% said average that is the stoves are inefficient in consumption of firewood in cooking and other heating activities as shown in Figure 4.7 below. This was supported by the Village Executive Officers as well as Ward Executive Officers that, in fact the rocket stoves are well in the use of firewood and if the adoption of the stoves could be higher then the rate of deforestation could decrease much. Moreover, the officers added that since most of the people even those

with rocket stoves are still using traditional stoves; the rate of deforestation is increasing because traditional stoves are very poor in the use of firewood.

Figure 4.7 Consumption of firewood by traditional stoves



Source: Field Data, 2015

4.4.2 Frequency of use of rocket stoves in the study area

This study found that, among 75 respondents who were stove users, only 20(26.7%) people were always using the rocket stoves for cooking and heating activities in their houses while 55(73.3%) people were sometimes using traditional three stoves stones in their houses as presented in Table 4.19 below. The findings indicate that, a big number of people were not always using rocket stoves as they were sometimes using traditional stoves. On the other hand, very few stove users were always using rocket stoves.

Table 4.9 Adaptive use of rocket stoves in the study area

Frequency of use	Frequency	Percent (%)
Always use	20	26.7
Sometimes use traditional stoves	55	73.3
Total	75	100.0

Source: Field Data, 2015

Moreover, the study found that there were different factors influencing adaptive use of the rocket stoves in the study area. Figure 4.8 below shows a woman who said she was always using rocket stoves when cooking and other heating activities at her home place in the study area.

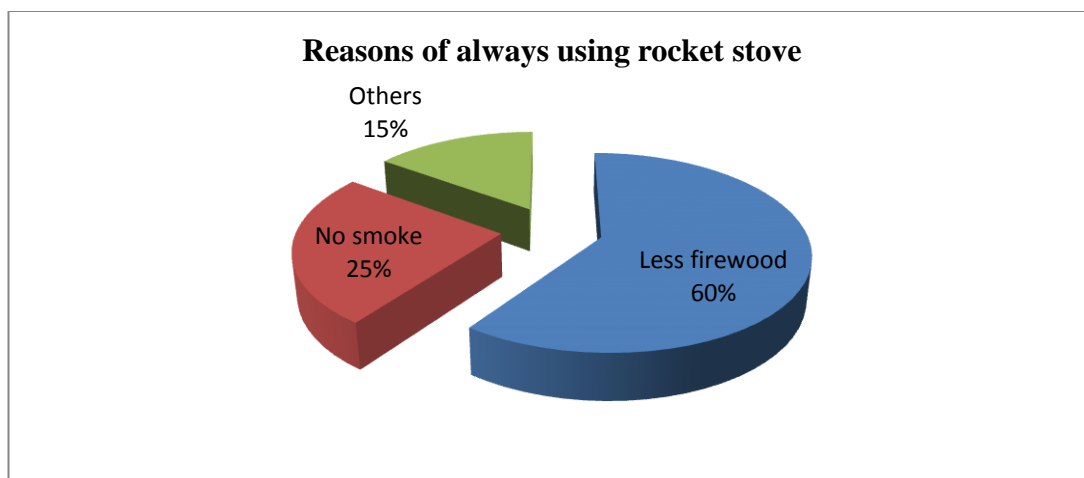
Figure 4.8 A woman cooking by using a rocket stove



Source: Field data, 2015

It was found that among the 20 respondents who said they were always using rocket stoves, 60% said the stoves uses less firewood, 25% said rocket stoves removes all smoke from the kitchen while 15% said other reasons like they have enough heat, they cook faster and others said they can be able to cook more than one kind of food at a time. Figure 4.9 present different reasons that influence use of rocket stoves.

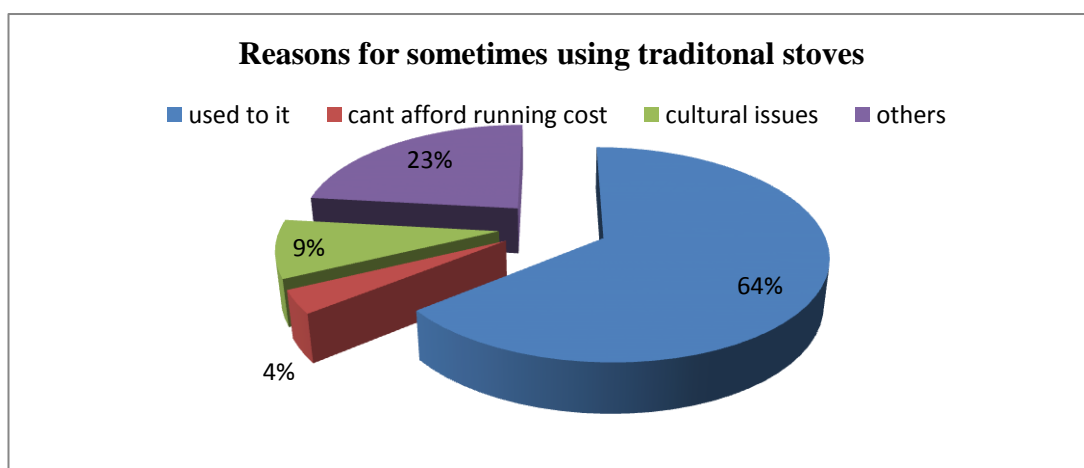
Figure 4.9 Factors affecting adaptive use of rocket stoves



Source: Field Data, 2015

On the other hand, there are different reasons hindering adaptive use of rocket stoves in the study area as such people were sometimes using traditional three stones stoves despite of efficiency of the rocket stoves which were introduced in their areas. Figure 4.10 present different reasons which caused adopters of rocket stoves to prefer use of traditional stoves.

Figure 4.10 Reasons for using traditional stoves by adopters



Source: Field Data, 2015

As it is indicated in Figure 4.10, the reasons for use of traditional stoves, among the 55 respondents who said sometimes use traditional stoves were: 64% said they were

used to traditional stoves, 23% said it is easy to start fire with traditional stoves, easy to clean and there is a problem of broken rocket stoves (Figure 4.11), 9% mentioned cultural issues such as a belief that food tastes good if it is cooked using traditional three stones stoves and the remained 4% said it was because they couldn't afford the running cost of rocket stoves.

Figure 4.11 A broken rocket stove



Source: Field Data, 2015

Lack of adaptive use of rocket stoves was also revealed in a Group Discussion with the peer groups whose members were selected by the STT. These peer groups were given special training so that they could later help in dissemination of knowledge on use and promotion of rocket stove. These groups revealed that they conducted a survey and found that, even those with rocket stoves at their houses were also using traditional stoves. Furthermore, the groups said that adaptive use of rocket stoves was very high in the beginning of the project but it suddenly changed because many

people shifted in use of traditional stoves due to complexity of the stoves as they are complicated in cleaning, not easy to light them up, and there is a problem of cutting the woods into small pieces. The groups also explained that, those who were having rocket stoves but still used traditional stoves were also affected by the lifestyle whereby it was very difficult for them to change completely towards a new technology which was implemented in their area. This was also observed in the study area that the house was having a rocket stove but the household was still using traditional stoves for cooking and heating. It is reported by Jameel (2014) that lifestyle is a typical way of life of an individual, group or culture which involves a combination of determining intangible or tangible factors; tangible factors relate specifically to demographic variables i.e. an individual's demographic profile, whereas intangible factors concern the psychological aspects of an individual such as personal values, preferences, and outlooks these factors. Therefore most of the respondents are much affected with the lifestyle of generation after generation in which every person who is born finds the parents he/she is living with using such stoves. This implies that the family had to search for more amount of firewood since they were still using traditional three stones stoves which in reality ended in destruction of the forest in the study area.

Therefore, findings generally indicate that, there are only few adaptive users of rocket stoves as people turned in use of traditional stoves, and the majority sometimes used traditional stoves due to different reasons. This implies that, adaptive use of the rocket stoves was very low and the technology of rocket stoves was not efficiently used. Moreover, adaptive use is determined by different factors which either enhance or hinder the use. Since the rocket stoves are truly efficient in the use of firewood, and adaptive use of rocket stoves in the study area was low, it implies failure in solving the problem of deforestation hence ongoing problem of deforestation. This is due to the fact that traditional stoves require more firewood compared to improved stoves.

4.5 Impact of rocket stoves on forest conservation

According to Food and Agriculture Organization (2010), forest is land with tree crown cover (or equivalent stocking level) of more than 10% and area of more than 0.5 hectare. The trees should be able to reach a minimum height of 5 m at maturity in situ. Forests are further subdivided into plantations and natural forests. Natural forests are forests composed mainly of indigenous trees not deliberately planted. Plantations are forest stands established by planting or seeding, or both, in the process of afforestation or reforestation. Figure 4.12 shows part of the forest which is not cleared in the study area. However, there were other places which were observed to be much cleared within the study area. This study assessed the impact of rocket stoves on deforestation through assessing community practices on use of rocket stoves in relation to deforestation and field assessment of forest cover change using ERDAS IMAGINE 2014, ArcGIS 10.2.2, Google Earth and Microsoft Office Excel.

Figure 4.12 Showing part of the forest which is not cleared in the study area



Source: Field data, 2015

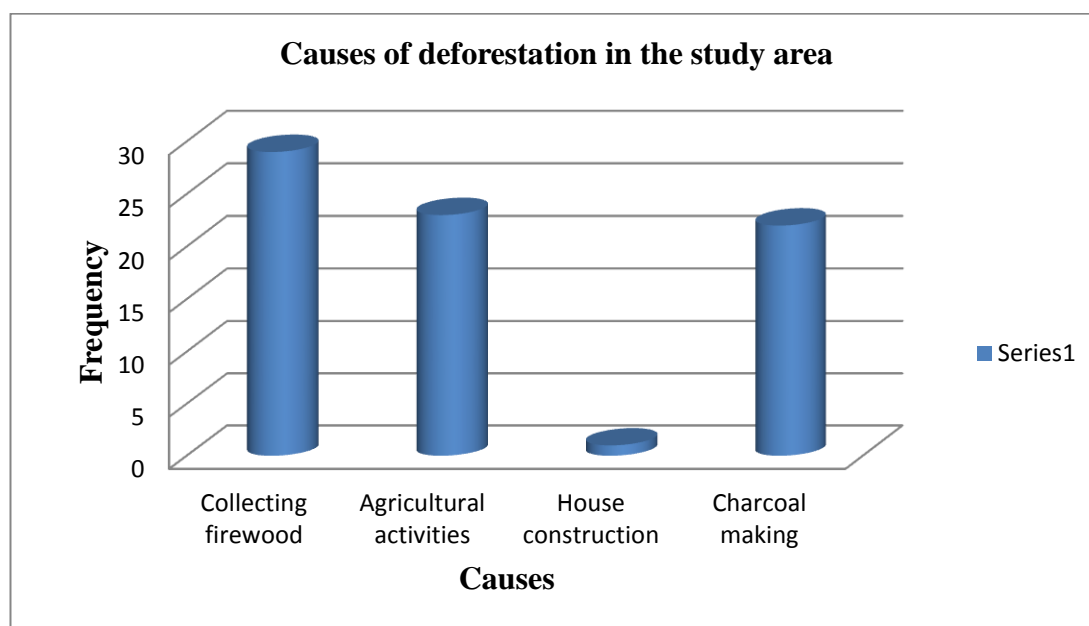
4.5.1 Deforestation as a problem in the study area

Deforestation occurs when there is permanent destruction of indigenous forests and woodlands. Rocket stoves were introduced in order to reduce the rate of deforestation in the study area. This study examined the deforestation as a problem in the study area through assessing its causes, awareness of the community about the problem and sources of firewood used by the community in the study area.

4.5.1.1 Deforestation based on its causes and community awareness

This study found that, there were different causes of deforestation in the study area as presented in Figure 4.13 below. A greater number of respondents 29(38.7%) said the main cause was collecting firewood, 23(30.7%) mentioned the need of agricultural land, 1 person (1.3%) said the main reason was due to house construction and 22(29.3%) said it was because of charcoal making.

Figure 4.13 Causes of deforestation in the study area



Source: Field data, 2015

The findings showed that the main cause of deforestation in the study area was collection of firewood in which people were mainly concerned with firewood collection for their daily home cooking or heating. Others were; the need of

agricultural land and charcoal making in which most of the people in the study area seemed to clear different areas in the forest for agricultural purposes as well as cutting down trees for charcoal making so that they could sell them to nearby places or at urban areas so as to get some money for running their daily life. Clearing of forest for house construction was seemed to be the smallest cause of deforestation in the study area whereby only one person identified this as one of the cause of deforestation. This implies that, the main cause of deforestation in the study area was due to energy sources as firewood collection in additional to charcoal making makes to 68% of all causes of deforestation. This was also revealed in the study of Holmes (2011) that, in rural areas, firewood in the main source of energy in cooking and this will always cause the rate of deforestation to keep on increasing if there are no strong efforts been done. Therefore, introduction of rocket stoves as efficient energy stove was an appropriate strategy for solving the problem of deforestation in the study area.

Surprisingly, though people were found to be aware on causes and impacts of deforestation, they were still doing activities which cause this problem. This study found that all 100 respondents including users and non users of rocket stoves were aware on what deforestation was, and that they had noticed a decrease in the forest cover. They also mentioned the impacts of deforestation such as lack of rainfall, drying of water sources and desertification. One among the respondents quoted explaining about deforestation as, *“It is the removal of trees so one can use them as firewood, for building, making charcoal or getting an area for cultivation”*. However, when they were asked why they keep on cutting trees for energy sources, they said that, *“trees are the only sources of energy in our area because other sources like electricity and gas are very expensive so we can’t afford them”*. Even the Forest Division officer though he was having inadequate information needed, but he said that, the main causes of deforestation in the study area was due to energy sources because firewood and charcoal are used every day for cooking at houses and charcoal is mostly sold to people living in town, compared to agriculture and construction as sources which are rare causes. This implies that, people will keep on

cutting trees in this area and the rate of deforestation will increase as time goes on. Figure 4.14 shows part of the forest which was cleared in the study area.

Figure 4.14 Part of the forest which was cleared in the study area

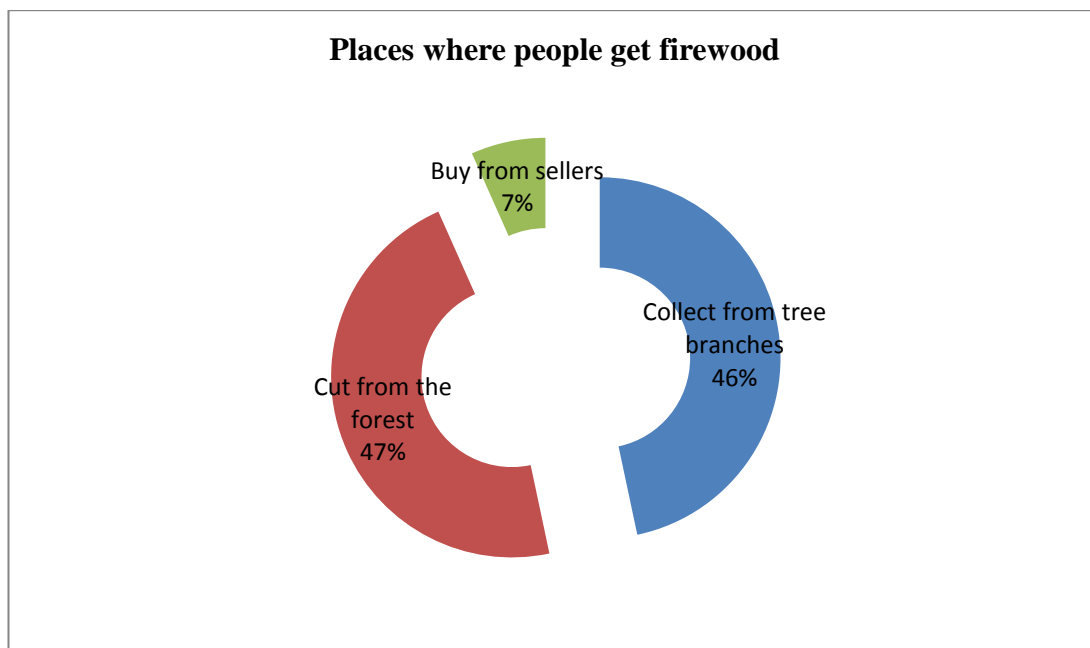


Source: Field data, 2015

4.5.1.2 Deforestation based on sources of firewood in the study area

Places where people get firewood always end up with huge environmental impacts because most of the trees which are cut down are not replaced (Makame, 2010). In the study area, the community which used rocket stoves normally got firewood for cooking and heating from different areas (Figure 4.15). It was found that 35(46.7%) collect tree branches from the forest, 35(46.7%) cut from the forest, and only 5(4.0%) respondents replied that they were buying from sellers.

Figure 4.15 Places where rocket stoves users get firewood for cooking and heating



Source: Field data, 2015

From the observation point of view, it was found that, most of the people were directly getting their firewood from the forest. People were cutting trees for firewood in the forests and use them at home for cooking and heating. Despite of having bylaws in the study area yet people were still cutting the trees to be used for cooking at home. This was due to the fact that, the leaders were the ones breaking the laws which contributed to increase in rate of deforestation. Figure 4.16 below shows a baggage of firewood which was found within the forest in the study area ready to be used as firewood.

Figure 4.16 A baggage of firewood being cut from the forest in the study area

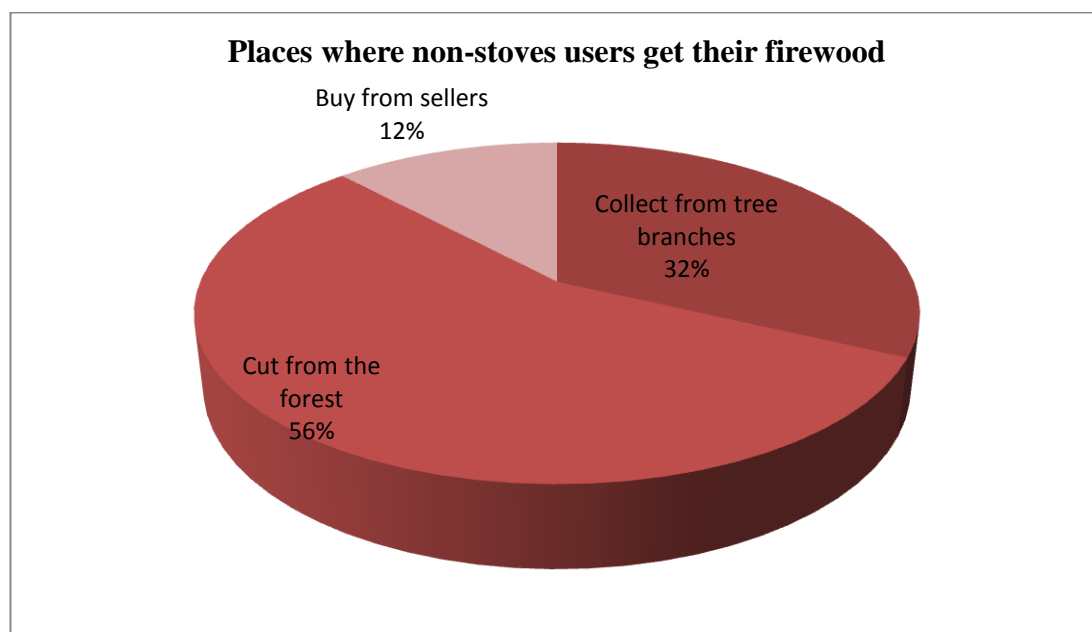


Source: Field data, 2015

Findings indicate that cutting of forest and collection of branches of trees are the main sources of firewood in the study area. The study reveals that, when people enter the forest areas, they tend to collect tree branches but at the same time cutting trees for firewood. Since most of the stove users sometimes used traditional three stones stoves, the small pieces which fall from the trees were not enough for their cooking so they were tempted in cutting trees which they could use in their traditional stoves. But also those who were buying from sellers, the sellers themselves also got firewood from the same forest and some of them said they had their own trees in their farming area which they sometimes sell them to people as firewood. Similarly, the majority of respondents in the village where the project was not implemented cut trees from the forest (56%), collected tree branches from the forest (32%) and only 12% bought from the sellers. This implies there is much destruction of forest in the study area. Figure 4.17 below shows where most of the respondents in the village

where rocket stoves were not implemented got their firewood for cooking and other heating activities.

Figure 4.17 Places where non-stoves users get their firewood



Source: Field data, 2015

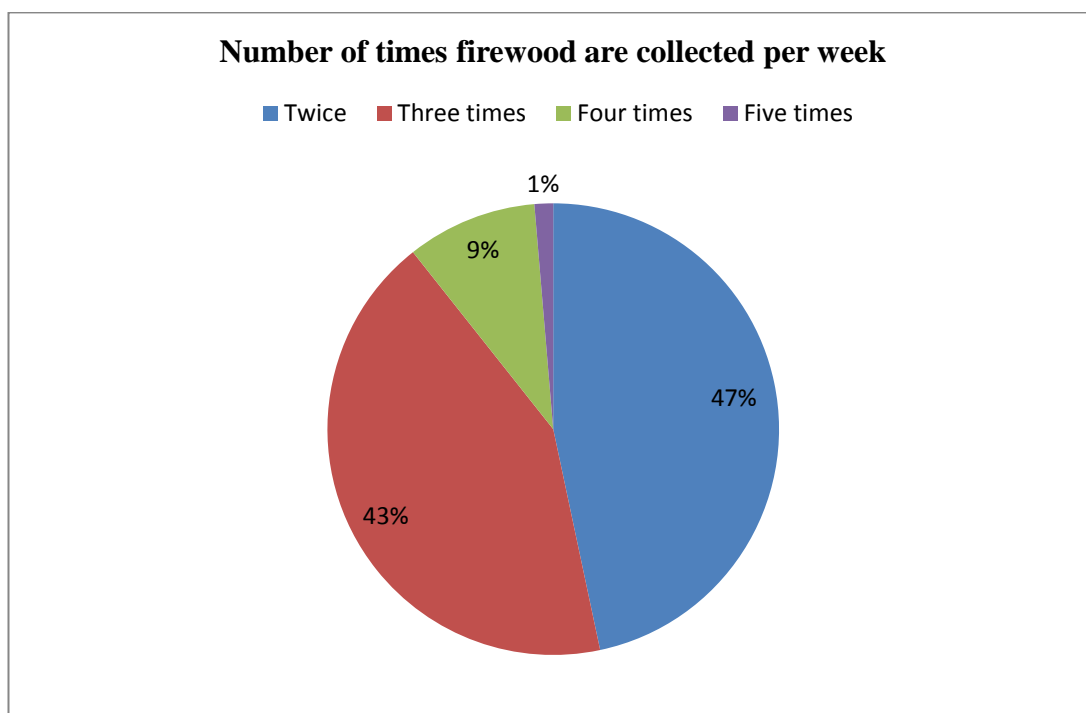
It also implies that, there are no implementations of strong by laws in the study area which could fully protect the forest from being destroyed by the people so as to decrease the rate of deforestation, because people seemed to take it easy saying that they were cutting firewood from the forest. However, in a Focus Group Discussion, villagers said that their villages have different bylaws like penalty of 300,000 Tshs and taken to the Ward Court to whoever found cutting trees in the forests, takes the cattle in the forests, cut trees for getting an area for cultivation. The information was taken to the village leaders by the members of Land and Environment Committee. Though the villagers complained that, the members of this committee were the ones breaking the laws and leading into cutting trees in the forest but leaders did not take any actions against them. They also said that other people were cutting trees from the forest but the committee leaders were always on their side so that they could be bribed and let them go later. So this is a big problem in their villages which catalyses

the deforestation rate too. So, the community was asking for more assistance from the government so that it can help punish those who go against the laws.

4.5.2 Impact of rocket stoves to extend of use of firewood in the study area

This study found that the frequency of collecting firewood differ among people in the study area. The study found that among the rocket stove users, 35(46.7%) said they collect firewood twice per week, 32(42.7%) said three times per week, 7(9.3%) said four times per week and only 1(1.3%) said five times per week. Figures 4.18 below shows number of times per week firewood were collected for cooking purposes and other heating processes by rocket stove users. Findings indicated that, most of the people in the study area were collecting firewood either twice or three times per week.

Figure 4.18 Extend of use of firewood by respondents

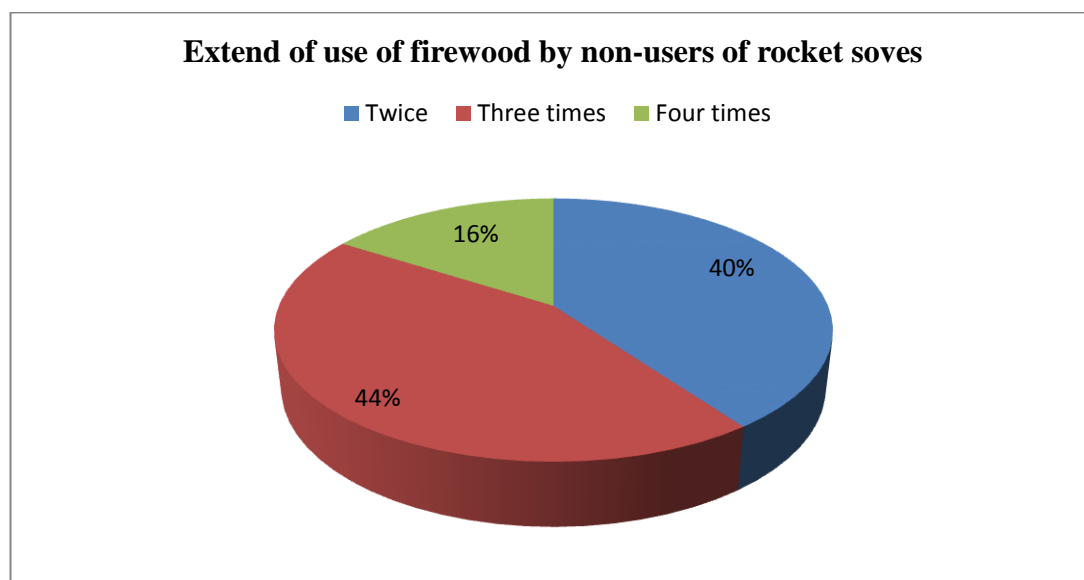


Source: Field data, 2015

Similarly, among non stove users, 10(40%) collected firewood twice a week, 11(44%) said three times and only 4(16%) said four times per week as presented in

Figure 4.19. As it was for stove users, the majority collected firewood either twice or three times per week.

Figure 4.19 Extend of use of firewood by non users of rocket stoves



Source: Field Data, 2015

Findings revealed that, there was generally no difference in frequency of collecting firewood between users and non users of the rocket stoves. The majority for both, users and non users were collecting firewood twice or three times per week. This implies that users of rocket stoves were not always using them as they were also using traditional stoves. This made them need the same amount of wood just like before the stoves were implemented in the study area. Moreover, since traditional stoves need more firewood compared to rocket stoves, it further implies increase in problem of deforestation. These findings are also supported by the study of Makame (2010) which revealed that, due to low adoption of rocket stoves and switching into use of traditional stoves, the need of the amount of firewood was increased which consequently caused high rate of deforestation in the study area.

4.5.3 Impact of Rocket stove in reducing deforestation

This study assessed whether rocket stoves contributed to reduction of deforestation in the study area positively. It was found that 68(90.7%) disagree while only 7(9.3%) agree that rocket stoves had positive impacts in reducing the rate of deforestation in the study area as indicated in Table 4.10.

Table 4.10 Respondent's response on impacts of rocket stoves on forests

Response	Frequency	Percent (%)
No	68	90.7
Yes	7	9.3
Total	75	100.0

Source: Field Data, 2015

According to the findings above, it shows that the stoves have not helped much in the conservation of the forests in the study area because almost more than a half number of respondents said no, they haven't helped. With these findings, the study explored the reasons showing why the stoves have not helped in reducing deforestation in the study area despite of consuming less firewood. It was found that low adoption and adaptive use of the stoves were the main reasons. They said that the number of people who owned them were very few compared to the total number of the people in the study area. They also said that if adoption of rocket stoves could be high then obviously they could have positive impacts on the study area. This means that, even if they could use them always the decrease in deforestation could not be significantly. Moreover, they also said, even the people in the study area who own the rocket stoves do not use them daily, if only they could be using them daily they could have positive impacts on the forests, but because they were not always using them, the stoves have not contributed to reduce deforestation in the study area significantly. Therefore, if there was significant number of people adopted the stoves and if those who adopted the stoves could use them daily then the need for firewood could also decrease as a result the rate of deforestation could also decrease.

4.5.4 Forests cover change assessment

Forest cover change assessment was done by using LANDSAT 7 enhanced thematic mapper plus (ETM+) images for 2002 and 2009 (Fig 4.20), and LANDSAT 8 image for 2015 (Fig 4.21). All three images were from almost similar season (2002, January 22nd; 2009, February 13th; and 2015, February 6th). Images from similar season are good because they help image interpreter to avoid being confused by season variation in land covers. The same vegetation cover during rainy season, under ceteris paribus, won't look the same in dry season.

Figure 4.20 Landsat 7 ETM+ Images displayed in False color

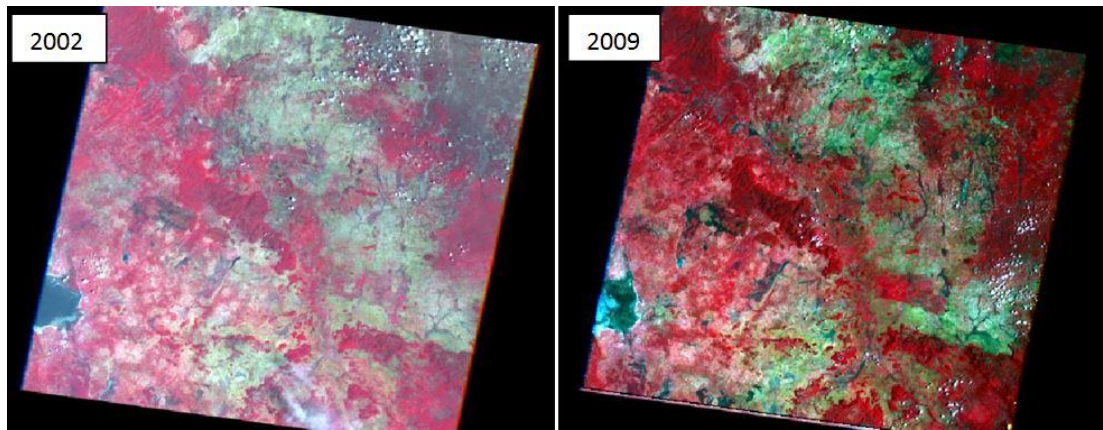
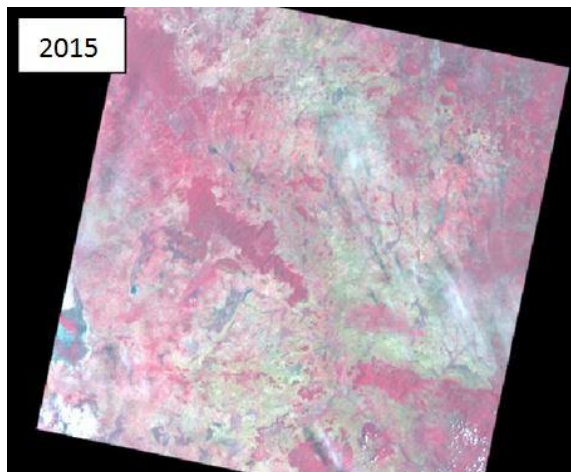


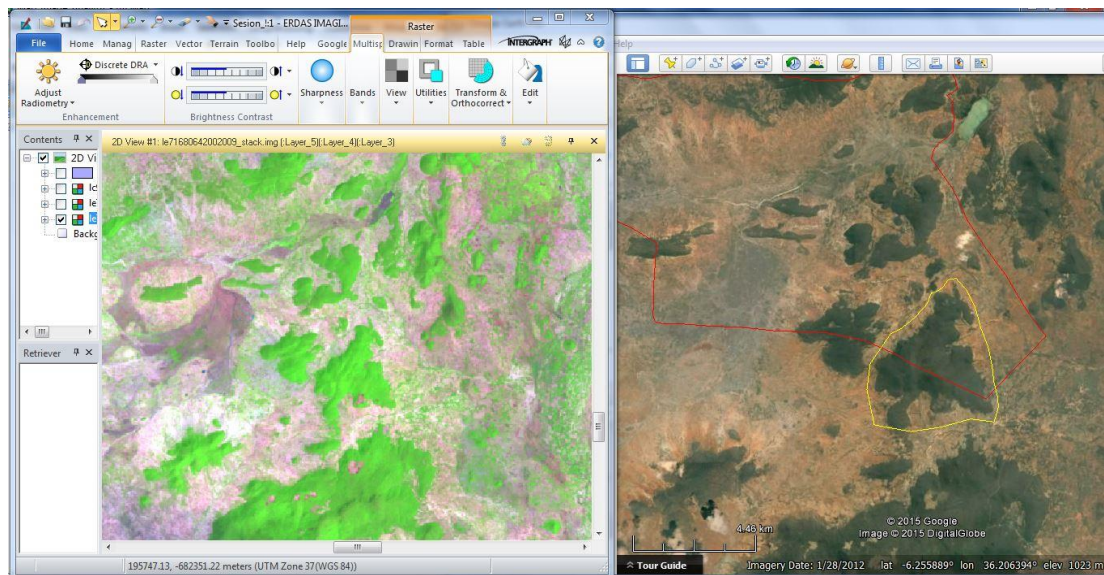
Figure 4.21 Landsat 8 image displayed in false color



4.5.4.1 Image acquisition and pre-processing

Landsat images were downloaded from the United States Geological Survey (USGS) website (<http://earthexplorer.usgs.gov/>). At USGS website, the images are geo-referenced using World Reference System 2 (WRS 2) with Path 168 and Row 064. Software used were ERDAS IMAGINE 2014, ArcGIS 10.2.2, Google Earth, and Microsoft Office Excel. All three images were band stacked first in ERDAS IMAGINE 2014 and then images were cross checked by linking them to the Google Earth (Fig 4.22) functionality found in ERDAS IMAGINE 2014.

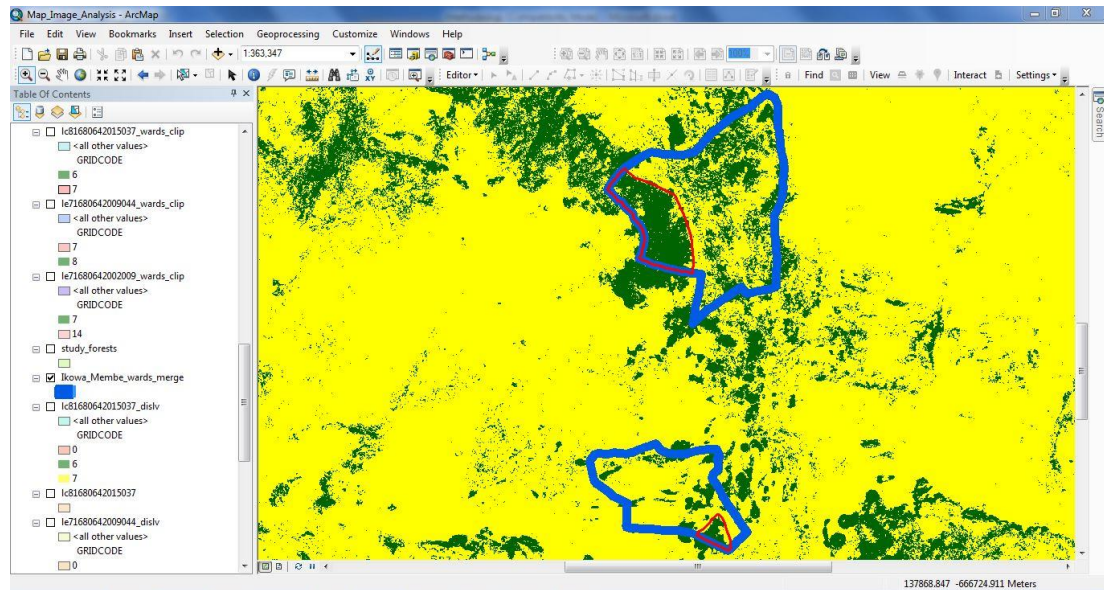
Figure 4.22 Linking ERDAS IMAGINE (Left) to the Google Earth (Right)



4.5.4.2 Image classification and post-processing

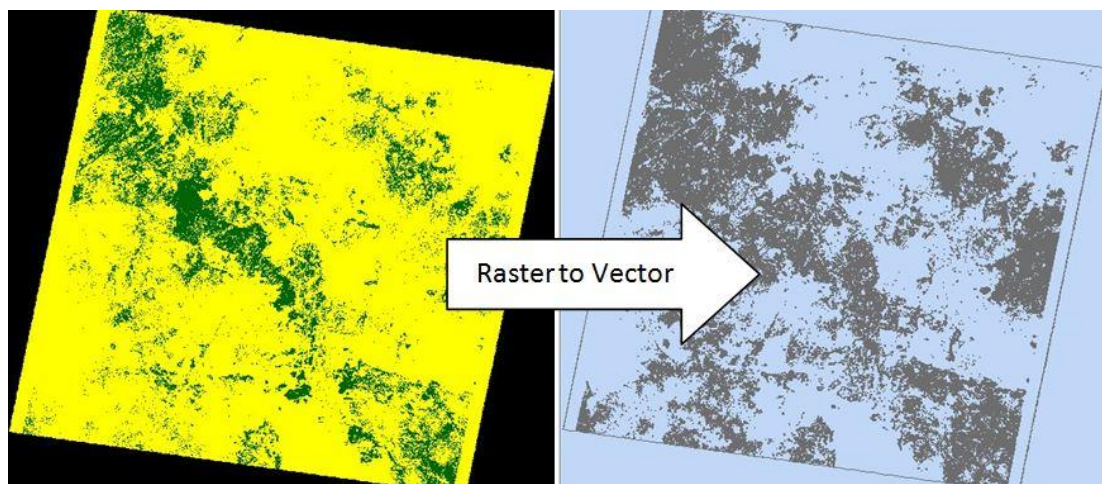
Since the interest was on forest cover change, supervised image classification, using maximum likelihood classifier, was used to classify the images into two classes (Forest, and Non-Forest). The classified images were then loaded into ArcGIS 10.2.2 together with the vector files for both study wards (Ikowa and Membe) and study forests (Chamhene and Chinyami) respectively. Figure 4.23 present the classified image of the study area.

Figure 4.23 Classified image (Green and Yellow), study wards (Bold blue), and study forests (thin red)



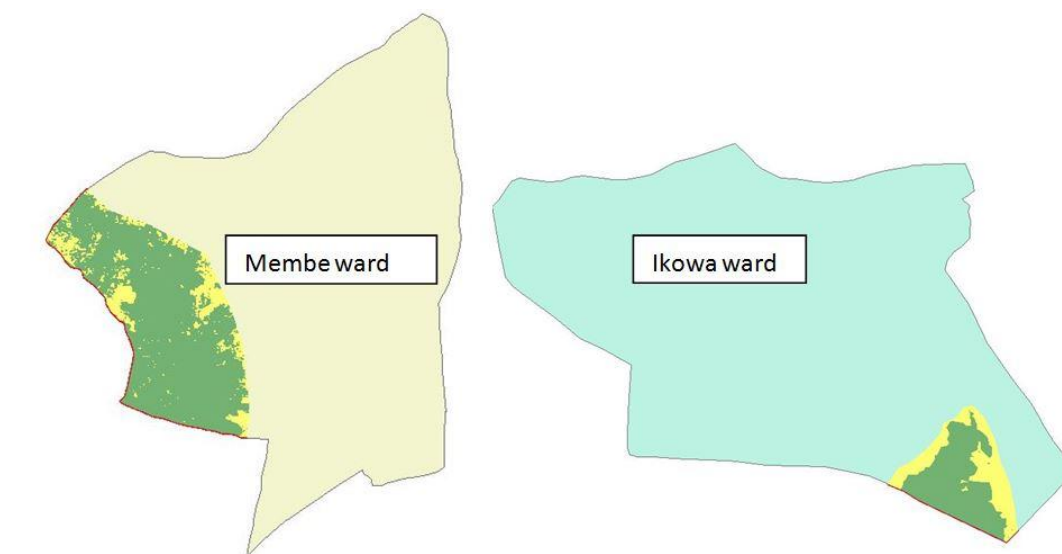
All images were then converted from raster to vector format for easy processing (Fig 4.24). The resulting vectors were then dissolved by land cover type (Forest, and Non-Forest).

Figure 4.24 Image conversion from Raster format to Vector format



The study forest's vector shape file was used to get (by clipping the classified image vector) the resulting forests and non-forests vectors for both study's forests (Fig 4.25).

Figure 4.25 Study forests, 2002, (green and yellow) in their respective study wards



From the derived study's forests vector shapefile, area in square kilometers, for both forest and non-forest area were computed using "Calculate Geometry" function in ArcGIS. The results were then exported to MS-Office Excel for further summaries and presentation (Table 4.11 and 4.12, and Fig 4.26 and 4.27).

Table 4.11 Forest cover change (2002, 2009, and 2015) for the study forest in Ikowa ward

SN	Land Cover Type	Area (Km ²)		
		2002	2009	2015
1	Forest	5.917	4.088	4.078
2	Non - Forest	3.549	5.377	5.388
TOTAL		9.466	9.466	9.466

Figure 4.26 Forest Cover Change in Ikowa ward

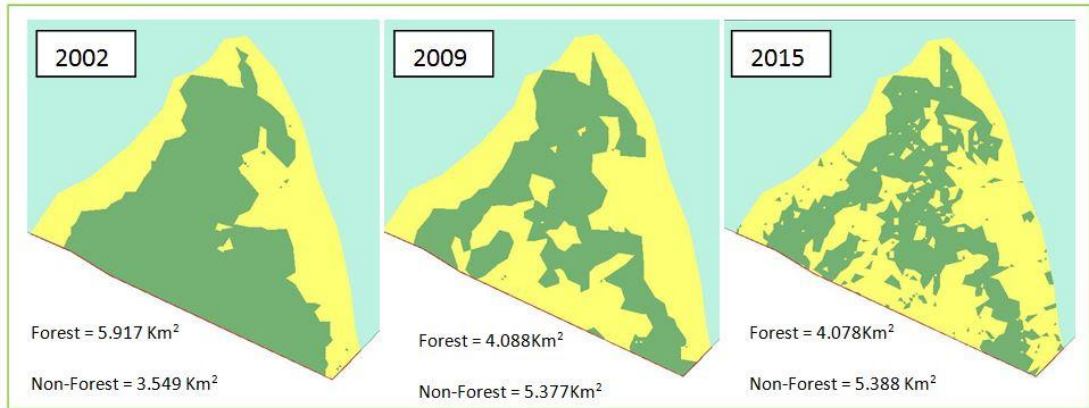
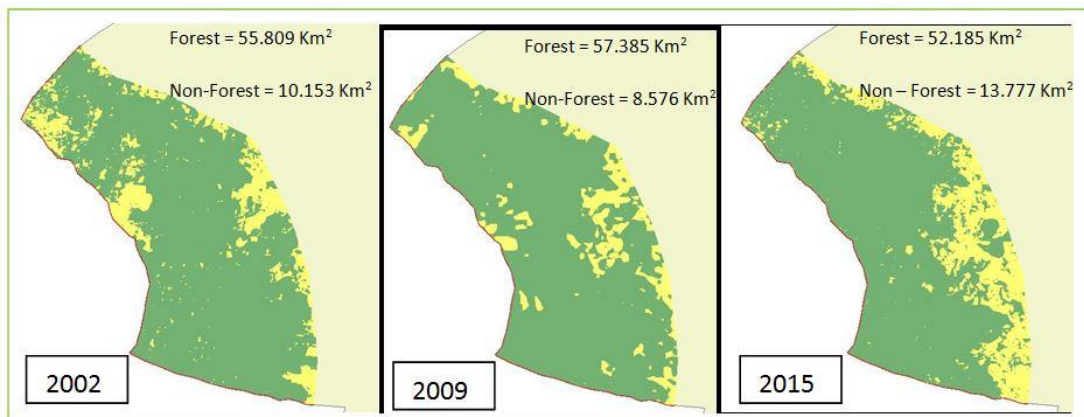


Table 4.12 Forest cover change (2002, 2009, and 2015) for the study forest in Membe ward

SN	Land Cover Type	Area (Km ²)		
		2002	2009	2015
1	Forest	55.809	57.385	52.185
2	Non - Forest	10.153	8.576	13.777
TOTAL		65.962	65.962	65.962

Figure 4.27 Forest Cover Change in Membe ward



Forest cover change in Ikowa Ward shows that; in 2002 (four years before implementation of the project) forest cover was 5.917Km², in 2009 (three years after the implementation of the project), forest cover was 4.088Km² and in 2015 (almost nine years after the implementation of the rocket stoves) forest cover was 4.078Km². While the forest cover was decreasing, the non-forest cover was increasing in which in 2002 it was 3.549Km², in 2009 was 5.377Km² and in 2015 was 5.388Km². Findings indicate that area of forest cover was large before introduction of rocket stoves compared to years during and after implementation of the project. Though there was still a decrease in forest cover even after implementation of the project, the rate of decrease was decreasing. This may imply a decrease in deforestation in more years to come; however low adoption and adaptive use of stoves will still cause increase rate of deforestation. Therefore, the rate of deforestation increased in Ikowa Ward despite people having rocket stoves in their house during the whole period. This was the result of low adoption as well as low adaptive use of the rocket stoves.

Also in Membe Ward, forests cover was 55.809Km² in the year 2002 four years before implementation of the project which increased to 57.385Km² in 2009 three year after implementation of the project. There was an increase in forest cover in 2009 which was 3years after implementation of the stoves in Membe village as indicated in the images in Figure 4.27. This was due to high adoption and use of rocket stoves since it was the beginning of the project and promotion of stoves by STT was high in the study area. But in the year 2015 nine year after implementation of the project, the rate increased which shows the decrease in forest cover again. This was due to the decrease in adoption as well as adaptive use of the rocket stoves and since the phase was already off. While the forest cover was increasing with decrease in years, it was the same with non-forest cover in which it was 10.153Km² in 2002 and decreased to 8.576Km² in 2009 and later increased to 13.777Km² in 2015. This shows that in Membe village it was different, the forest cover increased within the period where the project was on start but as time went on it decreased much and the reasons were the same that there was low adoption as well as adaptive use of the rocket stoves in Membe village.

The assessment in both wards implies that, there is no different between the two assessed forests because there was no much increase in forest cover. Since the interest was on the assessment of the energy efficient rocket stoves, it shows that in Ikowa Ward though the stoves were implemented in both villages, it couldn't help to reduce the rate of forest loss as most of the people shifted into use of traditional stoves instead of always using the rocket stoves. Also in Membe Ward; it shows that, one village was not introduced to this kind of technology but the other village was, but this didn't make any different with the other ward in which both of its two villages were introduced with this technology. Though it showed a bit decrease in rate of deforestation from 2002 to 2009, but the loss increased again in 2015. This was also due to low adoption as well as adaptive use in addition to phase off of STT project in the study area.

4.6 Challenges of rocket stoves in the study area

Despite the fact that the rocket stoves are very efficient in the use of firewood in the study area, there have been noticed different challenges faced by the community and initiators. These challenges in one way or another have contributed in low adoption and adaptive use of the stoves.

4.6.1 Challenges faced by the community in the study area

There were many challenges faced by the community which hindered adoption and adaptive use of the rocket stoves in the study area. This study found that the major challenges of adoption of rocket stoves in the study area were individual factors like lack of information, costs, low income, poverty, lifestyle and lack of education to most of the people. For instance, Rogers (1983) assumed that economic motivation is the main thrust for adopting an innovation, especially if the idea is expensive in both the initial and running costs. He also added that, an individual who is not exposed to mass media and peer groups' interaction will adopt an innovation later than those who are exposed.

Moreover this study found that 22(11.6%) of respondents said the rocket stoves were not movable, 13(6.9%) said too much heat, 15(7.9%) said not mosquito preventer, 34(18%) said the stoves are easy to break when get wet, 12(6.3%) said they were complicated in cleaning, 22(11.6%) said the stoves were not easy to light, 13(6.9%) said when the stoves break smoke comes back in the kitchen, 16(8.5%) said high cost in building and using that is repairing them when they break, 12(6.3%) said lack of skilled builders of the stoves and the last group of 30(15.9%) said the stoves have fixed size of pan which makes it difficult for them to cook using a big or smaller pan than the fixed size of the stove. Table 4.13 below shows that there were many challenges faced by the people who were using rocket stoves in the study area.

Table 4.13 Challenges of rocket stoves in use

Challenges of rocket stoves	Responses	
	Frequency	Percent (%)
Not movable	22	11.6%
Too much heat	13	6.9%
Not mosquito preventer	15	7.9%
Easy to break(when get wet)	34	18.0%
Not easy to start fire	22	11.6%
Complicated in cleaning	12	6.3%
When broke smoke comes in	13	6.9%
Cost in building and using	16	8.5%
Lack of skilled builders	12	6.3%
Has fixed size of pan	30	15.9%
Total		100.0%

Source: Field Data, 2015

The findings revealed that, there are many challenges in use of rocket stoves. However, the main challenge which was mentioned many times was easy breaking of

the stoves when get wet. Other main challenges were fixed size of pan of the stoves, the stoves were not movable and not easy to start fire. These challenges caused most of the people fail to use them and failure in adaptive use when cooking consequently people decided to return in the use of Traditional three stones stoves. For instance they said it's simple to use traditional three stone stove and one can use any size of pan in cooking. Also other challenges like too much heat, not mosquito preventer, complicated in cleaning, smoke comes in when broke, cost in building and using and lack of skilled builders of the stoves were not mentioned by the majority though they were also among the reasons which made them fail to use the stoves frequently. Moreover, one among the complications in use was that rocket stoves need small pieces of wood. Figure 4.22 below shows pieces of wood whereby the pieces shown in the right side were the ones required to be used in rocket stoves while pieces in the left side were required to be cut into small pieces because they are too big. Sometimes they had to collect even more big woods and cut them into small pieces. This is one of the challenge in which the adopters shift in use of traditional stoves because they said they could use any size of firewood without cutting them into small pieces.

Figure 4.28 Size of firewood which can be and cannot be used in a rocket stove



Source: Field data, 2015

Lack of skilled personnel was also revealed to be a problem in the study area. In Focus Group Discussion (Figure 4.29) members complained that, the stoves builders who were trained by Sunseed were not skilled enough because most of the stoves they had built were breaking within short period of time. They therefore suggested that, the members had to be trained again and the material for the stoves should be improved so that the stoves could be of high quality. However, the builders said that, in the beginning Sunseed were paying them half cost of each stove they were building making it 3000 Tshs. But when the phase was over, Sunseed were not contributing half the money to the builders anymore, so the owner had to pay only 1500 Tshs which to the builders wasn't enough for them. They further said it was better for them to do their own activities rather than building a stove at a cost of 1500 Tshs. Stove builders added that, adoption was low because people in the rural areas have this tendency of “better go and have alcohol instead of buying something which can help the family” so it was difficult to most of the people in the study area to adopt the rocket stoves because most of them considered the rocket stove technology as wastage of money and it was better for them to buy a drink but not a stove.

Lastly, the people asked the local government to help in some few categories like, visiting them most of the times and giving them education on the importance and consequences of destroying the forests. They also asked for provision of an Environmental Officer in at least each ward who could be visiting their villages frequently and remind them on the importance of the forest around their areas. In addition, people asked to be provided with National Environmental Policy (1997) so that it can be guideline because most of them have not even heard of it and even those who have heard of it have never seen it or read it.

Figure 4.29 Peer group (builders of rocket stoves) in a discussion.



Sources: Field data, 2015

4.6.2 Challenges to initiators of rocket stoves in the study area

Not only to adopters, but also the initiators (STT) had been facing different challenges in the implementation of the project in the study area. One amongst the challenges was the remoteness of the villages where they could find the people to whom they could introduce and ensure adoption and adaptive use of the rocket stoves. Most of the areas were very far in which the car couldn't pass so it was very difficult to reach the group of people living in those areas. This caused difficulties in promoting and educating them on use of the stoves and their advantages in conserving the forests. Another challenge was limited fund of the initiators which was an obstacle for them to reach in areas where they were supposed to reach and enable people to get information about the stoves. This had consequently caused low diffusion of the stoves since people had no information about the existence of stoves, which made them use only traditional stoves leading to more consumption of firewood.

In addition, most of the time the initiators when reached some areas in the study areas, the village leaders could not give them enough support until they were to give them a certain amount of money otherwise they were not going to invite enough number of villagers for a meeting. This caused the project to start late against the planned time which led them meet few villagers while it was supposed to be in all areas of the villagers where the stoves were introduced because there was lack of enough support from the leaders. This was revealed by one of the STT officer who said that, during the implementation of the project in the study area, some of the village leaders were not giving enough support and they were asking to be paid in return for their services so that they could do their work properly, this is one of the challenge the initiators met at the study area.

4.6.3 Challenges in control of deforestation based on key informants

Moreover, this study assesses views of key informants concerning contribution of rocket stoves in reducing deforestation, most of the Village Officers said that in reality, rocket stoves use less firewood and if they were highly adopted and well used they could be able to control the rate of increase deforestation in the study area. They also said that, most of the people adopted the stoves in the beginning when the stoves were introduced in the study area. But as time went on the adoption was decreasing because most of the people thought they were going to be given some aid from the STT Officers. Lack of this aid caused most of them to quit and stopped attending the trainings anymore. They also said that, the lifestyle people lived in was a problem that most of them seemed to be used to traditional stoves which caused low diffusion among the community, this reason caused even the people who adopted the rocket stoves to turn into use of traditional stoves which consume more firewood.

According to DEMO, lack of affordable alternative sources of energy is a problem. He said that, in rural areas in Tanzania, most of the people are using firewood as sources of energy because most of the alternatives are expensive and others can't be accessed by rural people. Therefore the only alternative is firewood and since it is obtained free, people harvest from the nearby forests. This makes them cut trees

because the stoves they are using require firewood for energy. Furthermore, he asked for assistance from different NGOs, government and other partners to help in addressing this issue by introducing other technologies which should be sustainable so as to help to reduce the rate of deforestation in the study area. He also insisted that, policies should try to address the existing problem at different areas and not be only kept somewhere as they need to be read by people so that they can be able to know what they should do and what they shouldn't do according to what policies say.

Lastly, the Forest Officer added that, they do not receive enough fund which could enable them to move from one place to another in their area of jurisdiction to educate the people on how they could conserve the forests. This causes some of the people to miss education concerning forest management as a result they keep destructing the forest. They also added that, almost all the people are not aware of the existence of the Forest Policy because they have never even heard of it. So, the government should at least take time to address the problem of deforestation according to what its policies are stating as well as making people aware of the existing policies especially the rural people.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter presents the summary, conclusion and recommendations based on findings of the study. It further points out recommendation for further research.

5.2 Summary

This study was interested to assess efficient rocket stoves on deforestation control in Chamwino District in Dodoma Region. The study was conducted specifically in Ikowa and Membe wards specifically in their respectively villages. Preference to these wards was due to the fact that the problem of deforestation is high and the efficient rocket stoves technology was implemented in some of those ward's villages. Moreover, the selected two villages (Makoja and Ikowa) represented the villages where natural forest is located between them and the project was implemented; one village (Membe) with natural forest within the village and the project was implemented; and the other village (Mlimwa) represented the villages where SST project was not implemented.

The study was guided by four main objectives such as to examine adoption of energy efficient rocket stoves technology, to examine adaptive use of energy efficient rocket stoves, to assess the impact of energy efficient rocket stoves technology in rate of deforestation, and to identify challenges in use of energy efficient rocket stoves technology. In this study, various literatures were reviewed whereby the concepts related to efficient rocket stoves and deforestation were defined, empirical studies were described and theory of change was used to develop a framework for use in the study.

The study was conducted using non experimental cross section design where the sample size used was 114 including 14 key informant and 100 community members from 2 wards. Also, the study employed focus group discussions and questionnaires

to collect data from the community and interviews to key informants such as: Sunseed Tanzania Technologies (STT), Chamwino District, Ward leaders, Forest officers, and Environmental officers on efficient rocket stoves and deforestation issues. The data were analysed using SPSS where descriptive statistics including cross tabulations was used for quantitative data. Also the study employed LANDSAT 7 enhanced thematic mapper plus (ETM+) images for 2002 and 2009 and LANDSAT 8 images for 2015 were used in Forest Change Cover Assessment for images which were downloaded from the United States Geological Survey (USGS). Besides, observation have been undertaken to collect more information from the study area.

Findings showed that there is a problem of deforestation in the study area which is mostly caused by collection of firewood as the main source of energy in the study area. It also showed that people were aware of this problem and its impacts on the environment but they were still cutting trees for use as firewood at their houses. The main reasons were; other alternatives like electricity are not accessible in their area and other are very expensive like gas which keep them use the traditional stoves which consume a lot of firewood and make the rate of deforestation increase too. Also weak bylaws of the villages in protection of the forest were the main reason of the people keeping on cutting tree directly from the forests.

It was also found that, adoption of rocket stoves was very low in the study area which was caused by cost of stoves, low education, lifestyle of people, lack of information as well as poverty. Also adaptive use of the stoves by adopters was very low due to different challenges they faced in use of the stoves such as immovable of the stove, easy breaking of the stoves, and coming in of smoke when the stove breaks caused most of the people turning into use of the traditional stoves which later increased deforestation rate as a result the assessment showed that the rocket stoves didn't have positive impacts on forests conservation in the study area.

Findings revealed that, there was initially an increase in adoption of rocket stoves after they had been introduced in the study area i.e. from 10 in the year 2007 to 34 in the year 2008. However, later on, there was a decrease in adoption of the stoves to a

large extent as for adoption also in use of rocket stoves it was found that among the 20 respondents who said they were always using rocket stoves, 60% said the stoves uses less firewood, 25% said because rocket stoves removes all smoke from the kitchen while 15% said other reasons like enough heat, they cook faster and others said they can be able to cook more than one kind of food at a time. But despite these majority of them turned into use of traditional stoves and the reasons were, used to traditional stoves, it is easy to start fire with traditional stoves, easy to clean and other mentioned cultural issues such as a belief that food tastes good if it is cooked using traditional three stones stoves and other said it was because they couldn't afford the running cost of rocket stoves. All these made majority of people turn in use of traditional stoves which used more firewood hence was concluded that the stoves did not help in deforestation control in the study area.

Furthermore, the study assessed different variables in relation to adoption as well as adaptive use of the rocket stoves in the study are management support (Programme, Policy, Monitoring and enforcement and Peer Groups) and Characteristics of Adopters (Income Poverty, Costs, Information, Education, Cultural Determinants (Lifestyle, Traditional Knowledge and Perception), Knowledge, Complexity, Compatibility and Relative advantage. In such assessment, it was observed that, in management support if all the criteria could be well implemented then the adoption would be very high and they could help decrease the problem of deforestation in the study area, also on the case of characteristics issues like income, poverty, costs, information, education, lifestyle as well as complexity contributed to low adoption of rocket stoves too in the study area which caused sustained deforestation, in addition, challenges of the rocket stoves like the fixed size of a pan in which one cannot be able to use smaller or bigger pan than the fixed one of a stove also contributed in low adaptive use of the stove in the study area. For example for a case of lifestyle, people seem to be used to traditional stoves which makes them use these stoves even when they have rocket stoves at their home places, this means this has affected generation after generation because people are born and grow within such a style of life which makes one not easy to adopt new technology or fail to change towards such technology.

5.3 Conclusions

Deforestation as one of the environmental problem is real and its effects are seen all over the world as well as in the country. The problem was also found still existing in the study area though the rocket stoves were introduced to reduce its rate. Therefore, based on this study, the following conclusion can be drawn;

The impact of rocket stoves in reducing deforestation can be realized if there is high adoption and adaptive use of the stoves. This was revealed in the study area where introduction of rocket stoves as a strategy towards controlling deforestation seemed as didn't succeed due to the fact that, there was a decrease in adoption and low adaptive use of the stoves as the majority turned into use of traditional stoves. Adoption of the stoves was only high at the initial stages of the project due to promotion and perceived benefits; however, later it decreases due to different reasons. Among the reasons are costs of the stoves, poverty, education level of the community, lifestyle of people, traditional beliefs, lack of knowledge as well as lack of enough information about the stoves and its benefit on conservation of the forest in the study area.

However, though rocket stoves are good alternative energy source due to their efficiency in use of firewood, all smoke goes out of the kitchen, there is enough heat that one cannot add more firewood and one can cook more than one kind of food at a time. However, they are associated with many problems including their technical design which limits its use by the community. These problems include, immovable of the stove, too much heat, not mosquito preventer, easy to break, not easy to start fire, complicated in cleaning, when broke smoke comes in, cost of the stoves, lack of skilled builders who could help in repairing of stoves when break and fixed size of pan of the stoves which sometimes prevented users to use bigger or smaller pan. This was evidenced in the study area where there was low adaptive use due to the mentioned challenges as a result failure in controlling deforestation because even those who adopted the stoves were not always using them.

Sustainability of the use of rocket stoves depends on different factors which can either promote or hinder their use by a community. In the study area, the factors

which promoted use of rocket stoves were, stoves uses less firewood, rocket stoves removes all smoke from the kitchen, they have enough heat, they cook faster and they can be able to cook more than one kind of food at a time. On the other hand, factors hindered use of the stoves were immovable of the stove, too much heat, not mosquito preventer, easy to break, not easy to start fire, complicated in cleaning, when broke smoke comes in, cost of the stoves, lack of skilled builders who could help in repairing of stoves when break and fixed size of pan of the stoves which sometimes prevent users to use bigger or smaller pan. Moreover, this depended on the challenges that the initiators of the stoves faced in the study area too, like the remoteness of the villages where they could find the people so as to promote the stoves and ensure adoption and adaptive use of the stoves, limited fund of the initiators which caused them not to reach in areas where it was possible to reach and enable people to get information about the stoves and also in some areas in the study areas, the village leaders could not give them enough support until they were to give them a certain amount of money otherwise they were not going to invite enough number of villagers for a meeting.

Moreover, the issue of deforestation is not adequately addressed though the National Environmental Policy 1997 addressed it as one of the major environmental problem in the country. Despite most of the people in the community being aware of its causes and impacts but still there have been unsustainable acts and low adoption of rocket stoves in the study area and hence concluded they haven't helped in controlling deforestation in the study area.

5.4 Recommendations

In this study, based on the findings, the following are recommended as ways to mitigate deforestation and its impacts through the use of energy efficient stove in the study area where rocket stoves were implemented.

Sunseed Tanzania Technologies

- i. Sunseed as implementers of rocket stoves in the study area should make enough awareness to the people through public meetings so as to make

people understand enough the importance of use of rocket stoves in conservation of natural forest surrounding their areas.

- ii. Several trainings to people as well as groups in the study area without forgetting the few from the District level should be considered by Sunseed so that the people can get enough skills and be able to build these stoves themselves without any cost and when broken they can be able to repair them well.
- iii. Also Sunseed should continue to work on her activity of monitoring and evaluating its programmes/projects management process and functions even if the phase is complete so as to make sure the adopters are real making use of the stoves or not, and if not what make them not using the stoves.
- iv. In order to make information disseminate in the study area, then STT should use techniques like use of posters, reports, radio as well as brochures so as to make people living in remote areas able to get information easily concerning the importance of rocket stoves and their relation to forest conservation.
- v. As far as challenges facing the people in adopting the stoves and adopter when using rocket stoves, then STT should try minimize the cost of each stove, improving the design of a stove so that one can be able to use smaller or bigger pan, also using medium pieces of firewood without cutting them into smaller pieces and improve the material so that these stoves won't break easily.

The community

- i. The community in the study area should be flexible to such programme/projects which are introduced in their area since they are the once benefiting from such projects and they should give enough support to the implementers especially when needed.
- ii. Community in the study area need to change towards the kind of technology which is introduced to them since most of the people in the study are seemed to be affected much by the traditional lifestyle like believing that the food tastes better if cooked b traditional stove compared to the one which is cooked by using rocket stove.

- iii. Also, the community in the study area should be flexible as far as they are faced with different challenges during adoption as well as when using rocket so that challenge can be addressed faster so as to make adoption as well as use of the stoves easily.

Government

- i. Government through the village leaders should be the ones giving enough support and cooperation to the implementers of such projects in their area so that many people can be able to participate from the beginning of the project and be able to get enough information as far as the project is concerned. Presence of enough support and cooperation from the leaders always make most of the project succeed.
- ii. The state, through Local Government Authority should make follow up on assessing the quality of the forest in assuring people do not disturb them, not only people but also the leaders of the areas concerned.
- iii. There should be transparency and awareness creation to community concerning laws and policies related to forest which include Environmental Act 2004, Forests Policy 1998 and Environmental Policy 1997. Forest Officers and other people concerned should provide these policies to people so as to make them aware of what they are suppose to do and what they are not allowed to do as far as the environment is concerned. In addition, these policies should be reviewed so as to capture the current situation because since they have been set it is so many years back while there can be other issues to be included in and others to be omitted if possible.

5.5 Areas for further research

It is clear that the findings of this study rose theoretical and methodological questions that require more investigations to be carried out. From this basis, further researches can be conducted in the following areas.

The study has based on assessment of energy efficiency rocket stove in control of deforestation, the study has mostly based on firewood as source of energy in rural

areas. Further research is required in order to strengthen evidence-based action/policy if progress is going to be made in changing the trends of adoption. The role that different actors could play for enhancing rocket stoves technologies dissemination is not well understood.

Further research can also be conducted to assess the impact of other types of improved cooking stoves to deforestation and how development activities affect natural vegetation in rural areas focusing on other causes of deforestation.

Also, since this study was cross-sectional, the findings did not give the process of change to reintegration over time. From this basis, longitudinal study is required from such areas. The study of this nature will give a useful insight into the reintegration process of deforestation across time

Moreover, since many areas of the country are affected by deforestation, it should be of importance to replicate this study in other areas apart from Chamwino District in order to get more data regarding deforestation and improved cooking stoves.

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APPENDICIES

APPENDIX Ia

Questionnaire No.: _____

Assessment of energy efficient rocket stoves contribution on deforestation control, a case study of Ikowa and Membe ward in Chamwino Distict, Dodoma-Tanzania.

Questionnaire – household level-stove users

Your honesty in responding to the statements is very important. Be sure to answer every question, even if it does not apply. Thank you for participating.

A. Basic information

1. What is your name? _____
2. Sex of respondent
 - a. Female
 - b. Male
3. How old are you? _____
4. What is your marital status?
 - a. Single
 - b. In a relationship
 - c. Married
 - d. Divorced
5. What is your highest attained educational level?
 - a. Primary school
 - b. Secondary school
 - c. College
 - d. University
6. What is your current occupation?
 - a. Farmer
 - b. Life stock keeper
 - c. Business woman/man

d. Other

(specify: _____)

B. Adoption of energy efficient rocket stoves technology

7. Do you have a traditional three stone stove?

a. Yes

b. No

8. Do you have a rocket stove?

a. Yes

b. No

9. Since when have you started owning the rocket stove at your house?

10. How does this stove minimize need for firewood? _____

C. Adaptive use of the energy efficient rocket stoves

11. Do you always use the rocket stove, or do you sometimes still use the traditional stove?

a. I always use the rocket stove(go to question 13)

b. I sometimes still use the traditional stove(go to question 12)

12. Why do you still use the traditional stove?

a. Because I am used to it

b. Because I cannot afford running the costs of a rocket stove

c. Because of culture, that I have to use it

d. Other (specify: _____)

13. Why do you always use the rocket stove?

a. The rocket stove needs less firewood

b. I can cook inside the kitchen

c. It generates less smoke

d. Other (specify: _____)

14. Which kind of stove do you prefer most? (Tick the appropriate)

Stove	
Traditional stove	
Rocket stove	
Other stoves	

15. Why do you prefer the above-mentioned stoves? Give reasons for each stove.

D. Impacts of rocket stoves on deforestation control

16. Do you know what deforestation is?

- a. Yes
- b. No

17. If yes, have you seen/noticed any changes of forest cover in your area?

- a. Yes
- b. No

18. If yes, which is the most change have you mostly noticed?

- a. Increase
- b. Decrease

19. According to you, which among the following causes of deforestation is the highest? (Tick the appropriate)

Causes	
Collecting firewood	
Burning trees for agricultural purposes	
Cutting trees for house construction	
Cutting trees for charcoal making	
Others	

20. Where do you mostly get your firewood? (tick the appropriate)

Getting firewood	
I collect tree branches in the forest	
I cut trees in the forest	
I buy from neighbours	
I buy from sellers	

21. Which stove needs more firewood?

- a. The rocket stove
- b. The traditional stove

22. Do you notice a difference in the amount of wood you use now that you have a rocket stove which is the most? (Tick the appropriate)

Amount of wood needed	
I need much less wood	
I need slightly less wood	
I still need the same amount of wood	

23. Do you think the rocket stoves have positive impacts on forest conservation?

- a. Yes
- b. No

24. Why Yes/No?

E. Challenges in use of energy efficient rocket stoves in the study area

25. Which among the following advantages of rocket stove is the best? (Tick the appropriate).

Advantages	
The rocket stove needs less firewood	
Less firewood, so I have time for other activities	
Don't need to walk long distances	
Generates less smoke	
Cooking process goes faster	

26. Which among the disadvantages of the rocket stoves is highest? (Tick the appropriate).

Disadvantages	
Provides too much heat	
Difficult to clean	
Need to cut wedges/firewood smaller	
Others	

Thank you for your cooperation

APPENDIX Ib

Questionnaire No.: _____

Assessment of energy efficient rocket stoves contribution on deforestation control, a case study of Ikowa and Membe ward in Chamwino District, Dodoma-Tanzania.

Questionnaire – household level where rocket stoves were not implemented

Your honesty in responding to the statements is very important. Be sure to answer every question, even if it does not apply. Thank you for participating.

A. Basic information

1. What is your name? _____
2. Sex of respondent
 - a. Female
 - b. Male
3. How old are you? _____
4. What is your marital status?
 - a. Single
 - b. In a relationship
 - c. Married
 - d. Divorced
5. What is your highest attained educational level?
 - a. Primary school
 - b. Secondary school
 - c. College
 - d. University
6. What is your current occupation?
 - a. Farmer
 - b. Life stock keeper
 - c. Business woman/man
 - d. Other
(specify: _____)

B. traditional and rocket stoves

- 7. Do you have a traditional three stone stove?
 - a. Yes
 - b. No
- 8. How is this stove in terms of consumption of firewood?
1-Poor (), **2-Below average** (), **3-Average** (), **4-good** (),
5-Exellent ()
- 9. Do you know what is a rocket stove?
 - a. Yes
 - b. No

10. If yes, have you ever used this kind of a stove? If no, go to question 12.

- 11. How is this stove in terms of wood consumption?
1-Poor (), **2-Below average** (), **3-Average** (), **4-good** (),
5-Exellent ()

12. If you were to choose between the two stoves, which kind of stove would you prefer? Give reasons why?

C. traditional stoves and other kind of stoves

- 13. Do you always use the traditional stove, or do you sometimes still use other kind of stoves?
 - a. I always use the traditional stove
 - b. I sometimes use other kind of stoves

14. If not always, which kind of stove do you sometimes use?

15. Why do you sometimes use the traditional stove?

16. If always, why do you always use the traditional stove?

17. If you were to choose kind of stove, which stove would do you prefer most?

(Tick the appropriate)

Stove	
Traditional stove	
Rocket stove	
Other stoves	

18. Why do you prefer the above-mentioned stoves? Give reasons for each stove.

D. Impacts of stoves on deforestation control

19. Do you know what deforestation is?

- a. Yes
- b. No

20. If yes, have you seen/noticed any changes of forest cover in your area?

- a. Yes
- b. No

21. If yes, which is the most change have you mostly noticed?

- a. Increase
- b. Decrease

22. According to you, which among the following causes of deforestation is the highest? (Tick the appropriate)

Causes	
Collecting firewood	
Burning trees for agricultural purposes	
Cutting trees for house construction	
Cutting trees for charcoal making	
Others	

23. Where do you mostly get your firewood? (Tick the appropriate),

Getting firewood	
I collect tree branches in the forest	
I cut trees in the forest	
I buy from neighbours	
I buy from sellers	

24. According to you, Do you think the rocket stoves have positive impacts on forest?

- a. Yes
- b. No

25. Why Yes/No?

26. According to you, do you think the traditional stoves have negative impacts on the forest?

- a. Yes
- b. No

27. Why Yes/No?

Thank you for your cooperation

APPENDIX II

Interview guide No.....

INTEVIEW GUIDE FOR KEY INFORMANTS (WEO AND VEOS)

Dear interviewee,

I am Annamaria Cornelius Gerome, a student from Mzumbe University pursuing Masters of Science Degree in Environmental Management. I am conducting a research with the purpose of collecting information concerned with/ related to the impact of rocket stoves on deforestation control, taking the case study of Membe and Ikowa wards in their respective villages in Chamwino District. Will you please spare your valuable time to answer the questions I have prepared for you?

Thank you

A. Basic Information

1. What is your name?

2. Title and roles:

3. What is your sex?

- a. Female
- b. Male

4. How old are you? _____

5. What is your marital status?

- a. Single
- b. In a relationship
- c. Married
- d. Divorced

6. What is your highest attained educational level?

- a. Primary school

- b. Secondary school
- c. College
- d. University

B. Adoption of energy efficient rocket stoves technology

7. Do you think that most people in the village have a traditional three stone stove?
 - a. Yes
 - b. No
8. Do you think that most people in the village have a rocket stove?
 - a. Yes
 - b. No
9. Since when have the people in your area started owning the rocket stoves at their home places

10. Do you think the people are really adopting this kind of technology?

11. If yes, to what extend?

C. Adaptive use of the energy efficient rocket stoves

12. Do you think villagers always use the rocket stove, or do they sometimes still use the traditional stove?
 - a. They always use the rocket stove (go to question 14)
 - b. They sometimes still use the traditional stove (go to question 13)
13. Why do they still use the traditional stove, according to you?
 - a. Because they are used to it
 - b. Because they cannot afford a rocket stove
 - c. Because they don't know the rocket stove exists
 - d. Other (specify: _____)

14. Why do they use the rocket stove, according to you?

- a. The rocket stove needs less firewood
- b. They can cook inside the house
- c. Other (specify: _____)

15. Which kind of stove do you think most of the people prefer most? (Tick the appropriate

Stove	
Traditional stove	
Rocket stove	
Other stoves	

16. Why do you think they mostly prefer the above-mentioned stove, according to you?

D. Impacts of rocket stoves on deforestation control

17. Which stove needs more firewood?

- a. The rocket stove needs more firewood
- b. The traditional stove needs more firewood

18. Do you know what deforestation is?

- c. Yes (go to question 19)
- d. No (go to question 22)

19. Have you noticed any change in forest cover in your area?

- a. Yes
- b. No

20. If yes, which change have you noticed in the forest cover?

- a. Increase
- b. Decrease

21. According to you, which among the following causes of deforestation is the highest? (Tick the appropriate)

Causes	
Collecting firewood	
Burning trees for agricultural purposes	
Cutting trees for house construction	
Cutting trees for charcoal making	
Others	

22. Where do you think most of the people mostly get their firewood? (Tick the appropriate),

Getting firewood	
They collect tree branches in the forest	
They cut trees in the forest	
They buy from neighbours	
They buy from sellers	

23. Which kind of stove do you think needs more firewood?

- a. The rocket stove
- b. The traditional stove

24. Do you notice any difference in the amount of wood people use now that they have a rocket stove (which is the most?) (Tick the appropriate)

Amount of wood needed	
They need much less wood	
They need slightly less wood	
They still need the same amount of wood	

25. Do you think the rocket stoves have a positive impact on forest conservation?

- a. Yes
- b. No

26. Why Yes/No?

E. Challenges in use of energy efficient rocket stoves in the study area

28. Which among the following advantages of rocket stove do you think is the best to the people in your area? (Tick the appropriate).

Advantages	
The rocket stove needs less firewood	
Less firewood, so I have time for other activities	
Don't need to walk long distances	
Generates less smoke	
Cooking process goes faster	

29. Which among the disadvantages of the rocket stoves do you think is highest to the people in your area? (Tick the appropriate).

Disadvantages	
Provides too much heat	
Difficult to clean	
Need to cut wedges/firewood smaller	
Others	

Thank you very much for your cooperation

APPENDIX III

Interview guide No.....

INTERVIEW GUIDE FOR THE STTs OFFICERS

Dear interviewee,

I am Annamaria Cornelius Gerome, a student from Mzumbe University pursuing Masters of Science Degree in Environmental Management. I am conducting a research with the purpose of collecting information concerned with/ related to the impact of rocket stoves on deforestation control, taking the case study of Membe and Ikowa wards in their respective villages in Chamwino District. Will you please spare your valuable time to answer the questions I have prepared for you?

Thank you

Your name _____

Designation _____

Department _____

1. What are the main duties have you been performed as far as rocket stoves are concerned?

2. How many times do you visit the rocket stoves users per month?

3. What were the criteria for choosing rocket stoves allocation?

4. What is the modality of assembling the rocket stoves users to join the rocket stoves project?

5. What was the level of adoption of the rocket stoves by the villagers? i.

- i. Vey low
- ii. Low
- iii. High
- iv. Very high

6. What comments do you have in adaptive use of the rocket stoves in the study area?

7. How was the situation of the forest in the study area before and after the implementation of the rocket stoves?

8. What kind of stoves were mostly used by the people in the study area before the implementation of the rocket stoves and how is the situation after the implementation?

9. Do you think the stoves were efficient in the use of firewood? Yes/No
If no, how did you overcome the situation?

10. Do you think the rocket stoves technology has decreased the rate of deforestation in the study area? Yes/No

If yes, to what extent? _____

If no, why?

11. Do you see any improvement of the forest recovering after the adoption of the rocket stoves in the study area?

12. How has the project benefited the stoves users members in improving their daily life?

13. Do the beneficiaries have any other support from any other stakeholders?

14. What are your recommendations to improve the situation/ to reduce the problem of deforestation as far as rocket stoves are concerned and if you have any ideas on the challenges people face as far as adoption and adaptive use is concerned?

Thank you very much for your cooperation

APPENDIX IV

Interview guide No.....

INTERVIEW GUIDE FOR THE FOREST OFFICERS AND DEMO

Dear interviewee,

I am Annamaria Cornelius Gerome, a student from Mzumbe University pursuing Masters of Science Degree in Environmental Management. I am conducting a research with the purpose of collecting information concerned with/ related to the impact of rocket stoves on deforestation control, taking the case study of Membe and Ikowa ward in their respective villages in Chamwino District. Will you please spare your valuable time to answer the questions I have prepared for you?

Thank you

Your name _____

Designation _____

Department _____

1. What are the main duties have you been performed as far as the forests are concerned?

2. How many times do you visit the forest area in your working area?

3. Have you noticed any change in the decrease of the forest cover in the past five years in your work area due to energy source?

4. If yes, what was the average rate of loss of the forest due to energy source?

5. As a forest officer, you must be aware of the rocket stoves as the implementation strategy of decreasing the rate of deforestation in your work area, so do you think this strategy is helping out solving this problem?

Yes/No

6. If yes, to what extent has the strategy helped regaining of the forest size since its implementation? _____

7. If no, why do you think the implementation of the rocket stoves have not helped out solving the problem?

8. What do you do to ensure that the forests as the main source of energy in rural areas are sustainable?

9. What were the average amount of trees per year the people used to harvest as source of energy before the implementation of the rocket stoves in your area and how is the situation after?

10. Are there any other strategies which have been used in helping reducing the problem of deforestation in the study area besides implementation of the rocket stoves? Yes/No

11. If yes, what are they and how do they help out?

12. Comparing rocket stoves and other strategies in solving the problem of deforestation which strategy does help much in regaining the forest cover?-

13. Do you see any social or economic improvement between rocket stoves members within the project and non-rocket stoves members after the adoption of the stoves?

14. If yes, what are the changes to the society?

15. What are your recommendations to improve the situation/ to reduce the problem of deforestation as far as rocket stoves are concerned and if you have any ideas on the challenges people face as far as adoption and adaptive use is concerned as a technology in reducing the problem?

Thank you very much for your cooperation

APPENDIX V

FOCUS GROUP DISCUSSION

Dear members,

I am Annamaria Cornelius Gerome, a student from Mzumbe University pursuing Masters of Science Degree in Environmental Management. I am conducting a research with the purpose of collecting information concerned with/ related to the impact of rocket stoves on deforestation control, taking the case study of Membe and Ikowa ward in their respective villages in Chamwino District. Will you please spare your valuable time to answer the questions I have prepared for you?

Thank you

Leading questions

- ✓ Are local communities aware of the use value of the forests?
- ✓ Do you use wood in your daily life?
- ✓ What do you use wood for?
- ✓ How do you collect your wood?
- ✓ Do you think the size of the forest has decreased?
- ✓ Do you know the consequences of deforestation?
- ✓ Do you know the rocket/traditional stoves?
- ✓ Which among the two do use a lot of firewood?
- ✓ Do you think rocket stoves are helping enough in controlling the rate of deforestation in your area?
- ✓ If yes/no, why do you think so? Can you explain?
- ✓ Is Sunseed doing enough in making sure people use the rocket stoves so as to control deforestation rate? What do they do if yes?
- ✓ What measures have been taken by the government to preserve the forest?
- ✓ Is there any initiative taken by the government to preserve the forests?
- ✓ If yes, what are they?
- ✓ Is the government taking enough measures to preserve the forest?
- ✓ If not, what are your suggestions?
- ✓ What the measures have been taken by the community to preserve the forest?
- ✓ Is there any initiative taken by the community to preserve the forests?

- ✓ What are they?
- ✓ Is the community taking enough measures to preserve the forest?
- ✓ If not, what are your suggestions?

Thank you very much for your cooperation

APPENDIX VI

OBSERVATION CHECKLIST

Energy sources

1. Firewood
2. Charcoal
3. Electricity
4. Gas

Impact of deforestation

1. Water flows
2. Soil erosion
3. Quantity/quality water
4. Quality of the soil
5. Rainfall amount

Use of stoves

1. Condition of rocket stoves
2. Use of rocket stoves(daily)
3. Amount of firewood used by rocket stoves
4. Time consumed by rocket stoves when cooking
5. Use of traditional stove(daily)
6. Amount of firewood used by traditional stoves
7. Time used by traditional stoves when cooking
8. The stoves preferred despite having a rocket stove

Challenges of stoves

1. Complexity of rocket stoves
2. Cost of rocket stoves
3. Advantages/disadvantages of both stoves

Forests conditions

1. Trees being cut daily
2. Trees being cut for kind of activities

3. Land with trees
4. Bare land

Rules/regulations

1. Any action taken for people who have ever been caught
2. People being caught for cutting trees
3. Any payment for
4. Bribe

Activities to deforestation

1. Cutting trees for firewood
2. Burning trees for agricultural purposes
3. Cutting trees for house construction
4. Cutting trees for charcoal making.

Any initiative against deforestation

1. By the government
2. By the village
3. Other Institutions