IMPACT OF IMPROVED COOK STOVE UTILIZATION PROJECT: THE CASE FOR HIFADI HIPROJECT, IN EMBU COUNTY

BY

KERARO M. MERCY

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SUPERVISOR

ZIPPORAH N. KIRUTHU

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DECLARATION

This research project is my original work and has not been submitted in any other University.

Date ……

KERARO M. MERCY

D61/73042/2012

This research project has been submitted for examination with my approval as the university supervisor.

Date……

Z N. KIRUTHU

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DEDICATION

To my Late brother Ken Keraro. May he rest in Peace.

To my parents, Mr. & Mrs. Keraro for their sacrifice, love, endless support and encouragement.

To my Fiancé Wilson Agata, for supporting me each step of the way.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

COPD	Chronic Obstructive Pulmonary Disease
DALY	Deaths and Disability Adjusted Life Years
ICS	Improved Cook Stoves
LPG	Liquid Petroleum Gas
NISP	Chinese National Improved Stove Program
TB	Tuberculosis
WHO	World Health Organization

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

1.1Background

Smoke from open fires and traditional cook stoves fires have been a silent killer in developing countries for a very long time. There are important signs that the sector is a tipping point strategy to develop a thriving market for clean cook stoves and fuels. More training is needed to maximize these opportunities and transform the sector (Hamilton & Akbar, 2010).

The use of modern cook stoves is considered a luxury in the developing world. Nearly three billion people across the developing world still cook their food the way it has been for thousands of years-over open flame or crude cook stoves. These stoves use solid fuels like wood, coal crop residues and animal dung. In sub-Saharan Africa and Asia, the lack of access to clean cooking fuels, is the reason why the vast majority of the rural poor use these solid fuels to cook over open fires or inefficient cook stoves (Legros & Organization, 2009).

In many African countries especially in the rural areas the rate of usage is 80% to 90% .The Energy agency estimates that by 2030, one hundred million more people will use traditional biomass fuels than do so today. Even where there is access to electricity or LPG gas, primarily in urban areas, the use of solid fuels for cooking persists due to cost and cultural factors (Birol, 2010).

1.1.1General assessment of cook stove utilization

Presently more than 160 cook stove programs are operative in the world, varying in scope, size, stove dissemination, type, technological design and financial mechanisms (Gifford, 2010). Currently attention is shifting towards development of new stove designs in large scale manufacturing, and financial incentives.

In fact, there is little information available regarding the success factors on cook stove adoption practices. Anecdotal information available indicates that households respond mostly to fuel savings, convenience, time taken to cook, technological compatibility with cultural cooking habits and practices and less pollution. Evidence also shows that factors affecting adoption and use stoves vary at community and household levels (Chuvieco et al., 2010).

Between 1977 and 1985, over 42,900,000 improved cook-stoves were distributed in developing countries (Cacereset al., 1989) at a minimum cost of US $40 million. Despite the large numbers of stoves disseminated, the experience with such programs has been, for the most part, discouraging. As of 1984, 10-20% of stoves introduced had fallen into disuse, and 20–30% were used only intermittently, this is because the cultural factors were not incorporated in the initial design of the cook stove (Manibog, 1984). Recent studies have shown that earlier lab tests demonstrating water boiling tests of improved cook stoves overestimated products of incomplete combustion emissions from improved vented stoves by 40% relative to daily cooking activities, as a result there were high smoke emissions in the environment (Johnson et al., 2008).

Presently, quality of cook stoves remains a major issue. Many projects that were initially perceived as a success by their funding institution were not self-sustained as either the construction of the cook stove was inadequate and therefore led to a severe reduction of efficiency gains. In other cases, cook stove maintenance and use degraded quality over time. In Malawi, the GTZ progress report only found 29% adoption rates and found that along with lack of awareness, the quality of stoves remained a major downfall (Brinkmann, 2006). The post-project evaluation report of a program in Uganda found that 18.5% of users found the chimney did not function properly and 5% of users found the stoves to crack easily (Wallmo, 2002). The initial cook stove program Kenya had difficulty with quality of clay liners. This assumption of performance by reliance on lab tests without actual field tests impaired project success (Djedje et al. 2009).

1.1.2 Project Evaluation

Project evaluation is a detailed assessment of the outcome of a project against established measures or expected results to determine if it achieved its objectives (Andersen & Jessen, 2000).

Evaluation is the final phase in the project life cycle. Evaluation should be carried out at or after project completion (Dexter, 2010). The purpose of evaluation is to make an assessment, as systematic and objective as possible, of an ongoing or completed project, its design, implementation and results. The aim is to determine the relevance and fulfillment of objectives, developmental efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful (Meredith & Mantel Jr, 2011).

Customer satisfaction is one of the ways of evaluating a project. Conversely, if the project did not meet the scope, time and cost goals but the customer or sponsor was satisfied, because the company spent more time or money to satisfy the customer, it still might be marked as a successful project. Project evaluation is therefore very crucial for success of any project (Schwalbe, 2009).

1.1.3 Hifadhi Project

The Hifadhi project is an efficient cook stoves and tree planting project for individual households in rural areas. This project intends to distribute 60,000 stoves within Embu county, through the distribution of 20,000 cook stoves in 3 districts: Embu East (2013), Mbeere South and Embu North (in 2014).

The Hifadhi cook stove uses about 57% less firewood than the traditional three stones stove. Less wood needs to be collected, allowing communities to save money and/or time collecting, besides through the use of the Hifadhi stove and less smoke is generated, improving people's health. Hence this project aims at protecting the forests, reducing carbon emissions from cooking, while providing a more efficient and healthier method of cooking to people.

The project is meant to last for at least 10 years. The cook stove lasts for almost 5 years, which means that all cook stoves will be replaced once during the project. This project is monitored closely by Climate Pal, to make sure the cook stoves are properly and continuously used, and that the seedlings have a high survival rate.

1.2 Research Problem

Approximately 2.4 billion people around the world, especially in the rural areas depend on wood, charcoal, dung, and other biomass fuels for their daily cooking. The largest percentage of these households cook on open three-stone fires, burning poorly hence resulting in low fuel efficiency consequently leading to high pollution emissions. These patterns of use result in significant negative impacts, including, indoor and outdoor air pollution, mortality, deforestation and climate change. There are social impacts also associated with the use of open fires: particularly too much time, risk and burden of fuel collection for children and women (Wilkinson et al., 2009).

Therefore there is a need to introduce a clean cooking solution meeting the needs of users and be culturally appropriate otherwise it will fail to be utilized over the long term. Carbon Financed projects ensure that these technologies are affordable, socially acceptable, easy to use, widely available, durable, and most of all desired. Hence they can be accessed by the poor households.

To counter negative environmental and health effects of the three-stone cooking style, Climate Pal Kenya Limited has introduced an energy efficient stove project called 'Hifadhi' (20,000 cook stoves under carbon finance) in Embu County in Kenya.

Improved cook stove project promoters focus on mass production resulting in impractical stove designs, with very little fuel saving benefits (Holmes, 2010). Early stove models were designed and tested in laboratories away from the user settings and were no more efficient than cooking with three-stones (Grieshop, Marshall, & Kandlikar, 2011). Impractical stove designs have caused 50-60% of stoves to go unused (Holmes, 2010). Another common reason for faulty improved cook stove projects is lack of education and training on stove purpose and use (Jagadish, 2004).

Unfortunately, research in the developing world regarding development and use of efficient cooking technologies is lower than for industrial nations. However, the few studies that have been carried out, most are based on observational designs, instead of focusing on direct exposure measurements (Smith-Sivertsen et al., 2004). Other studies have not been able to carry out project evaluation to determine the impact of the cook stove utilization projects. This study therefore seeks to carry out assessment of the hifadhi project and close the research gap by addressing the following questions:

i. What are the drivers of cook stoves utilization?
ii. Are the households deriving any benefits from cook stoves utilization?
iii. What are the impacts of cook stove utilization?

1.3 Research Objectives

The main objective of this study:

1. To assess the overall Impacts of Hifadhi cook stove utilization.

Specifically, the study is designed to achieve the following objectives:

1. To determine the drivers of cook stoves utilization.
2. To determine the benefits of cook stoves utilization.
3. To determine the outcomes of cook stoves utilization.

1.4 Value of the Study

Rarely does the global society have a chance to address problems affecting the households at the bottom of the pyramid. This study will provide an insight and opportunity for addressing this big yet silent challenge. Exposure to toxic smoke emissions and use of open fires is faced by three billion people in the world every day. While governments focus on other sectors like transport and boosting the economy, cooking practices are everyday realities which have not been addressed to a big extent. As a result, women are at great risk carrying out daily basic tasks of cooking for their families. Fortunately, there is a way to address this global challenge with the right mix of resources, advocacy and change. Better and improved energy efficient cook stoves technology and appropriate monitoring is the perfect ingredient for the success in addressing this issue.

By having a clear understanding on the impacts and benefits of these improved cook stoves, the government and the whole global society can channel their efforts and invest more in ensuring the poor households in the rural areas access these clean technologies.Finally the study will be of great value to future scholars and researchers by stimulating future research to develop and advance on better, more efficient and affordable cooking technologies that will benefit women while conducting their basic cooking tasks.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter discusses the various implications and status of cook stove usage in developing countries.

2.1 Solid Fuel and Indoor Air Pollution in Developing Countries

Indoor air pollution has been known to cause deaths, accounting for more than two million people annually. Moreover, it is responsible for 2.6% of the all ill-health globally (Smith and Mehta, 2003). This puts indoor air pollution, ranked 8th by the World Health Organization (WHO) on a scale of worldwide risk factors, very close to inaccessibility to clean water and appropriate sanitation and its effect on human health in the world.

Throughout the developing countries, air pollution is from fuel combustion, majorly emitting carbon monoxide and consequently particulate matter and other toxic materials and gases. In less developed countries, unprocessed solid fuels account for up to 90% of the households' source of energy for cooking and heating needs, and thus the households are exposed to high levels of pollution 3-7 hours a day (Bruce et al., 2002). Moreover, 4-5% of the total Deaths And Disability Adjusted Life Years (DALY) for the less 11 developed countries suffer from Acute Respiratory Infections (ARI), Chronic Obstructive Pulmonary Disease (COPD), Tuberculosis (TB), asthma, lung cancer, ischemic heart disease and blindness can be attributed to solid fuel use (Smith & Mehta, 2003).

ARIs in general are responsible for the major percentage of child mortality compared to other killers like diarrhea (Smith, Samet, Romieu, & Bruce, 2000). Moreover, COPD ranked world's sixth cause of death (22%) is attributed to indoor air pollution. About 40-45% burden of the same disease category, is experienced by women in developing countries (Smith-Sivertsen et al., 2004). Low birth weight and Middle ear infection are other health effects noted in developing countries due to high levels of indoor air pollution (Bruce, Perez-Padilla, & Albalak, 2002) .

2.2 Impacts of traditional fires

Daily exposure to toxic smoke from traditional open fires is one of the world's biggest but least known killers. The smoke's deep penetration into the lungs causes acute and chronic diseases as well as low birth rates in mothers who spend time cooking in these open fires (Smith and Mehta,

2003). This smoke has great health impacts. The world health organization (WHO) estimates the smoke exposure due to simple cooking to be the world's fifth risk factor for diseases in developing countries (Ezzati & Kammen, 2002).

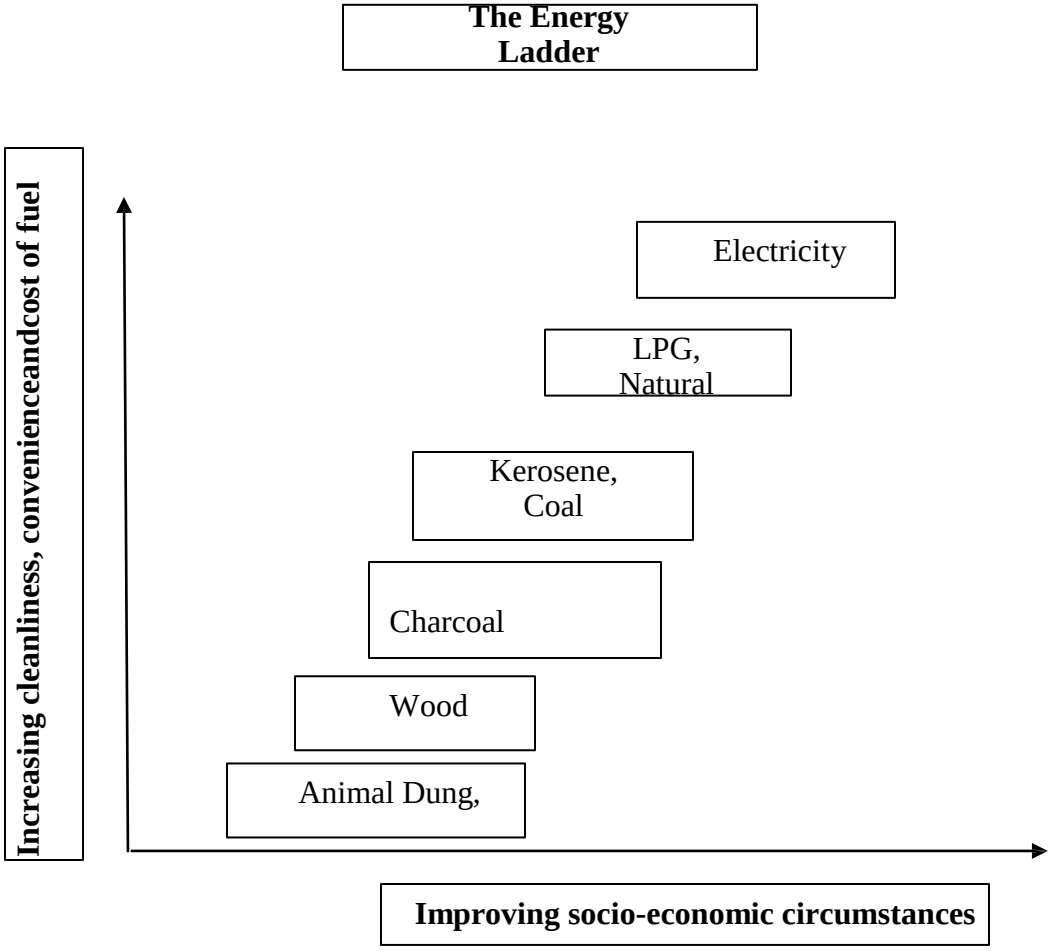
Relying on inefficient cook stoves places a heavy burden on gender and livelihoods particularly girls and women. Cooking is normally taken to be the responsibility of the woman in developing countries. Moreover, they collect fuel wood for cooking, and due to fuel scarcity there is a lot of labour involved in this exercise (Cecelski, 2000).

Use of inefficient and polluting cook stoves has negative implications on the environment. In many countries deforestation has been carried out to support charcoal burning and wood fuel for three stone stoves. The reliance on fuel for cooking puts pressure on the natural resources (Smith, Uma et al., 2000). Emissions from inefficient cook stoves highly contribute to outdoor air pollution, affecting both those with and without the cook stoves (Ruiz-Mercado, Masera, Zamora, & Smith, 2011). Burning of solid fuels release significant emissions to the atmosphere that impact climate in the short term (Wilkinson et al., 2009).

2.3 Air Quality Control Technologies and Health Interventions

General, as the household progresses up the "energy ladder", shown in Figure 1, the quality of indoor air improves especially with regard to carbon monoxide and particulate matter, and there is an assumption that COPD and ARI rates, and other diseases due to indoor air pollution reduce as a result of improved situation. Moving up the energy ladder is always associated with rise in economic status. A large number of households still use inefficient three stone stoves and open fires in developing countries due to lack of enough monetary resources. Liquefied petroleum gas (LPG) stoves are viewed as a solid transient technology but are expensive (Bruce et al., 2002), and their greatest disadvantage is non-renewability. The greatest challenge of addressing indoor air in rural households is striking a balance between improved and refined indoor air quality and the cost associated with moving up the energy ladder. This would ensure health comes before wealth. This would involve adoption of new cooking methods and new affordable cooking technologies, and health interventions. There are a number of factors that influence indoor air quality and consequently the health of households in rural areas. Interventions, whether educational, technical or social in nature can be put in place to address cooking technologies and human effects (Smith, 2002).

Figure1: The Energy Ladder, showing cooking technologies and their association with household



Economic status and cleanliness. Adapted from (Smith, Apte, Yuqing, Wongsekiarttirat, Kulkarni, 1994).

With regards to new cooking technologies, three approaches can be adopted to ensure cleaner Indoor air: These are: substituting alternative but cleaner fuels, increasing the efficiency of the cook stove efficiency to reduce pollutant emissions, and implementing chimney structures to eliminate pollutants from cook place.

The most effective way of improving indoor air quality requires more than technological and cultural transitions. Combining the two would probably give the best results (Smith et al., 2000). The improved and energy efficient approach provides added advantage of reduced fuel consumption and save time especially among women. Improved cook stoves have been established as a promising option to mitigate the negative effects of cooking with the three-stone open fires. Interventions for circulating improved biomass cook stoves dates all the way back to the 1970s. These stoves were majorly designed for efficient use of fuel because of the recognized link between household energy and deforestation (Arnold, Köhlin, Persson, & Shepherd, 2003). However, the major drawback is that they are more costly, putting a financial burden in women (Smith-Sivertsen et al., 2004). The chimney approach is relatively cheaper and simpler, but the major drawback is transferring the pollution outside rather than preventing it's appertained to above, any new technologies have to be appropriate to the habits and cooking culture of the local population otherwise it will not succeed. Moreover, constant education must be put in place to clinch proper and appropriate use of the adapted technologies (Smith, 2004).

2.4 Stove Interventions to Save Fuel, Lives and the Climate

Several organizations have devised improved Cook stoves to curb the problem of indoor air pollution. The term improved has been used to describe a range alternatives or replacements for the traditional cooking methods, with variations in performance. These interventions have improved efficiency, optimized heat transfer, increased ventilation and reduced fuel consumption (Sinton, Smith et al., 2004). Improved stove programmes normally introduce stoves with reduced emissions reducing health impacts and deforestation, which in turn reduces climate impacts (Smith-Sivertsen et al., 2004). New efforts are now being put in place to disseminate biomass cook stoves with very low smoke emissions and high efficiency. This technology should benefit the women at the bottom of the pyramid (Smith, 2010). Indoor air pollution has health impacts disproportionately affecting small children and women (Pope etal.,2010). The improved cook stove interventions have reduce indoor air pollution and respiratory infections (Smith-Sivertsen et al., 2009). Improved cook stove projects have garnered revived interest to mitigate against

climate change (Bond, 2007). The use of household fuel grant low risk means of mitigating climate change impacts. A number of factors impact environmental and health benefits of the cook stove intervention programs. For the success of the stove adoption, it has to respect the local culture and empower women. Development of these technologies is centrally focused on improved efficiency, combating climate change and reducing indoor air pollution (Ezzati & Kammen, 2002).

2.5 Adoption and Sustained Use of Cook Stoves

The stove's compatibility with the local cooking practices is very crucial for sustained use. The reason for lack of scientific and more reliable data is because of lack of monitoring of cook stove usage until recently. Most of the technologies adopted were short term. The largest and one of the most successful stove programmes in history, was the one by the Chinese National Improved Stove Program (NISP), was successful due to monitoring (Smith-Sivertsen et al., 2004).

Currently, the protocols for carbon offsetting projects in the voluntary and markets require the stove be in use 100% and in good condition and discourage unrealistic measures to optimize it. Failure to include sustainable use cook stoves in monitoring and programme planning is due to inadequate tools. But that is now changing as objective evaluation of cook stove usage is now improving, and digital and technological advancements are making it easier (Ruiz-Mercado et al., 2011).

2.6 Conceptual Framework

The assumption behind this framework is that acceptance and increased adoption of ICS (Improved cook stoves) will lead to reduced indoor air pollution exposure, and this will in turn have a positive impact to the environment and livelihoods of households. The research seeks to understand the influences or in this case drivers of cook stove adoption. Social drivers are core arrangements and social processes reflective of social and cultural norms, networks values and institutions which operate around individuals and are concert with their practices and behaviours, which influence what humans think and desire (Auerbach et al., 2011).

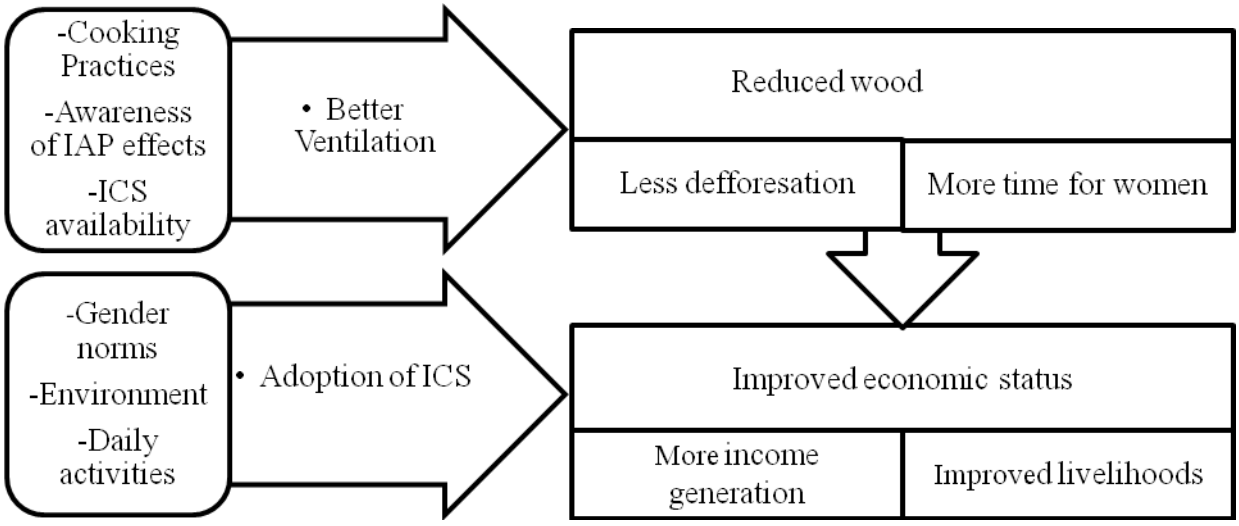
Social drivers of ICS include; cooking and food practices: This refers to the ways in which cook stoves are used, and these determine the stove design and adoption. Awareness of dangers of

Indoor air pollution involves the overall perception of the community on indoor air pollution. This determines whether the households view the smoke as dangerous to their health or not. Improved cook stove availability refers to the accessibility and availability of cook stoves in the community, the cost and the logistical requirements for obtaining the ICS .Gender norms are the understandings within the communities about the male and female roles and decision making regarding cooking practices. The environment refers to the physical arrangement of space within households and households within the community, and daily activities refer to the cooking practices and how they fit with other household activities. These social drivers influence the cook stove cooking practices, which in turn lead to Impacts and outcomes.

These impacts include reduced fuel consumption and economic benefits: Improved cook stoves burn biomass more efficiently, reducing the need for gathering firewood and less use of firewood, hence reduced fuel consumption. Regarding the economic benefits, use of improved cook stoves has a direct effect on household income. If households are able to use less money on fuel, they save and have more income to spend in other sectors like education and food.

INDEPENDENT VARIABLES **DEPENDENT VARIABLES**

SOCIAL DRIVERS **OUTPUT** **IMPACT**



CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Design

The researcher used a descriptive research. According to Ghauri and Gronhaug (2005), descriptive research is used when the problem is structured i.e. it gives answers to who, where, what, how and when questions. It is used to make clear the distinctiveness of a population or an observed fact. According to Zinkmund (2000), "descriptive research studies are based on some previous understating of the nature of the research problem".

3.2 Population

The target population was comprised of households in Embu County. There are 20,000 households using the hifadhi cook stove. (This information was obtained from Climate Pal's programme beneficiary list records).

3.3 Sample Size and Selection Method

Since it was not possible to interview all the households, owing to time and cost constraints, quota sampling was by the researcher. A sample of 243 households was selected to represent the entire population.

When selecting a sample size for a definite population, a significance of level of 95% is acceptable for academic research (Gardner & Altman, 1986). Therefore this being an academic research, a 95% significance level was used by the researcher.

For a finite size population,

$$Sample\ size = \frac{z^2 \times p \times (1-p)}{C^2}$$

Where

z – z distribution value, for example 1.96 for a 95% confidence interval.

p – An estimation of the population that you want to study, e.g. 20% of the cook stoves to be expressed as a decimal.

C – Alpha level (100% - confidence level) then expressed as a decimal.

For populations below 50, 000

$$\textbf{Corrected } Sample\ size = \frac{Sample\ size}{\left(1+\left[\frac{sample\ size-1}{population}\right]\right)}$$

In this case (20,000 cook stoves) – at 95% confidence interval and 20% of the population

$SS = \frac{1.96^2 \times 0.2 \times (1-0.2)}{0.05^2}$ =246

$\textbf{Corrected } SS = \frac{246}{\left(1+\left[\frac{246-1}{20000}\right]\right)}$ =243

3.4 Data Collection Instruments

Data was collected using a questionnaire administered to the respondents. The questionnaire was divided into three parts, the first part was comprised of cook stove information, the second part was comprised of the drivers and outcomes of cook stove utilization and the third part contained a five point rating Likert scale on the project satisfaction.

For a research instrument to be reliable, it must be able to yield consistent results when used more than once to collect data from two samples drawn randomly from the same population (Mugenda &Mugenda, 1999).The researcher carried out a pilot test of the instruments that were used to determine reliability. A sample of 20 households in Embu was used for the pilot testing. Once the instruments were established to be reliable through ease of interpretation by the respondents and consistently measure what they had intended to measure, they were adopted for the study.

The researcher put in place all the necessary arrangements for effective data collection. Before collecting data, the researcher obtained an official letter of introduction from the University of Nairobi explaining to the households the purpose of the survey.

3.5 Data Analysis

After administering the questionnaires and data collection, the data was coded and edited for completeness using the statistical software. Qualitative data was analysed via content analysis techniques, whereas quantitative data was analysed using descriptive techniques like frequencies and percentages. The data was presented in frequency tables.

CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND INTERPRETATIONS

4.1 Introduction

The findings are organized in three parts. The first part comprises of cook stove information, answering the main research question. The second part comprises of the drivers and outcomes of cook stove utilization, the third part contains a five point rating likert scale on the project satisfaction answering the three specific objectives of the study.

4.2 Response Rate

100% of the sampled respondents participated in the survey.

4.3 Type of fuel used

Respondents from various locations were interviewed and 99% of the respondents use firewood while 1 % use the LPG gas. This shows that a very high percentage of households in the region use firewood. This is consistent with research conducted by Bruce et al., (2002) where it was established out that in less developed countries, unprocessed solid fuels account for up to 90% of the households' source of energy for cooking and heating needs. .The results are shown in the table below.

Table 1: Type of fuel used

Type of fuel used	Frequency	Percentage
Firewood	241	99%
LPG gas	2	1%

4.4 Number of times cooked per day

99% of the respondents cook one to five times a day, 0.5 % cooks 6-10 times a day and 0.5% cooks less than once a day. Most people prepare less than five meals a day, spending an average of 5 hours in the kitchen. According to Bruce et al., (2002) the households are exposed to high levels of pollution 3-7 hours a day, and this is reflected in the findings of this research.

Table 2: Number of times cooked per day

Number of times cooked per day	Frequency	Percentage
Less than once	1	0.5%
1-5 times	241	99%
6-10 times	1	0.5%

4.5 Distance travelled to collect firewood

When asked about the distance covered to collect firewood per week, 48% covered less than one kilometre, 46 % one to five kilometres and 16% travel six to ten kilometres.

Table 3: Distance travelled to collected firewood

Distance travelled to collect firewood	Frequency	Percentage
Less than once kilometer	116	48%
1-5 kilometers	111	46%
6-10 kilometers	16	6%

4.6 Usage of Hifadhi stove

The researcher went further to find out the situation on stove usage, 95% of the respondents are still using the Hifadhi stove, while 5% are not using the hifadhi stove. This shows that a high percentage of beneficiaries are using the stove. This is inconsistent with the research conducted by Manibog, (1984) which showed that 10-20% of stoves introduced had fallen into disuse, and 20–30% were used only intermittently.

Table 4: Usage of Hifadhi stove

Still using hifadhi stove	Frequency	Percentage usage
Yes	231	95%
No	12	5%

4.7 Reasons for not using the Hifadhi stove

For the responds that were not using the Hifadhi stove, 54 % stated that the stove was slow, 28 % were not happy with the stove, 9% indicated that the stove was damaged and 9% gave other reasons. With a small percentage not using the stove because of dissatisfaction, it can be concluded that most people are satisfied with the stove. This is shown in the table below.

Table 5: Reasons for not using the Hifadhi stove

Reasons for not using the Hifadhi stove	Frequency	Percentage
Slow	6	54%
Not happy with the stove	3	28%
Damaged	1	9%
Other	1	9%

4.8 Kitchen environment Improvement and reduction of fuel use

The research further sort to find out if there was any improvement in the kitchen environment and reduction in fuel use, The results shows that 96% of the respondents have seen their kitchen environment improve by having less smoke and have reduced fuel use, and 4% have not noticed any kitchen improvement. This shows that the Hifadhi stove significantly reduces smoke emissions in the kitchen. The orientation is reflected in the table below. These interventions have improved efficiency, optimized heat transfer, increased ventilation and reduced fuel consumption (Sinton, Smith et al., 2004).

Table 6: Kitchen improvement and reduction of fuel use

Kitchen improvement and reduced fuel use	Frequency	Percentage
Yes	235	96%
No	8	4%

4.9 What has improved

As per the table below, the respondents who noticed improvement in the kitchen environment and reduction fuel use, 62% indicated that they are experiencing less smoke, 25% less firewood, 7% experience less health problems and 6% experienced faster cooking and heating. The Hifadhi stove's strong point is the reduction of smoke when cooking. Improved stove programmes normally introduce stoves with reduced emissions reducing health impacts and deforestation, which in turn reduces climate impacts (Smith-Sivertsen et al., 2004).

Table 7: What has improved in the kitchen environment?

What has improved	Frequency	Percentage
Less smoke	143	62%
Less firewood	57	25%
Less health problems	17	7%
Faster cooking and heating	15	6%

4.10 What else they like about the stove

The researcher found out that there were additional benefits the beneficiaries liked about the hifadhi stove. 42% experienced economic benefits, 31% saves time collecting firewood, 15% liked its portability, while 7% preferred it due to the fact that it is a new product, and 2% felt it cooks Good food. From these results it can be deduced that most people are saving money as a result of the Hifadhi stove. These interventions have improved efficiency, optimized heat transfer, increased ventilation and reduced fuel consumption (Sinton, Smith et al., 2004).

Table 8: What else they like about the stove

What else they like about the stove	Frequency	Percentage
Economic benefits	104	45%
Saves time collecting firewood	76	31%
Portable	37	15%
New product	16	7%
Good food	4	2%

4.11 Effects of indoor air pollution

When asked about their awareness to the effects of indoor air pollution, 90% of the respondents, were aware while 10% were not. This shows that there is high awareness on the effects of smoke on pollution. The results are tabulated below.

Table 9: Awareness of the effects of indoor air pollution

Awareness of the effects of indoor air pollution	Frequency	Percentage
Yes	219	90%
No	24	10%

4.12 Effects of indoor air pollution

For the respondents who were aware of the effects of indoor pollution, 56% indicated respiratory infections, 30% staining the house with smoke, while 14% said eyes infection. In this regard, there is a high percentage of households that have knowledge on the respiratory effects. This is consistent with the research conducted by (Smith and Mehta), 2003 which established smoke from indoor air pollution has health impacts. The results are shown in the table below:

Table 10: Effects of indoor air pollution

Effects of indoor air pollution	Frequency	Percentage
Respiratory Infections	123	56%
Staining the house with smoke	30	30%
Eyes infection	31	14%

4.13 Effects of firewood collection

According to the results, 94% gave an indication that collection of firewood affected their other duties while 6% did not perceive that as having any effect consequently, it can be concluded that firewood collection affects other household activities. This is shown in the table below.

Table 11: Effects of firewood collection

Firewood collection	Frequency	Percentage
No	24	6%
Yes	229	94%

4.14 Firewood collecting responsibility

On firewood collection, 96% indicated that this was done by women. However, firewood collection was rarely undertaken by men (4%), and 96% .It is evident that women bear the greatest burden of this undertaking the task .This is in line with the research conducted by Cecelsk, (2000), siting that there is a lot of labour involved by women in firewood collection.

Table 12: Firewood collecting responsibility

Firewood collecting responsibility	Frequency	Percentage
Men	11	4%
Women	232	96%

4.15 Overall impact of Hifadhi Project

On the impact of Hifadhi project, 39% of the responds cited deforestation reduced global warming (22%), more time for women (19%), economic savings (13%), and improved livelihoods (3%). However, 4% did not give a response. It can be concluded that the visible benefit from the project to the community is reduced deforestation. These stoves were majorly designed for efficient use of fuel because of the recognized link between household energy and deforestation (Arnold, Köhlin, Persson, & Shepherd, 2003).

Table 13: Overall impact of Hifadhi project

Impact of Hifadhi project	Frequency	Percentage
Less deforestation	94	39%
Reduced global warming	54	22%
More time for women	46	19%
Economic savings	31	13%
Improved livelihoods	8	3%
N/A	10	4%

4.16 Quality of Hifadhi cook stove

The quality of Hifadhi cook stove was rated excellent by 22% of the respondents, Good by 56%, average by16%, Fair by 4%, and poor by 2%. In this regard, it can be concluded that the stove is of reasonably good quality.

Table 14: Quality of cook stove

Cook stove quality	Frequency	Percentage
Average	39	16%
Excellent	59	22%
Fair	6	2%
Good	135	56%
Poor	4	2%

4.17 Frequency of cook stove usage

On how often they use their cook stove were, 65% of the respondents indicated frequently, 22% very frequently, 7% occasionally 2% very rarely, 2% rarely, and 2% did not respond to the question. With a low percentage on stove usage being rarely, it can be concluded that the stoves are reasonably well used by the beneficiaries.

Table 15: Frequency of cook stove usage

How often they use cook stove	Frequency	Percentage
Very Rarely	4	2%
Rarely	5	2%
Occasionally	18	7%
Frequently	157	65%
Very Frequently	53	22%
N/A	6	2%

4.18 Life improvement by Hifadhi cook stove

On Life improvement by Hifadhi cook stove, 93% were positive. This shows that the stove has improved the lives of the community members. Improved cook stove projects have garnered revived interest to mitigate against climate change and improve the livelihoods of the rural women (Bond, 2007).

Table 16: Life improvement by Hifadhi cook stove

Life improvement	Frequency	Percentage
Yes	226	93%
No	17	7%

4.19 Level of life improvement by use of cook stove

Concerning the level of improvement by use of the hifadhi stove, 71% of the respondents indicated much, 20% a great deal, 9% somewhat, 0% not much, and 0% little. This can therefore be a good indicator for project success.

Table 17: Level of life improvement by use of Hifadhi cook stove

How much	Frequency	Percentage
Not much	1	0%
Little	1	0%
Somewhat	21	9%
Much	159	71%
A great deal	44	20%

4.20 Level of satisfaction with Hifadhi project

Responses to how satisfied the respondents were with Hifadhi project, 2% were very dissatisfied, 2% somewhat dissatisfied, 1% neither satisfied nor dissatisfied, 28% somewhat satisfied, 65% very satisfied and 2% did not respond to the question. In this regard, it can be concluded that the people are satisfied with the hifadhi project. This is because the stove design improves efficiency

and is culturally acceptable in the region. The most effective way of improving indoor air quality requires more than technological and cultural transitions. Combining the two would probably give the best results (Smith et al., 2000)

Table 18: Level of Satisfaction with Hifadhi project

Level of satisfaction with cook Hifadhi project	Frequency	Percentage
Very dissatisfied	4	2%
Somewhat dissatisfied	4	2%
Neither satisfied nor dissatisfied	3	1%
Somewhat satisfied	67	28%
Very satisfied	159	65%
N/A	6	2%

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter is divided into four parts. The first part is the summary that ties the research findings to the research objectives and existing bodies of knowledge. The second one is the conclusion which comprises a discussion of the findings and analysis. The third one highlights the limitations of the research as well as limitations of the findings. The final part gives recommendations for further research.

5.2 Summary

This research study was conducted in order to evaluate the hifadhi project to find out if it was effective in achieving its stated objectives or not. From the study, the findings showed that most families used firewood to cook their meals. The number of times cooked in a day by the respondents is one to five times per day. Most households walk less than one kilometer to collect firewood. It was also noted that most of the respondents are still using their Hifadhi stove. The major reason for those who are not using their Hifadhi stove is because it is slow.

Most respondents have experienced kitchen improvement since purchase of the Hifadhi stove. The improvement is associated with less smoke emission. When it comes to additional benefits of the Hifadhi cook stove, most respondents have experienced economic benefits since they use less firewood hence saving on cash used to buy fire wood**.** Most respondents are aware of the effects of indoor air pollution and the ones that are most commonly known are respiratory infections

Fire wood collection affects other activities at home and the responsibility of fire wood collection is for women. The respondents overall view of the impact of the project is reduced global warming. The quality of the stove is good according to most of the respondents. The respondents use their cook stove is frequently. Most of the respondents have experienced life improvement through the use Hifadhi Cook stove. The level of satisfaction with the Hifadhi project is high since majority of the respondents are very satisfied with the project.

5.3 Conclusion

The study was able to assess the overall impacts of hifadhi Cookstove utilization. Based on the research findings, most households use their stove frequently and are very satisfied with the project. The study was also able to establish the drivers and outcomes of Cookstove utilization. The results showed that most respondents were aware of the respiratory infections due to indoor air pollution and the hifadhi Cookstove has significantly reduced smoke emissions in the kitchen. Improved stove programmes normally introduce stoves with reduced emissions reducing health impacts and deforestation, which in turn reduces climate impacts (Smith-Sivertsen et al., 2004). Other additional outcomes include economical savings and general improvement of livelihoods through the hifadhi project. Hence evaluation of the project effectiveness is successful since a very high percentage of stoves are in use. This success is similar to one of the largest and one of the most successful stove programmes in history was the one by the Chinese National Improved Stove Program (NISP), which distributed 180 million Cook stoves between 1983 and the mid-90s. Part of its success is owed to monitoring.(Smith-Sivertsen et al., 2004).

5.4. Recommendations for practitioners and theory of study

The research study established the hifadhi project was successful due to the high level of satisfaction from the respondents. The general findings confirm improvement in livelihoods of people and smoke reduction through use of the hifadhi stove. Therefore it is important for project developers to evaluate the effectiveness of projects on the ground, to increase the success rate and find out if the intended objectives are being attained. Project evaluation should be a key aspect in every project.

It would also be helpful to the policy makers in the country to formulate strategies that would be geared towards enabling the entrepreneurs design and disseminate affordable stoves to the rural poor. Based on the results of the study, it is important for the households to realize the benefits of the improved cook stoves and adopt them fully. Other NGOs should also carry out more research on the similar field and compare the results, and come up with more effective ways to make a cook stove project a success.

5.5 Limitations

The research study was constrained by time and funds availability which resulted in limiting the respondents as opposed to covering the whole population. With structured questions on the data collection instrument, some valuable responses may have been left out. It is however, worth noting that sample is a true representation of the entire population as it comprises the beneficiaries of the hifadhi project.

5.6 Recommendations for Future Research

The research study has explored the overall impacts, drivers and outcomes of the hifadhi cook stove project. Similar studies may be replicated with even larger samples with other cook stove projects in the country and find out the reality on the ground rather than focussing on lab experiments. This could enable design of projects that succeed and are appreciated by the beneficiaries on the ground, while at the same time making a difference in the society.

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APPENDIX 1: QUESTIONNAIRE

UNIVERSITY OF NAIROBI

MBA RESEARCH PROJECT QUESTIONNAIRE

SECTION I: COOKSTOVE INFORMATION

Please tick or mark a cross where appropriate

1. What type of fuel do you use for cooking?

   a.) Firewood ( ) b.) Charcoal ( ) c.) LPG gas ( ) d.)Electricity( )

   e.) Solar ( ) f.) other ( )

2. How many times do you cook per day?

   a.) Less than one ( ) b.) 1 to 5 ( )

   c.) 6 to 10 ( )

3. How far do you travel to collect firewood?

   a.) Less than one km ( ) b.) 1 to 5 km ( )

   c.) 6 to 10 km ( ) d.) Above 10 km ( )

4. Are you still using the Hifadhi stove?

   a.) Yes ( ) b.) No ( )

5. If no, why?

   a) Damaged ( ) b.) Slow ( ) c.) Expensive ( ) d.) culture ( )

   e.) Not happy with the stove ( ) f.) other ( )

6. Is there improvement in your kitchen environment and reduction of fuel consumption since?

   a.) Yes ( ) b.) No ( )

b.) What improved?

a) Less smoke ( )
b) Less health problems( )
c) faster cooking and heating( )
d) use of less firewood( )
e) easy to use( )
f) other( )

c.) What else do you like about the Hifadhi stove?

a) Portable ( )
b) new product( )
c) economic benefits ( )
d) good food( )
e) saves time collecting firewood ( )
f) other ( )

SECTION II: DRIVERS AND OUTCOMES OF COOKSTOVE UTILIZATION

7. Are you aware of the effects of indoor air pollution?

a.) Yes ( ) b.) No ( )

8. If yes, which ones?

a) Respiratory infections( )
b) Eye infections( )
c) Staining the house with smoke ( )
d) Other( )

9. Does collecting firewood affect the other daily activities?

a.) Yes ( ) b.) No ( )

10. Who bares the most responsibility in collecting firewood?

a.) Women ( ) b.) Men ( )

11. What is the overall impact of the Hifadhi project?

a) Less deforestation ( ) b.) More time for women ( )

c.) Economic savings () d.) Improved livelihoods ( )

e.) Reduced global warming ( )

SECTION III : SATISFACTION WITH THE HIFADHI PROJECT - 5 POINT LIKERT SCALE

12. How is the quality of the Hifadhi cook stove?

a) Poor ( ) b.) Fair ( ) c.) Average ( )

a.) Good ( ) e.)Excellent ( )

13. How often do you use the Hifadhi cook stove?

a) Very rarely ( ) b.) Rarely ( ) c.) Occasionally ( )

d.) Frequently ( ) e.) Very frequently ( )

14. Has the Hifadhi cook stove improved your life

a) Yes ( ) b.) No ( )

15. If yes, how much

a.) Not much ( ) b.) Little ( ) c.) Somewhat ( )

d.) Much ( ) e.) A great deal ( )

16. How satisfied are you with the Hifadhi project?

a) Very dissatisfied ( )

b) Somewhat dissatisfied ( )

c) Neither satisfied nor dissatisfied ( )

d) Somewhat satisfied ( )

e) Very satisfied ( )

Thank you so much for your cooperation in answering the questionnaire.

APPENDIX 2: RESEARCH AUTHORIZATION LETTER

UNIVERSITY OF NAIROBI
SCHOOL OF BUSINESS
MBA PROGRAMME

Telephone: 020-2059162
Telegrams: "Varsity", Nairobi
Telex: 22095 Varsity

P.O. Box 30197
Nairobi, Kenya

DATE.....

TO WHOM IT MAY CONCERN

The bearer of this letter .....

Registration No.....

is a bona fide continuing student in the Master of Business Administration (MBA) degree program in this University.

He/she is required to submit as part of his/her coursework assessment a research project report on a management problem. We would like the students to do their projects on real problems affecting firms in Kenya. We would, therefore, appreciate your assistance to enable him/her collect data in your organization.

The results of the report will be used solely for academic purposes and a copy of the same will be availed to the interviewed organizations on request.

Thank you.

PATRICK NYABUTO
MBA ADMINISTRATOR
SCHOOL OF BUSINESS

UNIVERSITY OF NAIROBI
P.O Box 30197 - 00100, NAIROBI
01 SEP 2014

APPENDIX 3: LIST OF INTERVIEWED HOUSEHOLDS

Name of user	Location		Name of user	Location
Jacinta Mukami njue	Kagaari South East		Mary muthoni	Kyeni N.West
Grace kagendo	Kagaari South East		Susan Igoki	Kyeni N.West
Rose Ngina	Kagaari South East		Hwllen kangai	Kyeni N.West
Lucy muthoni	Kagaari South East		Sarah Igandu	Kyeni N.West
Esther wanjiru	Kagaari South East		Ann Wanjira	Kyeni N.West
Rose Wangui	Kagaari South East		Catherine karimi	Kyeni N.West
Itugura munyi	Kagaari South East		Stella m. karimi	Kyeni N.West
Isaak njue Itugura	Kagaari South East		Jane Rwamba	Kyeni N.West
Evangeline Warue	Kagaari South East		Stanley Njeru njoka	Kyeni N.West
Ekira gikiri	Kagaari South East		Faith wawira kinthinji	Kyeni N.West
Leadys Rwamba Njoka	Kagaari South East		Lisper wanja	Kyeni N.West
Lucia Weruma Ireri	Kagaari South East		Lilly wanjiru	Kyeni N.West
Liberatar Gikiri	Kagaari South East		Julia marigu	Kyeni N.West
Lydia wanira	Kagaari South East		Lydia thaara	Kyeni N.West
Niceta Warue Thathi	Kagaari South East		Virginia maitha	Kyeni N.West
Fides Murugi Waweru	Kagaari South East		Grace wanjuki	Kyeni N.West
Jane Gicuku Thathi	Kagaari South East		Felista Gicuku	Kyeni N.West
Teresia Warue Njiru	Kagaari South East		Agnes marigu	Kyeni N.West
Naomi Wanja	Kagaari South East		Asafia maitha	Kyeni N.West
Alice Wanja Namu	Kagaari South East		Agata wawira	Kyeni N.West
Teresia Wandiri Nyaga	Kagaari South East		Rose kanari	Kyeni N.West
Laurenzia Macaki	Kagaari South East		Agusta wangui	Runyenjes West
Ekra Rwamba	Kagaari South East		Dancan njeru	Runyenjes West
Jane Wanjiku muriithi	Kagaari South East		Janet njoki	Runyenjes West
Ephraim Ireri Nyaga	Kagaari South East		Jane karimi	Runyenjes West
Rosemary Njoki	Kagaari South East		Dorothy gitiri	Runyenjes West
Susan Gatakaa	Kagaari South East		Patricia mbuya	Runyenjes West
Agnes Muthoni	Kagaari South East		Dorothy muriithi	Runyenjes West
Lydia warue	Kagaari South East		Miliam Igoki	Runyenjes West
Jane Gitiri kinyua	Kagaari South East		Susan wambura	Runyenjes West
Laurenzia Warue	Kagaari South East		Agnes njoki	Runyenjes West
Mercy karimi	Kagaari South East		Irene wanjiku	Runyenjes West
Madres Weveti	Kagaari South East		Hilda wawira	Runyenjes West

Name of user	Location		Name of user	Location
Emily Muthanje	Kagaari South East		Jane wangari	Runyenjes West
Mary Wanja	Kagaari South East		Dorothy murugi	Runyenjes West
Sara Wanja mbogo	Kagaari South East		Martha muthoni	Runyenjes West
Sarah Njeri njue	Kagaari South East		Mercy muthoni	Runyenjes West
Jane Rose Mbogo	Kagaari South East		Sifia njeri	Runyenjes West
Charity Wanja Nthiga	Kagaari South East		Lucy Rwamba	Runyenjes West
Mary Wanja Alvan	Kagaari South East		Rosemary muthoni	Runyenjes West
Elizabeth njoki mbogo	Kagaari South East		Teresia wanja	Runyenjes West
Joylene thaara	Kagaari South West		Florence kathambi	Runyenjes West
Dianisia Wambugi	Kagaari South West		Anjerica njura	Runyenjes West
Juliet muthoni nyaga	Kagaari South West		Rose Igoki	Runyenjes West
Pamela muthoni njue	Kagaari South West		Beth wambui	Runyenjes West
Sophia Igoki karira	Kagaari South West		Martha wandia	Runyenjes West
Lucy catherine ngari	Kagaari South West		Jane joyce njeri	Runyenjes West
Teresia kirigi	Kagaari South West		Rebaca njoki	Runyenjes West
Joseph muriithi	Kagaari South West		Anisia njagi	Runyenjes West
Ritah mwaniki	Kagaari South West		Joan Gicuku	Runyenjes West
Stellah W. njue	Kagaari South West		Silvester muthoni	Runyenjes West
Zakaya Ireri David	Kagaari South West		Casty muthoni	Kyeni south
Rebecca Ikamba	Kagaari South West		Conseta marigu	Kyeni south
Virginia Muthoni	Kagaari South West		Fides ikamba	Kyeni south
Rosemary murugi Ireri	Kagaari South West		Millicent njeri	Kyeni south
Mercy p. nyaga	Kagaari South West		Benson murage	Kyeni south
Emmericiana marigu	Kagaari South West		Leah wanja	Kyeni south
Catherine Wanja Njeru	Kagaari South West		Rose wawira	Kyeni south
Elizabeth Rugure	Kagaari South West		Fridah Igoki njue	Kyeni south
Juliet Gatavi	Kagaari South West		Rosemary marigu	Kyeni south
Naleah Murugi	Kagaari South West		Teresia wanjiku	Kyeni south
Stephine Mukundi	Kagaari South West		Aleta njura	Kyeni south
Eunice werimba	Kagaari South West		Grace muthoni	Kyeni south
Sarah muthoni	Kagaari South West		Bancy ngai	Kyeni south
Dionisia Igoki	Kagaari South West		Catherine wawira	Kyeni south
Grace wawira	Kagaari South West		Kirigi njeru	Kyeni south
Rachael Wambeti mugo	Kagaari South West		Judith makena	Kyeni south
Jane Ruguru mbogo	Kagaari South West		Fridah kina	Kyeni south
Judy wawira	Kagaari South West		Madris igandu	Kyeni south

Name of user	Location		Name of user	Location
Ritah mwaniki	Kagaari South West		Gaterina Gitiri	Kyeni south
Jacinta Muthoni	Kagaari South West		Alice koki	Kyeni south
Sarah njeru m	Kagaari South West		Aleta njura	Kyeni south
Isaac Gitonga njeru	Kagaari South West		Sepastian mugo	Kyeni south
Rose muthoni	Kagaari South West		Lydia mboya	Kyeni south
Stellah Njue	Kagaari South West		Winfred njoki	Kyeni south
Rose njoki	Kagaari South West		Pamela mumbi	Kyeni south
Letasia nyaga	Kagaari South West		Paul njeru	Kyeni south
Joice Kaari	Kagaari South West		Pauline munyiva	Kyeni south
Lucia Wanjiku njagi	Kagaari South West		Julia kaari nyaga	Kyeni south
Lydia karimi	Kagaari South West		Ether njeri	Kyeni south
Mary N karimi	Kagaari South West		Lilian ndiri	Kyeni south
Nancy Wanja	Kagaari South West		Ann njoki samuel	Kyeni south
Grace Rwamba	Kagaari South West		Joyce kina	Kyeni south
Loise muthoni nyaga	Kyeni N.West		Jacob nyaga	Kyeni south
Hellen Njeri	Kyeni N.West		Winfred murugi	Kyeni south
Catherine murugi	Kyeni N.West		Gilian mwende	Kyeni south
Jacob Njagi	Kyeni N.West		Irene Gicuku	Kyeni south
Venesia Thara	Kyeni N.West		Carina wanjue	Kyeni south
Roseline Ciamwari	Kyeni N.West		Beatrice wanjiru	Kyeni south
Niceta Weruma	Kyeni N.West		Jackson nthiga	Kyeni south
Cecilia murugi	Kyeni N.West		Sabina warue	Kyeni south
Nancy wanja	Kyeni N.West		Liberata thaara	Kyeni south
Teresina Ciamwari	Kyeni N.West		Aggatha magwi	Kyeni south
Irene karimi	Kyeni N.West		Patrick njagi	Kyeni south
Mary Warue	Kyeni N.West		Apita wakio	Runyenjes East
Mary Marigu	Kyeni N.West		Charity njura	Runyenjes East
Hellen njoki	Kyeni N.West		Dorcas gatavi	Runyenjes East
John nyaga	Kyeni N.West		Agnes gatavi	Runyenjes East
Elias mugendi	Kyeni N.West		Lilian john	Runyenjes East
Catherine wanja	Kyeni N.West		Anold mugendi	Runyenjes East
Salome kaari	Kyeni N.West		Jane kanyiri	Runyenjes East
Ann mbui	Kyeni N.West		Beatrice njambi	Runyenjes East
Elizabeth muthoni	Kyeni N.West		Evalyne mumbi	Runyenjes East
Winniejoy mwende	Kyeni N.West		Miriam Gicuku	Runyenjes East
Jane Igandu	Kyeni N.West		Ann thara	Runyenjes East

Aloysia njeri	Kyeni N.West		Peris njeri	Runyenjes East
Fridah murugi	Kyeni N.West		Rose muthoni	Runyenjes East
Leah mukami nyaga	Kyeni N.West		Lucy Igandu	Runyenjes East
Ann wangui	Kyeni N.West		Jerusha warue	Runyenjes East
Linus mugendi	Runyenjes East		Beth muthoni	Runyenjes East
Rahab Igandu	Runyenjes East		Justine muriuki	Runyenjes East
Denis murethi	Runyenjes East		Ann marigu	Runyenjes East
Alice rwamba	Runyenjes East		Mercy kaari	Runyenjes East
Pulity wawira	Runyenjes East		Flora karimi	Runyenjes East
Dorcas karimi	Runyenjes East		Charity njura	Runyenjes East
Dorothy bulwa	Runyenjes East		Mercy wanja	Runyenjes East
Regina wanja	Runyenjes East		Jackline karimi	Runyenjes East
Mary wangai	Runyenjes East		John munyi	Runyenjes East
Ann karimi	Runyenjes East		Damaries wanja	Runyenjes East
Simon njuguna	Runyenjes East		Sarah thaara	Runyenjes East
Julia mwaniki	Runyenjes East		Virginia Igandu	Runyenjes East
Nasaria muthanje	Runyenjes East			