SOCIO-ECONOMIC FACTORS INFLUENCING THE ADOPTION OF IMPROVED COOK STOVES IN KISUMU, KAKAMEGA AND UASIN-GISHU COUNTIES IN KENYA

BY

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DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented for a degree in any other University. No part of this thesis may be reproduced without the prior written permission of the author and/or the University of Eldoret.

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DEDICATION

This work is dedicated to my children Perpetual, Silas,Victoria and Rose Ochieng'.

ABSTRACT

Despite the economic advantages of improved cook stoves' (ICS) technologies, progress toward widespread adoption and use has been extremely slow, leading to the destruction of forest resources, high household expenditure on domestic fuel, increased indoor pollution, increased disease burden, and time used to source for fuel. The study looked into the effects of socioeconomic characteristics such income level, home size, awareness of ICS, level of education, and amount of fuel wood utilized and ICS characteristics on the adoption of ICS in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya. Six estates from Kakamega (Shikambi, Amalemba, and Milimani), Kisumu (Manyata, Tom Mboya, and Milimani), and Uasin-Gishu (Langas, Kapsoya, and Elgon View) were chosen to represent the research population's Low, Middle, and High-Income Estates using a multistage sample technique. Twenty-one academic institutions, fifty households from each income level, twelve large hotels (serving more than 101 people per day), twenty-one medium hotels (serving 51 to 100 people per day), and thirty-six small hotels (serving approximately 50 people per day) were all sampled. Semi-structured questionnaires and focus group talks were used to gather the data. The information was gathered using focus groups and semi-structured questionnaires. With the aid of SPSS version 23, the acquired data were analyzed using both descriptive and chi-square (χ^2) statistics. The findings showed that household size, education level, knowledge of ICS, and characteristics of charcoal-saving cook stoves substantially influenced families' adoption of ICS (χ^2=115.7548, df=49, *p<0.05*). In contrast, only the number of clients served each day had a significant impact on the amount of ICS adoption in institutions (χ^2=10.0535, df=49, p<0.05). Education level and awareness level of the head cooks, stove characteristics and quantity of fuel wood used per day did not have significant influence on ICS adoption (χ^2=0.6622, df=49, p<0.05; χ^2=0.5057, df=49, p<0.05; χ^2=2.2622, df=49, p<0.05; χ^2=3.4796, df=49, p<0.05 respectively). In hotels, hotel sizes (χ^2=2.3333, df=68, p<0.05), head cooks education level (χ^2=0.4333, df=68, p<0.05), head cook ICS awareness (χ^2=0.1000, df=68, p<0.05), quantity of fuel wood used per day (χ^2=0.6667, df=68, p<0.05), and stove characteristics (χ^2=4.9667, df=68, p<0.05), did not influence ICS adoption significantly. The study concluded that household size, increase in stove awareness; education level, income level, and saving on fuel wood positively influenced adoption in households. In institutions and hotels high awareness level, education level, and stove characteristics positively influenced ICS adoption. It is recommended that more ICS awareness be created and stove manufacturers come up with new designs for improved durability and wood fuel saving.

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LIST OF ABBREVIATIONS

AML	-	Amalemba
ANOVA	-	Analysis of Variance
ASTAE	-	Asia Sustainable and Alternative Energy
CBO	-	Community Based Organization
CDM	-	Clean Development Mechanism
CER	-	Certified Emission Reduction
CV	-	Cumulative Value
EA	-	East Africa
EAC	-	East Africa Community
ELV	-	Elgon View
EnDev	-	Environment Development
ER	-	Emission Reduction
FAO	-	Food and Agriculture Organization
GACC	-	Global Alliance for Clean Cook Stoves
GCF	-	Green Climate Fund
GDP	–	Gross Domestic Product
GHG	-	Green House Gas
GPS	-	Geographic Position System
GTZ	-	Deutsche Gesellschaft Furechnische Zusammenarbeit (German Agency for Technical Co-operation)
GVEP	-	Global Village Energy Partnership
HAP	-	Household Air Pollution
HH	-	Household

IAP	-	Indoor Air Pollution
ICS	-	Improved Cooking Stove(s)
IDP	–	Internally Displaced Persons
IEA	-	International Energy Agency
IWA	-	International Workshop Agreement
KAP	-	Kapsoya
KCIC	-	Kenya Climate Innovation Centre
KCJ	-	Kenya Ceramic Jicko (Energy Efficient Charcoal Stove)
KFS	-	Kenya Forest Service
KNBS	-	Kenya National Bureau of Statistics
LA	-	Latin America
LAC	-	Latin America and the Caribbean
LAN	-	Langas
LED	-	Light Emitting Diode
LPG	-	Liquefied Petroleum Gas
M	-	Million
MAN	-	Manyatta
MDGs	-	Millennium Development Goals
MKK	-	Milimani Kakamega
MKS	-	Milimani Kisumu
NEMA	-	National Environmental Management Authority
NGO	-	Non-governmental Organization
PM	-	Particulate Matter
SA	-	South Africa

SCODE	-	Sustainable Community Development Services
SKM	-	Shikambi
SMEs	-	Small and Medium Enterprises
SPSS	-	Statistical Package for Social Sciences
SSA	-	Sub Saharan Africa
TOM	-	Tom Mboya
UN	-	United Nations
UNDP	-	United Nations Development Program
USAID	-	United States Agency for International Development
WHO	-	World Health Organization

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Over 2.64 billion people around the world, particularly in developing nations, rely on traditional biomass (fuel wood, charcoal, dung, and agricultural wastes) for their everyday cooking activities (International Energy Agency (IEA) 2013a). High usage of fuel wood in cooking is one of the factors that contribute to high rates of deforestation in the world (Daioglou *et al.,* 2012; Nerini *et al.,* 2017).

With the global population increase and economic development, the use of fuel wood is likely to rise in the coming years (Malla & Timilsina, 2014). It is projected developing countries' energy demand will increase from 46 to 58 percent between 2004 and 2030 (Malla & Timilsina, 2014). Energy demand in industrialized countries is anticipated to increase at a slower rate of 0.9 percent annually, while beginning from a significantly higher starting point (East Africa Community). (EAC), 2007; Islam, 1997). In 2005, the world produced 1.7 billion cubic meters of industrial round wood, compared to 1.8 billion cubic meters of fuel wood (Suliman, 2010; IEA, 2004). Brazil produces 138 million cubic meters of fuel wood, China produces 191 million, and the USA produces 306 million cubic meters (Aggarwal & Chandel, 2004).

In Sub-Sahara Africa (SSA), biomass energy makes 80% of the total energy used where wood fuel, crops, and animal residues are used in household cooking among other uses (Mograbi et al., 2015). A study by IEA (2014) identified that 60% of sub-Saharan Africa relies on biomass energy. The African wood fuel usage is projected to increase from 2.5 to 2.7 billion tons by 2030. This exceeds the current fuel wood supply rates (IEA, 2006; Matsika *et al*., 2012). Fuel wood takes 24% of the total energy consumed in Africa. In South Africa, around 55% of rural residents utilize fuel wood as their primary source of energy, yet only about 55% of the country's 2.4 million rural residents have access to electricity (Madubansi & Shackleton 2006).

In Kenya, the main source of energy in overall household consumption remains to be firewood and charcoal (Murphy *et al*., 2018). As fuel wood extraction faces a challenge of scarcity, the environmental problems that have placed high burdens and challenges on households, women that cook according to African culture, and children health in most rural population continue to increase (Stoppok *et al*., 2018). The ICS technology improves the usage of the fuel wood consumption quantity by scaling down, is environment friendly, and cost-effective. However, challenges that face its use in Kenya are diverse (Yip et al., 2017).

As the energy consumption rate in the world increases, the need to contain the environmental effect and sustainability of the wood supply is apparent (Yip *et al*., 2017). Studies reveal that numerous efforts have been put in place to reduce the rate of consumption of wood fuel to check its impact on the existing forest cover. Many institutions have been supported to produce technologies that will adapt other methods of cooking using wood-based fuel without cutting trees.

China is one of the few countries in the world that have attained both high distribution and adoption of ICS, with 70% of the ICS produced and used in the world (World Bank, 2014). In developing countries, the diffusion of ICS technology is low and mostly faces socio-economic barriers (Rhodes *et al.,* 2014). In Latin America and Asia, ICS adoption remains low because of the inability of technologies to meet the socio-cultural and functional needs of the consumers (Wang & Bailis, 2015). According to DeCarolis *et al.*(2012), cook stove designs and models should be simple enough and compatible with various consumers needs to be widely adaptable.

In Africa, the availability of various energy sources about 80% of households is still dependent on traditional biomass for cooking energy (Khambalkar *et al.,* 2010; IEA & Wold Bank, 2016). Due to the inefficient nature of the traditional fuel and numerous side effects, the ICSs are developed to check the deforestation and other side effects resulting from the use of traditional fuel (Agrawal & Yamamoto, 2015). Various researches have demonstrated that ICS has various socio-economic and environmental benefits but adoption is still very low (Mobarak *et al.,* 2012). According to Pachauri & Jiang (2008), financial and other economic factors lowered the possibility of about 90% of the populations in Mali, Burundi, Liberia, Somalia, and Madagascar, from accessing and using ICS. According to Figueres (2010) and Soni *et al.* (2018, women's income was important in the success of ICS programs. High-income levels increased accessibility and use of ICS in Ethiopia by 30% (Damte & Koch, 2011). A study by Fatihiya & Kenneth (2015) in Tanzania revealed that there was low adoption of ICS among individuals with low education levels.

In Kenya, ICS awareness is considerably high. However, ICS adoption is depicted to below acceptable moderate levels. Studies in Homa Bay revealed only 47.7% of farmers had adopted ICSs (Okuthe & Akotsi, 2014). The cost of small ICS ranges between Ksh. 150 to 250, which was looked at considerable to most households in Homa Bay but the general use of the stoves, remained low. In Kakamega, Maseno, and Nyeri, Kenya, Akoth et al. (2014) evaluated the usage of ICS in comparison to other cooking methods. They discovered that 60.94% of the households used a three-stone fire, 15.63% used a charcoal stove, 9.38% used a Jua-Kali Jicko with lining, and 14% used LPG. This indicated that ICS adoption in households, institutions, hotels, and other energy consumers faces various challenges.

1.2 Statement of the problem

The traditional wood-based cook stoves have been noted to be detrimental in terms of high costs of accessing fuel wood, pollution, and health side effects on the users (Köhlin *et al.,* 2011). The cumulative world cost of the adverse effects adds up to over $ 123 billion annually with other multiple underlying side effects (Lewis & Pattanayak, 2011). As the technologies seeking to reduce the overall dependency on fuel wood continue to emerge, ICS has proven successful in reducing deforestation by 45% (Gebreegziabher *et al*., 2012). The ICS technologies have been purported to have vast socio-economic benefits, which are a step ahead in achieving their large-scale adoption (Mitchell, 2010; Ezzati & Kammen, 2014).

The adoption of ICS has been low since its inception in the 1980s due to various factors (Gebreegziabher *et al*., 2012). In Kenya, culture, income, and accessibility were identified as hindrances to ICS adoption in Nyeri, Homa Bay, and Coast regions (Akoth *et al.,* 2014; Nerini *et al.,* 2017). In Kisumu, Kakamega, and Uasin-Gishu counties study the influence of education level, household/population size, ICS awareness, income level, the quantity of fuel wood used, and stove characteristics on the adoption of ICS have not been extensively studied. Studies on the socio-economic barriers and stove characteristics affecting its adoption in the areas selected are therefore necessary to design strategies that will inform the community and policymakers on increasing ICS adoption and thus rip maximum benefits due to its use in those areas.

1.3 Justification for the study

The adoption of ICS technologies accrues considerable benefits including a reduction in the destruction of forest resources, reduce household expenditure on domestic fuel, lower indoor air pollution, reduce disease burden, and saves on time used to source fuel. Understanding the factors that affect its adoption is important in designing an adoption promotion program. Therefore, this study is important because it will generate sufficient scientific data that will be important in understanding the influence of education level, household/population size, ICS awareness, income level, the quantity of fuel wood used, and stove characteristics on the adoption of ICS in Kenya. A clear degree of influence of the factors listed above about the economic levels, and forest resource availability will be important in designing conclusive ICS adoption strategies and policies. The Kisumu country was considered because of the scarcity of its forest resource, Kakamega was considered because of the intermediate availability of forest resources, while Uasin-Gishu was considered because of its availability of plenty of forest resources. This information will be important because it will help key policymakers in the counties and the country at large to design formidable policies that will enable sustainable energy production and utilization (Polsky & Ly, 2012).

1.4 Research Objectives

1.4.1 Broad objective

The study broad objective of the study was to investigate the socio-economic factors and ICS properties that affect the adoption of stoves in Uasin Gishu, Kisumu, and Kakamega Counties in Kenya.

1.4.2 Specific objectives

The study specifically aimed at: -

i. Assessing the influence of household size/ population served, education level of household heads or head cooks, and awareness level on the adoption of ICS in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties.

ii. Determining the influence of household income level and quantity of fuel wood used per day on the adoption of ICS in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties.

iii. Investigating the influence of ICS characteristics (durability, fast cooking, and saving on charcoal properties) on its adoption in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties in Kenya.

1.5 Research Questions

a) Does the size/population of household served, education level of household heads or head cooks, and ICS awareness influence ICS adoption in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties in Kenya?

b) Do household income level and quantity of fuel wood used per day influence adoption of ICS in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties in Kenya?

c) Does ICS characteristics (durability, fast cooking, and saving on charcoal properties) influence ICS adoption in households, institutions, and hotels in Uasin-Gishu, Kisumu, and Kakamega Counties in Kenya?

Ho: Socio-economic factors have no significant influence on the adoption of improved cook stoves in Kisumu Kakamega and Uasin-Gishu counties in Kenya.

1.6 Study assumptions

The study assumed that the ICS were distributed in the country evenly and that cultural setting did not affect the adoption or distribution of the stoves. It also assumed that the three counties chosen from western Kenya were cosmopolitan enough for cater to all cultural backgrounds. The three countries would also yield results that could be used to generalize the socio-economic factors affecting the adoption of ICS in Kenya. The study also assumed that the distribution and use of ICS in the three counties begun at the same time and there was no disparity in the duration of the existence of ICS in the market and accessibility of the region.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of the world’s ICS programs and distribution

The first ICS programs started in the 1970s, and in subsequent decades they have rapidly spread throughout the world (Urmee & Gyamfi, 2014). Over 100 clean cook stoves programs were in operation worldwide by 2010. (Urmee & Gyamfi, 2014). Over time, cook stoves programs have changed from relying heavily on large-scale subsidies to more demand-driven approaches that combine direct support for stove makers and customers with indirect subsidies for the growth of the market (Silk *et al*., 2012).

In order to address the manufacturing, distribution, and utilization of clean cook stoves in the developing world, the United Nations (UN) Foundation and Global Alliance support numerous organizations and partners. Only 200 million ICS units were reportedly in use in 2012, out of the over 700 million households worldwide that rely on wood fuels (Simon *et al*., 2010; Evans, 2019). Only 30% of families utilizing solid fuel, or roughly 17–18% of all households, were represented by this, according to the GACC (2014).

Sub-Saharan Africa has the highest percentage (71%) of traditional, unimproved solid fuel stove users. South Asia (66%) and Southeast Asia (41%) came in second and third, respectively (Gifford & Louise, 2010). In China, where the usage of biogas is expanding quickly and the solar sector is historically strong, renewable fuel stoves (such as biogas and solar) make up a sizeable portion of the market (Shen *et al*., 2015).

2.2 Global ICS adoption trends

Modern societies account for 45% of energy consumption. On average daily fuel wood consumption per person was in Ethiopia was identified to be 0.63 ± 0.2 kg day^{-1}, which reflected over 27.5 Mg year^{-1} total biomass used (Gruber *et al*., 2015). Biomass from palm oil and other agricultural activities, such as fruit crops, can be used to produce energy and renewable resources in addition to hydropower and solar energy, though fuel wood is still in great demand. The use of ICS was developed as a strategy to ease high consumption rates of wood in the world (Bujang *et al*., 2016). A high rate of ICS use was recorded in China where over 70% of ICS distributed in the world is adopted and used (Shen *et al.*, 2015). Other developed countries like the USA, United Kingdom (UK) and France, have rapid programs that promote the use of energy-saving stoves which has seen high adoption rates in such countries. For instance, while the USA has about 65% ICS adoption rate (IEA, 2016), the most profound barrier to ICS adoption was the economic factors.

Economic factors such as micro-credit mechanisms and promotional offers increased the rates of poor households' access and use of ICS in Bangladesh. Despite these short payback periods, high interests and limited economic abilities deterred the adoption of ICS (Sovacool & Drupady, 2011). Sovacool and Drupady (2011) found out that sociocultural factors affected the design and durability of the stove thus influencing its use in Bangladesh, Nepal, and India. In their study, the traditional meals needed specific designs of cooking stoves and cooking methods too. The ICS was not very compatible with their needs and thus the low adoption (Pandey, 1989; Gordon *et al.*, 2007; Troncoso *et al.*, 2007; Chowdhury *et al.*, 2011).

2.3 ICS programs in Africa

According to Global Village Energy Partnership (GVEP) - USAID (2012) and Clough (2012), Sub-Saharan Africa is primarily a market for users of portable stoves, with three stone fires serving as the traditional firewood and crop waste cooking solution and metal brazier or bucket stoves serving as the traditional charcoal cooking solution. Several

African nations, like Ethiopia (fixed stoves for injera cooking), Uganda, Rwanda, and Nigeria, have a tradition of utilizing built-in and semi-portable stoves despite the fact that the vast majority of them have been created over several generations of improved stove programs. Despite being uncommon, chimney stoves are occasionally utilized (GVEPUSAID, 2012). Given this pattern, it should not come as a surprise that the vast majority of ICS (whether basic, intermediate, or advanced stoves) in Sub-Saharan Africa are portable, frequently chimneyless, single-burner stoves designed to handle wood fuels, crop waste biomass, or a combination of solid fuels, and that the majority of ICS are produced by artisans (Zamora, 2010). Although it has increased, Africa still has a low level of ICS penetration when compared to Asia and Latin America (World Bank, 2014). According to a 2011 GACC evaluation, just 6% of persons in sub-Saharan Africa who use solid biomass fuels use ICSs. Comparatively speaking, this is much lower than the 27% of ICS consumers in other emerging countries. In most African countries, 44% of all users cited financial considerations for the adoption of ICS (GACC, 2019). However, the most pressing issues in Malawi, South Africa, and Mali were the prices and affordability of the stoves (Kapfudzaruwa *et al.*, 2017).

According to Kapfudzaruwa *et al.* (2017), each country had different levels of variation of ICS adoption based on the existing macro-economic environment that included driving individual income levels, prices of the stoves, and fuels values. In South Africa for instance, the per capita is higher (US$12, 2240) compared to Malawi (US$226) and thus adoption was higher in South Africa compared to Malawi. In Mali and Malawi, the cost of fuel was higher compared to Lesotho. This is because, in Malawi, the government dropped fuel subsidies due to procurement bureaucracy (Kapfudzaruwa *et al.*, 2017).

2.4 ICS adoption in Kenya

According to the International Workshop Agreement (IWA) guidelines for ICS, Kenya's ICS solutions should include all cook stoves that increase fuel use efficiency without reducing particulate matter emission to low levels, according to the Global Alliance for Clean Cook (GACC) stoves technical report (GACC, 2014). (Scot, 2012). Stoves that fulfill tier 2 of the IWA requirements are regarded as efficient and clean, while those that meet tier 3 of indoor emissions or higher are regarded as having little impact on the environment (GACC, 2016). The five main types of stoves are traditional, basic, intermediate-advanced, modern, and renewable fuel stoves (GACC, 2014).

According to Environment Development (EnDev) Kenya (2016), 3.5 million households were using stoves by 2016. These adoption levels were low compared to the general household number of 9.6 million by 2016. Kenya has more than 50 ethnic groups, which face different cultural needs. The socio-economic factors affecting ICS adoption may be diversified by this aspect of society. To increase the trend observed above, various stakeholders have come together to address the barriers to ICS adoption and increase both availability and affordability. Various projects by Green Climate Fund (GCF) (2019) were launched with a projection of 1.9 million ICS users by 2020. Creating rural commercial networks for the distribution of home stoves, training potters in the production and sale of high-quality (Maendeleo) Upesi stoves, and developing business skills were some of the other activities (GCF, 2017). As a result, high-quality energy saving stoves are now made using paddle molds (Kohlin *et al*., 2011).

Upesi stoves, Kenya ceramic jicko, and 1500–2000 inventive wood-burning stove designs have all been made and sold to date (World Bank, 2014). The actual demand has climbed to around 7500 stoves every year with the aid of groups like Sustainable Community Development Services (SCODE). Self-help groups authorized by the ministry of women, sports, and culture, through which an estimated 150,000 individuals have directly benefited, made it possible to purchase the stoves (Kohlin *et al*., 2011). Additionally, the projects' commercial potential has benefited approximately 130 Small and Medium Enterprises (SMEs).

In order to help women potters in West Kenya diversify the types of pottery they make, a number of NGOs, including Practical Action, collaborate with them (Kenya Climate Innovation Centre (KCIC), 2017). The building of rural commercial networks for household stoves, the growth and diffusion of business skills, and the training of potters are all included in this program. Additionally, quality (Maendeleo) Upesi stove manufacture and marketing are also included. The implementation of ICS in Kenya still has a lot of challenges, nevertheless.

2.5 Factors affecting adoption of ICS

The range of energy sources and cooking technology options, both domestically and internationally, is substantial (GCF, 2019). Additionally, homes frequently cook with a combination of fuels (fuel stacking) as opposed to using more effective or superior fuels (Okuthe & Akotsi, 2014). In the literature, among other factors that affect households' choice of cook stoves, and energy sources are socioeconomic, fuel availability, cultural, environmental, cook stoves characteristics, and government policies (Ruiz-Mercado *et al.*, 2011).

2.5.1 Socio-economic factors

Several studies have demonstrated that a range of socioeconomic characteristics, including household size, time spent at home, ownership, age and gender distribution, and the kind of dwelling, affect the fuel and cook stoves that households choose to use for cooking (Okuthe & Akotsi, 2014). However, in Ethiopia Tidze and Tchouamo, (2018) noted that household size, age, cooking patterns, stove characteristics did not influence ICS adoption. In this study, the researchers noted that users had high knowledge of the environmental benefits of the stoves. Moreover, a high economic level was perceived to influence the high adoption of the stoves.

2.5.1.1 Awareness levels about ICS

The high awareness level of clean cooking stoves in the global population was crucial in its adoption. This has been observed in both developed and developing countries (World Bank, 2014). Research in South Africa revealed that awareness of the ICS stoves was high (40%). However, various other factors influenced its adoption thus high awareness did not translate to high adoption (Urmee & Gyamfi, 2014). The ICS awareness in Kenya was considerably high (above 40%) (Okuthe & Akotsi, 2014).

Replica studies to investigate the influence of awareness level on ICS adoption in other areas in Kenya are necessary to strengthen these findings.

2.5.1.2 Household income level

Household economic levels influence many choices in its expenditure. Barnes *et al.* (2012) found that as per capita income increases, households tend to switch to cleaner and more efficient fuels for cooking. However, a few empirical studies present evidence against the energy ladder hypothesis. A study by Sehjpal *et al.* (2014) found that in India, household income is less significant in influencing choices of clean fuels compared to other social and cultural factors. Berrueta *et al.* (2008) and Pine *et al.* (2011) observed that in rural northwest Pakistan and rural Mexico respectively, household income influenced household willingness to adopt improved biomass stoves. A similar trend was observed in replica study in Michoacan mexico (Jan, 2012).

Andadari *et al.* (2014) established that household expenditure impacted the choice of cooking techniques used in rural and urban areas in India and Indonesia. However, Jingchao and Koji (2012) discovered that in rural Beijing, changes in the cost of coal and LPG, which are primarily used for cooking, had little influence on the use of other energy sources. This was mostly caused by the wide variances in income levels, consumer habits, and energy resource availability. In Kenya, a study by Okuthe and Akotsi (2014) revealed that farmers' income was mainly used to purchase household consumables. In their study, over 45% of ICS adopters earned less than Ksh. 6,000 from their firms. Only 9% of the adopters earned more than Ksh. 6000 from the firm. Research on the influence of the number of monetary institutions and hotels handle on the levels of adoption of clean cook stoves like ICS in Kenya is missing. This study sought to investigate the factors leading to the low adoption of ICS in Kenya.

2.5.1.3 Stove price to the adoption of ICS

The cost of the stoves and other financial obstacles both significantly affect spending on ICS. According to Jain (2010), the prohibitive cost of clean and modern fuels has led rural communities in northwest Pakistan to continue using old-fashioned, inefficient fuels. Additionally, household surveys in ten developing nations found that Liquefied Petroleum Gas (LPG) use had increased as well as the level of education and cost of alternative cooking fuels in general, particularly in South Asia (SA), Latin America (LA), and the Latin America Caribbean (LAC) regions (Kojima *et al* (2011). However, a study by Zhang and Kotani (2012) indicated that while an increase in fuel costs had a significant impact on ICS demand, they did not exhibit substitution effects between cooking fuels (coal and LPG).

In a study by Andadari *et al.* (2014), ICS pricing mechanisms greatly influenced its use among households in the rural and urban areas in India. The authors also noted a similar trend in Indonesia. Pricing of alternative energy sources influenced ICS adoption in rural Beijing which however greatly varied depending on the household income level (Jingchao & Koji, 2012). Kojima *et al.* (2011) also established that in Sub-Saharan developing countries like South Africa, the high price of alternative cooking fuels in general, increased the use of LPG, thus lowering ICS adoption.

Due to high labor and material costs, inadequate distribution infrastructure, and other factors, stove prices are often expensive throughout the African continent. The cost each item ranged from $5 to $10. Industrial ICS solutions are primarily imported, and the high import customs, taxes, and transportation charges increased the price to $25 to $100.

(Lewis & Pattanayak, 2012).Nearly 99% of the population in Mali, Liberia, Burundi, Somalia, and Madagascar are significantly impacted by economic and other financial considerations affecting availability to and adoption of ICS and other modern energysaving cooking appliances (Pachauri, 2004). Takama *et al*. (2012) determined that product-specific factors such usage cost, stove price, safety, and smokiness strongly influenced stove and fuel selections in Addis Abeba, Ethiopia, after comparing the relative strength of determinants in terms of marginal willingness to pay.

In Senegal, Beltramo and Levine (2010) and Bensch and Peters (2018) observed that subsidies on the stove pricing increased affordability and choice of ICS use in households. Using panel data at the household level According to Alem *et al.* (2013), the price of electricity, the availability of fuel wood, and access to financing were significant factors in determining the adoption of electric cook stoves in urban Ethiopia. Similarly,

Lambe and Atteridge (2012) discovered that even though households in rural Haryana State, India were willing to buy ICS, price remained the most crucial consideration in decision-making. According to a review study by Rehfuess *et al.* (2014) and another study by Puzzolo et al. (2013), adoption of ICS was more likely to occur in households with higher incomes than those with lower incomes.

A study by Nerini *et al.* (2017) in Nyeri found out that the use of ICS was moderately less costly compared to LPG, Kerosine, 3-stone cook stoves, and electricity. Despite this, the percentage of people using ICS was low. The ICS cost ranged between Ksh. 150 to 250, which was viewed as considerable to most households in Homa Bay but the general use of the stoves, remained low. The accessibility of less expensive cooking methods also affected the adoption of ICS (Nerini *et al*., 2017). In Kakamega, Maseno, and Nyeri, Kenya, Akoth *et al.* (2014) discovered that, on average, 60.94% of the households used a three-stone fire, 15.63% used a charcoal stove, 9.38% used a Jua-Kali Jicko with lining, and 14% utilized LPG. The low rate of economic growth and financial factors may be playing part in the low adoption level. According to the observations above, it is clear that ICS adoption has numerous benefits although in Kenya this is still very low compared to other parts of the world (GCF, 2019). The removal of the 16% value-added tax (VAT) on LPG in Kenya slightly improved LPG biogas stove adoption levels.

The study from Western Kenya (Kakamega area), Nyanza (Maseno area), and Central Kenya (Nyeri area) showed that the use of family income to purchase fuel wood insignificantly influenced the use of ICS (Akoth *et al.*, 2014). This was because the majority of the households did not purchase fuel wood but collected it from farmlands and government forests. In these regions, the cost of a locally made stove was Ksh. 200, while the imported stove versions were trading at Ksh. 2,000. According to the researcher, the availability and prices of stoves influenced their use in these regions (Akoth *et al.*, 2014). Despite this, the studies reviewed did not analyze how household income influenced ICS adoption substantially. Further, the pricing of the stoves and other financial factors have not been studied especially on ICS adoption in institutions and hotels and this has led to the adoption of technologies that do not meet their needs. Hence, this needs further study.

2.5.1.4 Education level of the households

The likelihood of a home upgrading to cleaner/more advanced technologies was highly influenced by the education level of the household (Suliman, 2010). In India and Mongolia in particular, the proportion of educated females between the ages of 10 and

50 and the educational level of the typical family had a favorable and significant influence on the likelihood of utilizing clean cooking fuels/technologies (Pandey and Chaubal, 2011). In urban settings, households with more educated members were more likely to pick cleaner fuels for cooking, according to Gebreegziabher *et al.* (2012). In rural northwest Pakistan and rural Mexico, respectively, Jan (2012) and Pine *et al.* (2011) found that education level had a substantial impact on a household's readiness to adopt improved biomass stoves. In a study by Andadari *et al.* (2014), results revealed that the education level of the household heads positively impacted the decision-making process of adopting ICS energy-saving cooking means (Tomlinson, 2018).

Data from the 2008 Nigerian Demographic and Health Survey showed that urban people and educated household heads had much more access to electricity and contemporary cooking energy sources (Oyekale, 2012). According to Okuthe and Akotsi (2014), the high education level among Homa Bay farmers influenced their decision to use ICSs in their households. In their findings, the researchers noted that 47.7% of the farmers with considerable education used the stoves. The influence of the education level of the head cooks in institutions and hotels in Kenya or household heads in deciding on the use of ICS in Kisumu, Kakamega and Uasin-Gishu has not been studied explicitly. Hence, the current study aimed at investigating this among other variables to generate knowledge to fill this gap.

2.5.1.5 Size of the household

The size of the household is a great determiner of the spending of any household. Jan (2012) and Pine *et al.* (2011) observed that in rural northwest Pakistan and rural Mexico respectively, the household size significantly impacted the household’s willingness to adopt improved biomass stoves. Household size also influenced cooking fuel and technology decisions. For instance, fuel wood was by far the fuel of preference for the majority of households with a comparatively bigger size (more than six persons) in rural Nigeria, according to Nnaji *et al.* (2012). The study also discovered that when home location and land area became more remote, the likelihood of adopting biogas reduced.

Beyene and Koch (2013) discovered that the cost of the stove, household income, and wealth were the key factors influencing the adoption of clean fuel-saving technology in urban Ethiopia. The outcomes also showed that the accessibility of alternative electric ("Mitad") and metal cook stoves tended to prevent Ethiopia from adopting ICS (Beyene and Koch, 2013). Moreover, in Kenya Okuthe and Akotsi (2014) observed that high ICS adopters in Homa Bay were households with more than 6 family members. Despite these findings, studies on the impact of the sizes of the population served by institutions and hotels on the levels of adoption of ICS are scant. Hence, the current study aimed at investigating this to fill the knowledge gap.

2.5.1.6 Behavioral and cultural factors

The choice of cooking stove is also influenced by behavioral and cultural factors such household preferences, food preferences, cooking habits, and cultural beliefs. For instance, Taylor *et al.* (2011) discovered that migrant households in Guatemala frequently used the traditional method of food preparation despite the fact that LPG was accessible and reasonably priced. Families in rural Guatemala valued traditional cooking stoves as sources of heat and light as well as a place to socialize, according to research by Bielecki and Wingenbach (2014). According to a study conducted in rural India by Bhojvaid *et al.* (2014), social factors including how neighbors are seen to act play a role in encouraging the adoption of ICS. According to Ramirez *et al*. (2014), men dominate the long-distance spread of ICS in Western Honduras whereas women mostly communicate locally. According to Urmee and Gyamfi (2014), the ICS program's success depends on local users and craftspeople helping to build a self-sustaining sector.

In a study carried out in India's Karnataka Barnes *et al.* (2012) revealed that 30% of ICS users appreciated it based on its aptitude for preparing regional meals including Aloo gobi, crispy papadum, chana masala, and palak paneer. Similar findings were made by Miller and Mobarak (2012) and Pine et al. (2011) about the role of community leaders on the adoption of ICS in rural Bangladesh. However, Troncoso *et al.* (2011) and Person *et al.* (2012) discovered that a decreased likelihood of ICS adoption was connected with the inadequacy of producing traditional dishes using larger pots and a change in cooking habits.

In India, economically empowered women increased the potential of adopting energy saving clean cooking stoves by 30% (Malhotra *et al.,* 2004). Damte and Koch (2011) made similar observations in Ethiopia. Increasing subsidies lowers the cost of the ICS. In Asia, literature revealed that high adoption is tagged on the subsidies availed (Köhlin *et al.,* 2011). After the ICS subsidized projects, poor liquidity reduced the uptake of ICS among poor households. The stove acquisition by installment payments, promotion offers, and other price incentives coupled with consumer finances variedly influenced ICS uptake rates in various parts of the continent (Simon *et al.,* 2014). Although further studies point to comparable outcomes According to Jeuland and Pattanayak (2012), the private net advantages of ICS are more likely to be unfavorable since these users' altered behaviors result in either no change or net increases in the amount of time spent cooking or preparing fuel, which lowers the overall benefits. The findings of

Asaduzzaman *et al*. (2010), who claimed that the slow adoption of ICS was due to the high cost of modern fuel and a lack of supply, were comparable to those of the prior study. A 2012 study by Person et al. in rural Kenya discovered that recommendations from friends and family who had already adopted the stove had a big influence on households' decisions to buy ICS.

The only distributor of a more effective technology, such as ICS, did not produce an ICS sustainable impact in a peri-urban community in western Kenya, claim Sesan (2012) and Djédjé *et al*. (2009). The study made the case that it was critical to take into account local people's interests and viewpoints, as well as their requirements and customs, when thinking about how to spread ICS. Based on the above observation, it is evident that studies on the effect of cultural factors on ICS adoption in institutions and hotels are scarce. This study aimed at investigating this information to fill the gap of knowledge.

2.5.1.7 Stove characteristics

The cost-effectiveness of the product in satisfying consumers' needs is a major factor in the adoption of the ICS. Rehfuess *et al*. (2014) claim that numerous ICS programs have unique design flaws that cause users to modify their stoves, reducing their effectiveness and encouraging the usage of conventional stoves. According to the study, cook stoves portability was crucial where households alternated between cooking outdoors and indoors according to the season. Despite this, Hanna *et al*. (2012) discovered that there is no proof that the adoption of ICS in rural Orissa, India, has improved health or reduced fuel use. The study identified the primary causes as improper use, misuse, and a lack of household investments in ICS maintenance.

In a study to examine how the physical characteristics of the stoves affected adoption rates, Jeuland *et al*. (2013) discovered that households in Uttarakhand, India, strongly preferred traditional stoves and were more willing to pay for the ICS's feature that reduces smoke emissions than for decreased fuel requirements and improved convenience. Many people in Bangladesh, Mongolia, and rural India choose it based on the ability of the stove to save on fuel (Gordon *et al*., 2007; Chowdhury *et al.,* 2011; Anderson, 2014). In these foregoing studies, the value for fuel wood considerably varied about proximity and collection risks. In Mongolia, the fuel-saving property was highly beneficial because most of the fuel wood used was purchased (Gordon *et al.,* 2007). However, in Mexico, the time aspect associated with the collection of fuel woods were significant when fuel wood cost was not attached (Troncoso *et al.,* 2007). In Central Nepal and Bangladesh, the inability of the stoves to burn leaves and other agricultural farm residues was associated with its less use (Pandey, 1989; Chowdhury *et al.,* 2011).

The perceived reduction in the workload influenced stove adoption in Bangladesh, Mongolia, and rural India (Gordon *et al.,* 2007; Chowdhury *et al.,* 2011; Anderson, 2014). According to Gordon *et al.* (2007), ICS reduced the workload of women in cooking activities. On the contrary, Chowdhury *et al.* (2011) and Sovacool and Drupady (2011) reported that women in Bangladesh experienced increased workload including chopping, drying, and storing fuel wood. Troncoso *et al.* (2007) and Christoff (2010) reported the same observation in rural Mexico. The numerous potholes were a significant stove’s characteristic which increased adoption in Bangladesh, Nepal, Mexico, and India (Troncoso *et al.,* 2007; Gordon *et al.,* 2007; Chowdhury *et al.* 2011; Anderson, 2014). In Mexico and India, stove durability and design influenced high adoption. Women modified the stove to enlarge the entrance and grate (Jagoe *et al.*, 2007; Christoff, 2010). However, the modification reduced stove durability and efficiency. The ICS with the fixed chimney influenced high adoption among residents with grass-thatched houses. This was associated with a low risk of fire in rural India (Chowdhury *et al.*, 2011).

2.5.1.8 Environmental friendliness

In Africa, most ICS adopters cited saving on charcoal in small-scale cooking while 40% in South Africa used it because it preserved a clean indoor environment. In Malawi, 29% of the population liked the stove and were ready to use it because it preserved a clean indoor environment and reduced greenhouse gases emission (Kojima *et al.*, 2011). In Kenya, Person *et al.* (2012) found that most rural households that purchased fuel wood valued the stove because it saved on fuel wood. However, in settings that did not purchase fuel wood, the less time used to cook influenced its use (Person *et al.*, 2012). The stove was adopted for use in most rural parts of Kenyan because it was perceived to reduce the workload of collecting fuel wood and storing it. On the other hand, the time-saving characteristic of the fixed stoves with multiple cooking potholes increased adoption levels (Person *et al.*, 2012).

The design and durability of the stove had a varied influence on the adoption of the ICS in rural Kenya although the data on the specific influence was not available (Sesan, 2012). However, the design and durability of the ICS in 29 counties in Western, Central, and coastal regions of Kenya, was affected by the style of cooking cultural meals. Traditional meals needed large stove potholes and thus traditional stoves were preferred (GCF, 2017). The impact of the ICS characteristics on adoption for use in institutions and hotels in Kenya had not been studied. This study therefore aimed at investigating this information to fill the gap of knowledge.

CHAPTER THREE

MATERIAL AND METHODS

3.1 Study Areas

The three counties that were selected for this study are Uasin-Gishu, Kisumu, and Kakamega. Details on these subsequent counties are given in subsequent sections below.

3.1.1 Uasin-Gishu County

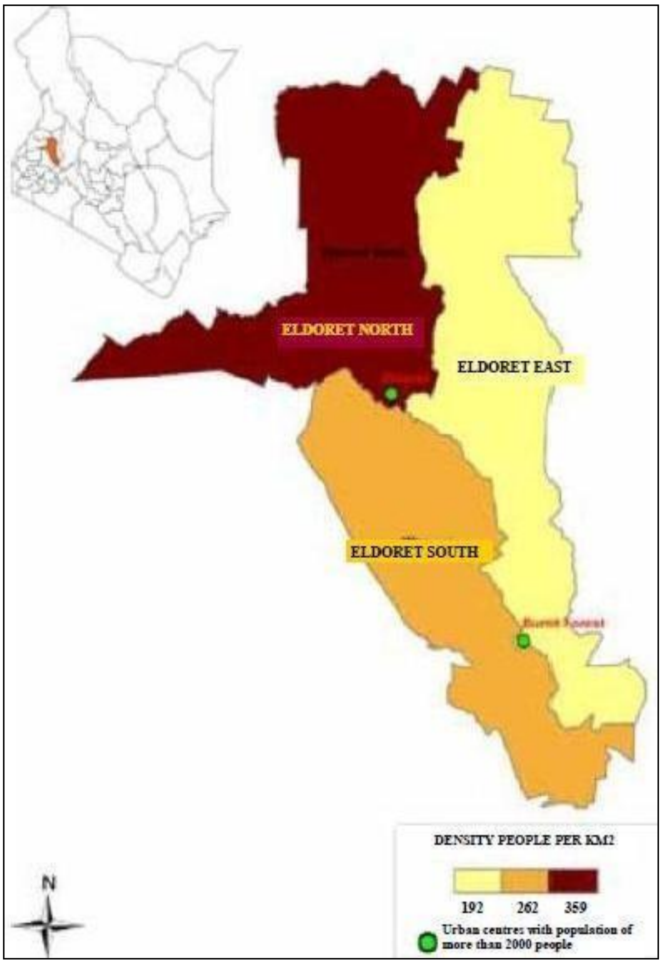


Figure 3. 1: A map showing Uasin-Gishu County in Kenya (Source: Kenya County Fact Sheets (KCFS), 2011)

The total area of Uasin-Gishu County (shaded) is 2,112 km^2 (1,141.0 sq. m). Its neighbors are Kericho County on the south, Nandi and Kakamega counties on the west, Tran Nzoia County on the north, Elgeyo-Marakwet on the north east, Baringo County on the south east, and Tran Nzoia County on the south (Fig 3.1). According to the 2009 Census, there are 894,179 people living in the county, including 202,291 households with a total of 445,185 people who are women and 894,179 people who are men (Table 3.1). 42 percent of households are made up of 0–3 people, while 37.9% have 4-6 people living there. There are 20 institutions altogether, including 43 large hotels and both private and public universities, colleges, and campuses (Cheserem, 2011).

Table 3. 1: Population of Uasin-Gishu County

County	Household Number	Area (Km^2)	Population density	male	Female
Uasin-Gishu	202,291	2,112	423.4	448,994	445,185

Source: KCFS, 2011.

3.1.2 Kisumu County

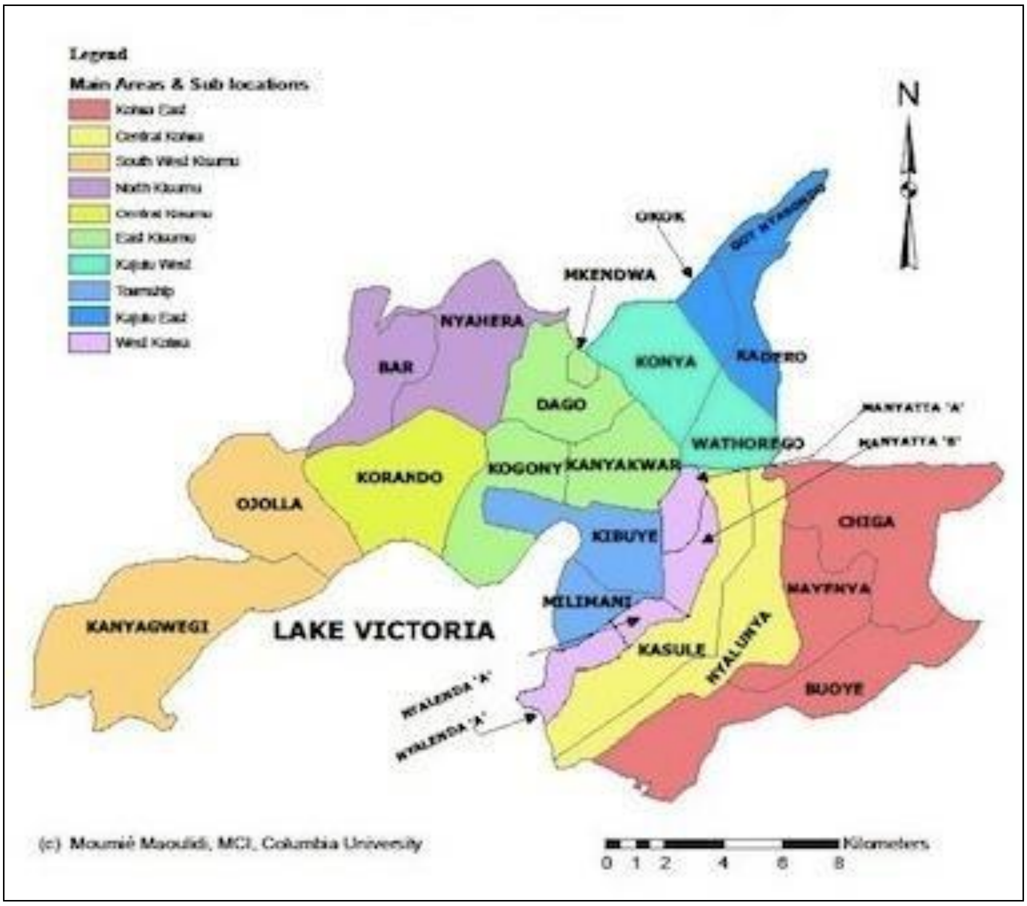


Figure 3. 2: A map showing Kisumu County (Source: KCFS, 2011)

The land area of Kisumu County is 224407 Km² with a population of 968,909 constituting 494,149 females and 474,760 males (Table 3.2).The county borders Busia County on the West,Kakamega, Vihiga, and Nandi Counties on the North, Kericho County on the East, and Homa Bay County on the South. Colleges and universities within the county include Maseno University, Great Lakes University, and several teaching and nursing colleges.

Table 3. 2: Population data of Kisumu County

County	Household Number	Area (Km^2)	Population density	male	Female
Kisumu	226,719	2,407.0	402.5	474,760	968,909

Source: KCFS, 2011

3.1.3 Kakamega County

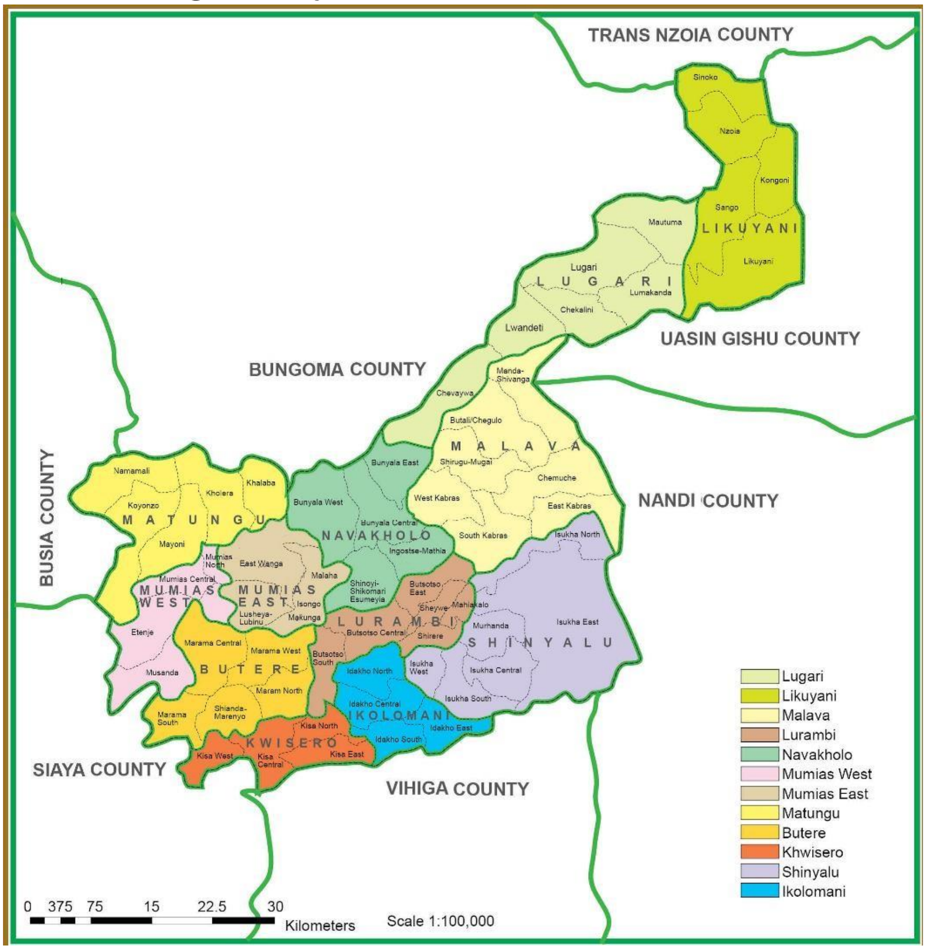


Figure 3.3.: A map showing Kakamega County (Source: KCFS, 2011)

Kakamega County has an area of 3,343 km² (Figure 3.3). The area has a population of 1,660,651 constituting 859,662 females and 800,989 males. The population density (persons/sq.km) of the county is 496.8 with approximately 355,679 households (Table 3.3). Kakamega has 2 universities and branches of colleges with over 10 major hotels.

Table 3. 2: Population data of Kakamega County

County	Household Number	Areas (km^2)	Population Density	Male	Female
Kakamega	355,679	3,343	496.8	800,989	859,662

Source: KCFS, 2011

3.2 Research design

A survey research design was employed in which Uasin Gishu, Kisumu, and Kakamega counties were selected based on the abundance and accessibility to forest resources. A stratified multi-stage sampling design was applied to select three estates from each county based on economic quartiles (low, middle, and high-income levels). In the lowincome level estates, Langas, Manyatta, and Shikambi were selected from Uasin Gishu, Kisumu, and Kakamega Counties respectively. In the middle-income levels, Kapsoya, Tom Mboya, and Amalemba estates were selected from Uasin Gishu, Kisumu, and Kakamega counties respectively, while in the high-income levels, Elgon View estate in Uasin-Gishu County, Milimani estate in Kisumu County, and Milimani estate in Kakamega County was selected.

3. 3 Target Population and sample size

The study targeted the household heads and head cooks of institutions, hotels, and hospitals. In each income level estate, 50 households, 21 institutions, and 69 hotels (12 large hotels serving more than 151 people per day, 21 medium hotels serving between 51 to 151, and 36 small size hotels serving less than 50 people) were randomly selected.

Table 3. 3: Sample sizes in Uasin Gishu, Kisumu, and Kakamega County

Households	**Number of respondents**
Low income	50
Middle income	50
High income	50
Total	**150**
Academic Institutions	21
Total	**21**
Hotels	
Large hotels	12
Medium size hotels	21
Small hotels	36
Total	**69**

3.4 Data collection methods

3.4.1 Semi-structured questionnaires

Semi-structured questionnaires were prepared and 10 questionnaires were pre-tested on randomly sampled individuals in Langas, Tom Mboya, and Amalemba estates. After correction and adjustment on the questionnaire as observed from the field during pretesting, questionnaires were formatted for study. The parameters sought in the questionnaires were respondents' educational levels, level of awareness of ICS stoves, preferred stove for cooking, most appealing properties for ICS, and quantity of fuel wood used per day. The respondents were administered the questionnaires and given time to fill and return them within the same day.

3.4.2 Focus group Discussions

The Focus Group Discussions (FGDs) sessions were used on the key informants in the study areas to verify the information collected by questionnaires. The parameters that were addressed in the Focus Groups were similar to those in the questionnaires. The factors that affect the level of adoption of the ICS stoves in the three counties were investigated.

3.5 Study variables

The dependent variable in the study was ICS adoption whose level of adoption was tested against independent variables like education level, household size, awareness level, stove characteristics, and quantity of fuel wood used per day in households.

3.6 Ethical considerations during the study

The researcher obtained research permission from the University to allow research in the mentioned areas. Moreover, the consent of the management of the sampled institutions was obtained before conducting the study. The respondents were informed of the research objectives and filled a consent form. They were assured anonymity and confidentiality of information collected. The respondents were not allowed to indicate their names on the questionnaires. The data collected was strictly used for the intended research purpose only. The researcher considered high standards of professional code of conduct. The study did not incur any form of harm on the respondents.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1 Data analysis and presentation of results

Data collected using semi-structured questionnaires and focus groups discussions were cleaned by sieving unclear statements and incomplete questionnaires. Data on household sizes, population served per day, household heads or cooking staff education levels, awareness of the ICS, stove properties, and quantity of fuel wood used per day was coded and fed in an excel spreadsheet. Data was fed into the analytical tool program SPSS version 23. The frequency of adoption of the ICS was descriptively studied and displayed in frequency tables and graphs based on the home sizes/population serviced per day, awareness level, education level, and amount of fuel wood utilized per day. The significant level of adoption in the counties of Uasin-Gishu, Kisumu, and Kakamega was regressed at 0.05 against the number of households/people serviced daily, awareness level, education level, and daily fuel wood use. Based on the reported Chinese adoption levels, the predicted ICS adoption level was set at 70%. (Shen et al., 2015). Tables are used to present the results.4.2 Socio-economic factors affecting ICS adoption in households

4.2.1 Adoption trends based on household sizes

Table 4.1 shows results on the trends of ICS adoption in Kakamega, Kisumu, and Uasin- Gishu counties based on the sizes of the households.

Table 4.2.1: Kakamega, Kisumu, and Uasin-Gishu county ICS adoption trends

County	Household Size	**1-3** (%)	**4-6** (%)	**7-9** (%)	**10 >** (%)
UASIN GISHU	Langas	57.1	53.3	33.3	12.5
	Kapsoya	33.3	58.3	20.0	16.7 14.3
	Elgon View	28.6	42.9	20.0	
KISUMU	Manyatta	62.5	60.0	40.0	28.6
	Tom Mboya	30.0	66.7	28.6	12.5
	Milimani Kisumu	27.3	53.8	22.2	14.3
KAKAMEGA	Shikambi	64.3	55.6	50.0	9.1
	Amalemba	38.5	61.5	25.0	16.7
	Milimani	28.6	44.4	14.3	12.5
Average		41.13	55.17	28.16	15.24

Among the low-income estates, ICS adoption was high among households with 1 to 3 members, followed by 4 to 6, 7 to 9, and least in households with greater than 10 members. Shikambi estate had the highest adoption levels (64.3%) among households with 1 to 3 members, followed by Manyatta (62.5%), and the least was Langas (60.0%). In the households with 4 to 6 members, Manyatta led with 60%, followed by Langas (57.1%) and Shikambi (55.6%) in that order. In households with greater than 10 members, Manyatta led with 28.57%, followed by Langas (12.5%), and least was Shikambi with 9.1% (Table 4.1).

Figure 4.1 shows the results of ICS adoption in middle-income estates based on household sizes.

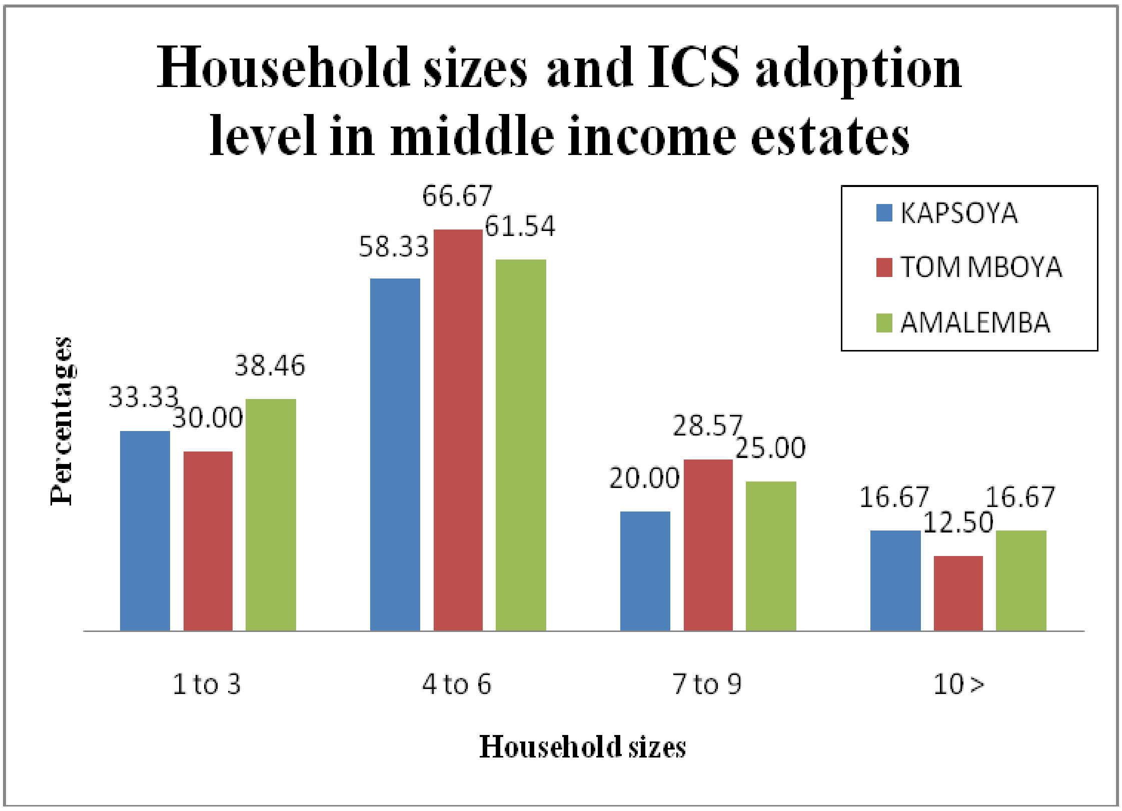


Figure 4. 1: Household sizes and ICS adoption among middle-income states

In middle-income estates, ICS adoption was high among households with 4 to 6 members followed by 1 to 3 household members, and the least adoption was recorded among households with seven and above members. Tom Mboya had the highest adoption in households with 4 to 6 members (66.7%), followed by Amalemba (61.5%), and least was Kapsoya (58.3%) (Figure 4.1).

Figure 4.2 shows the ICS adoption levels in high-income estates in the three counties studied.

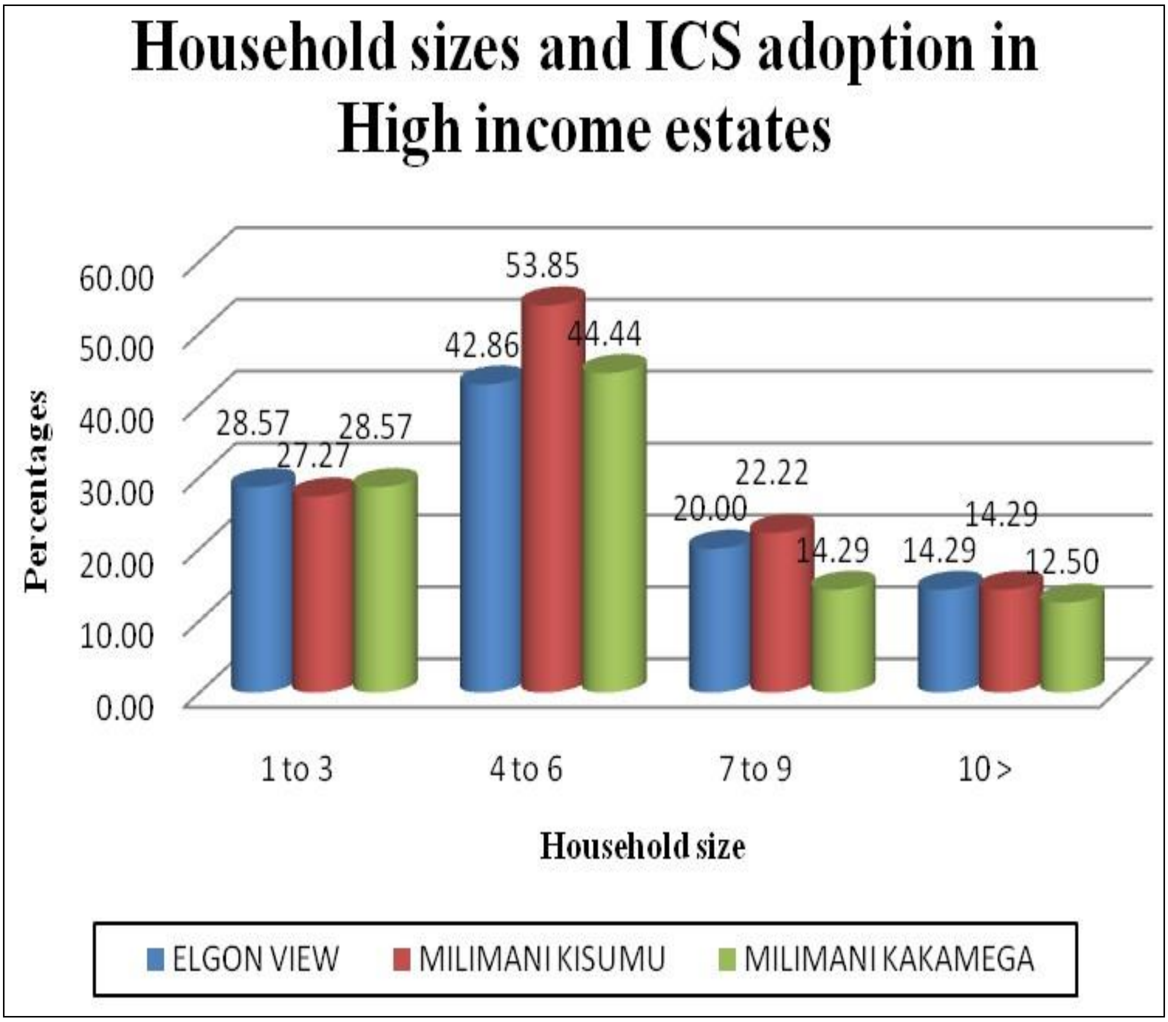


Figure 4. 2: Household sizes and ICS adoption among high-income states

The cumulative adoption level of the ICS was highest among households that had 4 to 6 members. Milimani Estate in Kisumu led in ICS adoption with 53.9%, followed by Milimani in Kakamega (44.4%) and least was Elgon View in Eldoret (42.9%). The households with 1 to 3 members were second in the level of adoption followed by 7 to 9 and the least was large households with more than 10 members (Figure 4.2).

4.1.2 Adoption trends based on household income class

The results in Table 4.2 revealed the adoption levels of the households based on their income levels in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

Table 4.2: Household Income levels and ICS adoption among income levels

	Low income estates				Middle Income Estates				High Income Estates			
Household Income per month	Langas	Manyatta	Shikambi	Average	Kapsoya	Tom Mboya	Amalemba	Average	Elgon View	Milimani	Milimani	Average
Class 1	14	12	12	**13**	14	12	15	**15**	16	10	10	**12**
Class 2	17	16	17	**17**	16	17	16	**16**	7	15	17	**13**
Class 3	2	2	3	**2**	2	2	2	**2**	5	2	4	**4**
Class 4	0	0	0	**0**	1	1	1	**1**	1	1	1	**1**
Av	**33**	**30**	**32**		**33**	**32**	**34**		**29**	**28**	**32**	

GAv 31.67 32.67 29.67

Key: Class 1= >20000, Class 2=20001-40000, Class 3=40001-80000, Class 4=<80001,

GAv= Grand estate average

Results revealed that adoption was high in middle-income estates, followed by low income and high-income estates across all household income classes. The ICS usage was observed to be high (17 out of 50) in low income, followed by middle income (16 out of 40) and high income (13 out of 30) among the households that had a monthly income of between Ksh. 20001- 40000 (class 2). Household heads that earned Ksh. >20000 (class 1) had medium adoption levels while class 3 (Ksh. <40000) recorded the least adoption levels (Table 4.2).

Figure 4.3 shows the cumulative result of the adoption of ICS per county, income level estate, and household sizes.

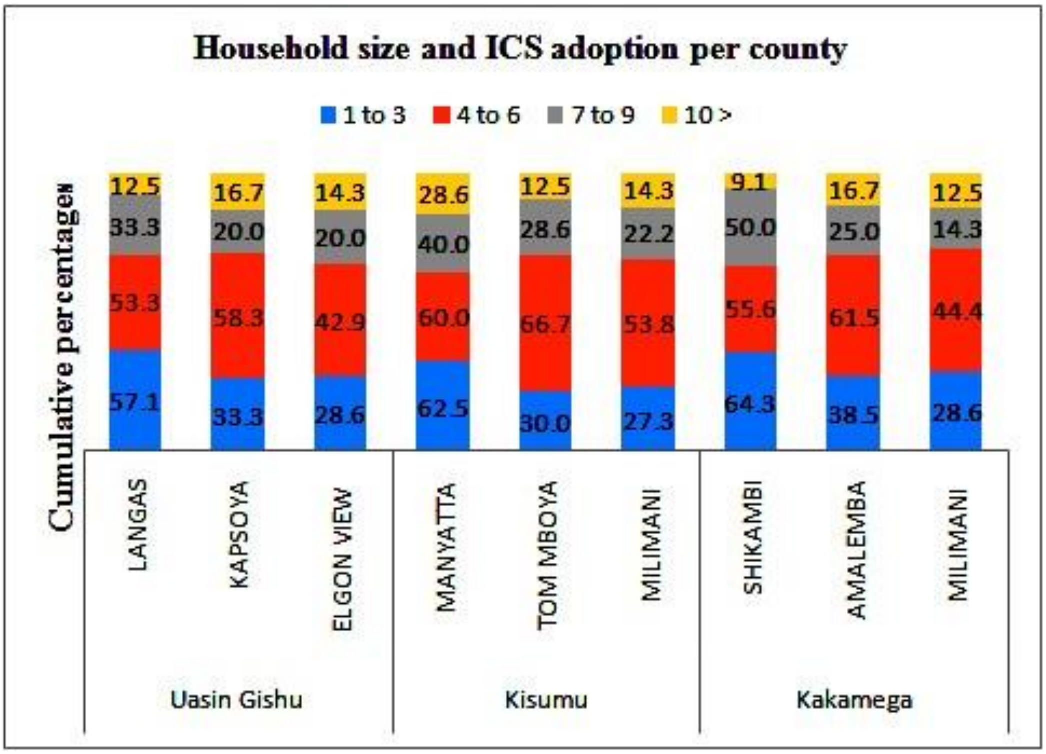


Figure 4. 3: ICS adoption trends in Uasin Gishu, Kisumu, and Kakamega Counties

Manyatta estate showed a high level of ICS adoption across all groups of household sizes followed by Shikambi and Langas both in low-income levels. In the middle-income category, the level of ICS adoption was similar (12.5%) while in high-income estates, Milimani in Kisumu was high followed by Elgon View in Eldoret, and least was Milimani in Kakamega County (Figure 4.3).

4.1.3 Adoption trends based on education levels of household heads

Figure 4.4 shows the trends of ICS adoption based on the education level of the head cooks in the households in Kakamega, Kisumu, and Uasin-Gishu counties.

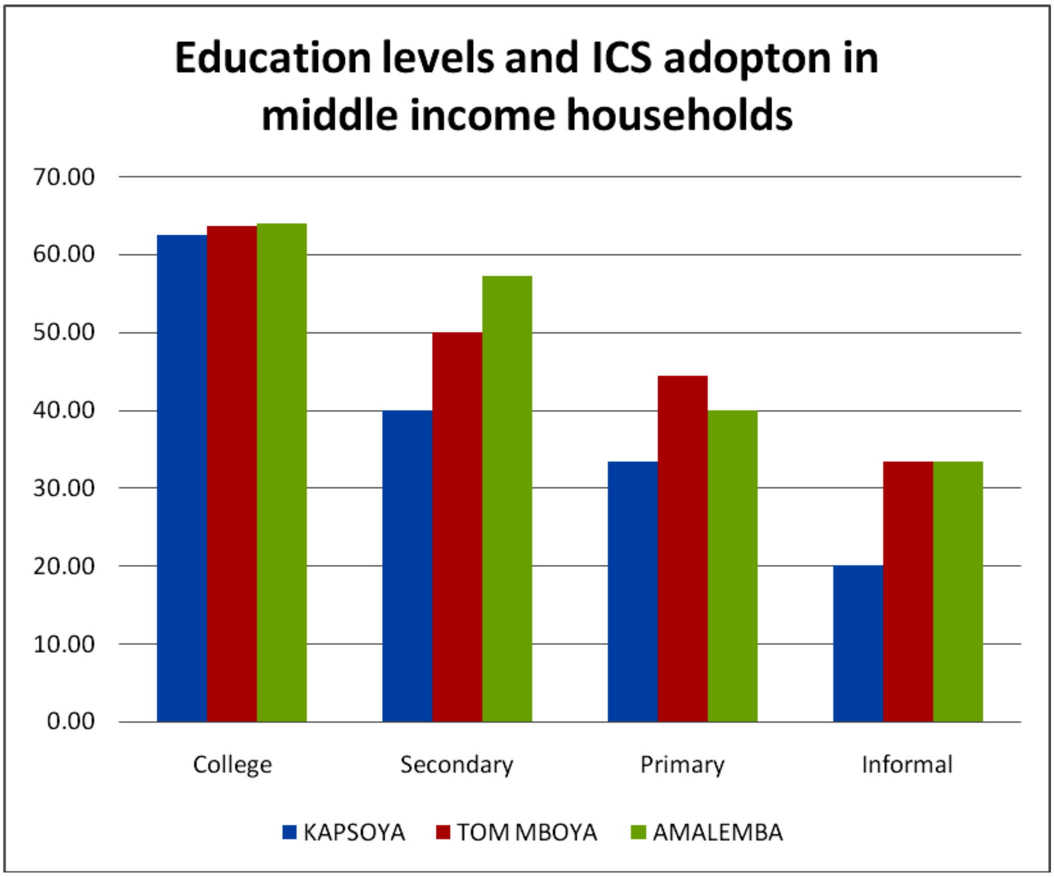


Figure 4. 4: Education levels and ICS adoption in low-income households

Adoption levels among households headed by those with a college education and above were generally higher among low-income households in all counties with Manyatta recording the highest adoption among those with college degrees and above at 62.5% and Shikambi estate recorded the lowest adoption (60.0%). The lowest adoption level was among households headed by informally trained household heads. Langas recorded the lowest adoption level of 25% while Manyatta and Shikambi followed at 33.3% (Figure 4.4).

Table 4.3 shows the results of the influence of the education level of the head cooks in the households on ICS adoption in various income levels estates in Kakamega, Kisumu, and Uasin-Gishu counties.

Table 4. 3: Percentage adoption based on education levels across income level estates

Education Level	Low Income (%)	Middle Income (%)	High Income (%)	Average (%)
College	61.47	63.38	66.29	63.71
Secondary	50.98	49.05	52.38	50.80
Primary	44.81	39.26	28.89	37.65
Informal	30.56	28.89	23.33	27.59

High adoption levels were observed among respondents with a college education level, followed by a secondary education level. The lowest adoption level was among households headed by heads with only informal education (Table 4.3).

Figure 4.5 shows results of ICS adoption in middle and high-income estates based on the education level of the household head.

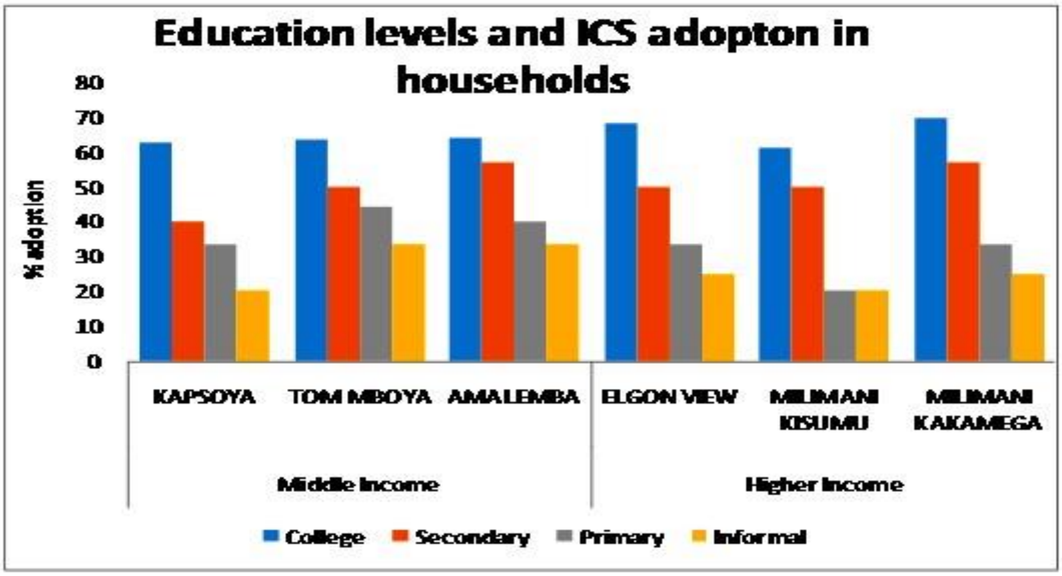


Figure 4.5: Adoption in middle and high-income estates

High-income households recorded the highest adoption levels in which adoption in Milimani Kakamega recorded the highest levels (69.6%) among those with a college education. Milimani in Kisumu County recorded the lowest levels (61.1%) among heads with a college education in that category. Generally, the lowest adoption levels were observed among household heads with informal education levels only with adoption levels of 20%, 25%, and 20% in Milimani Kakamega, Elgon View ad Milimani Kisumu estates respectively (Figure 4.5).

4.1.4 ICS Awareness level and adoption levels

Figure 4.6 shows results of the awareness level of the ICS awareness among the household heads in Kakamega, Kisumu, and Uasin-Gishu counties.

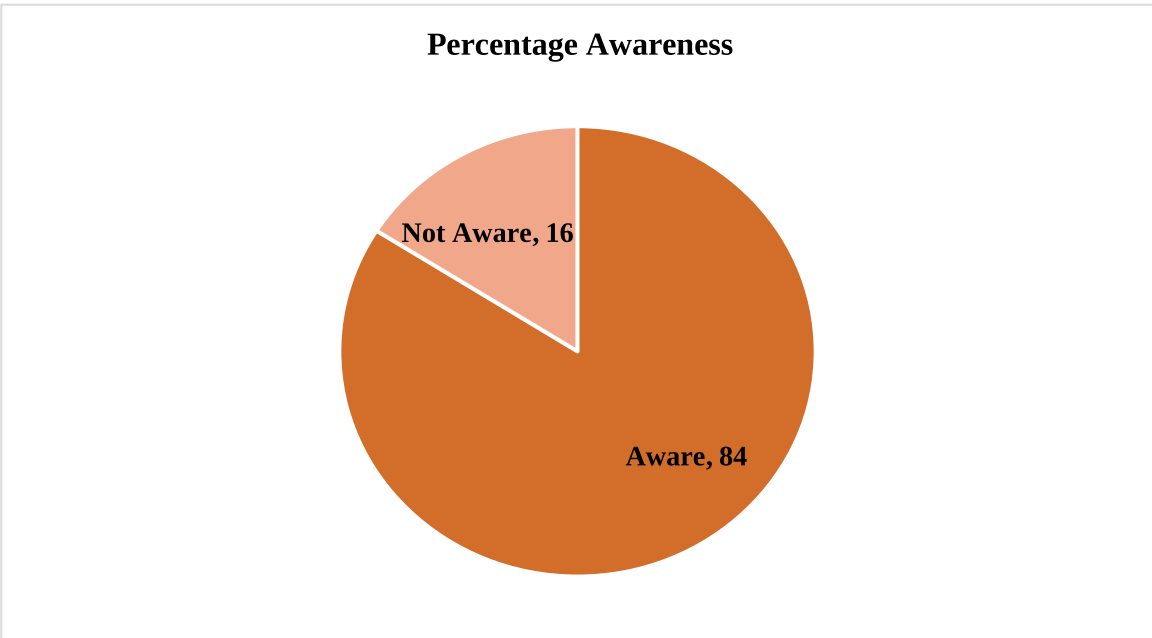


Figure 4. 6: ICS Awareness Level in Uasin Gishu, Kisumu, and Kakamega Counties

In all three counties, the average level of ICS awareness was generally over (84%) (Figure 4.6). Table 4. 4's analysis of the relationship between awareness level and ICS adoption among household heads in the counties of Kakamega, Kisumu, and Uasin-Gishu revealed that ICS awareness was highest among low-income estates (93.3%), followed by middle-income estates (81.1%), and lowest among high-income estates (76.7%).

Table 4. 4: Awareness of ICS and adoption across three counties

Income Levels	Estates	Counts	Percentage Adoption	Average income level on adoption	Overall Adoption (%)
Low	Shikambi	28	93.3		
	Manyatta	29	96.7		
	Langas	27	90.0	93.3	
Middle	Amalemba	23	76.7		
	Tomboya	24	80.0		
	Kapsoya	26	86.7	81.1	
High	Milimani	21	70.0		
	Milimani	24	80.0		
	Elgon View	24	80.0	76.7	83.7

4.1.5 Quantity of fuel used per day and ICS adoption

Results in table 4. 5 show percentage adoption of ICS based on the quantity of fuel wood consumed by a household every day. This adoption was based on income level across the sampled estates.

Table 4. 5: ICS adoption based on the quantity of fuel wood used per day

Estate's income level	**Low (%)**			**Average**	**Middle (%)**			**Average**	**High (%)**			**Average**
Quantity Used	**Langas**	**Manyatta**	**Shikambi**		**Kapsoya**	**Tom Mboya**	**Amalemba**		**Elgon View**	**Milimani**	**Milimani**	
1-5 kg/L	78	68	72	73	44	50	54	49	25	30	33	29
6-10 Kg/L	38	33	38	36	70	76	62	69	71	73	79	75
11-15 Kg/L	0	0	0	0	0	0	0	0	0	0	0	0
16>Kg/L	0	0	0	0	0	0	0	0	0	0	0	0

The results revealed that the fuel wood quantity used per day affected more the decision to use ICS in middle-income levels, followed by low income and least in high-income estates. A large number of households that used 1-5 kg (73%) fuel wood in low-income level estates adopted ICS. This was followed by middle income and least in high-income estates. Generally, high adoption was observed among households that used between 6 - 10 Kg/L fuel wood (high income=75%, middle income=69% and low income= 36%) (Table 4. 5).

4.1.6 Preferred ICS characteristics for adoption

Figure 4. 7 reveals the influence of ICS characteristics on the adoption level among the three counties studied (Kakamega, Kisumu, and Uasin Gishu).

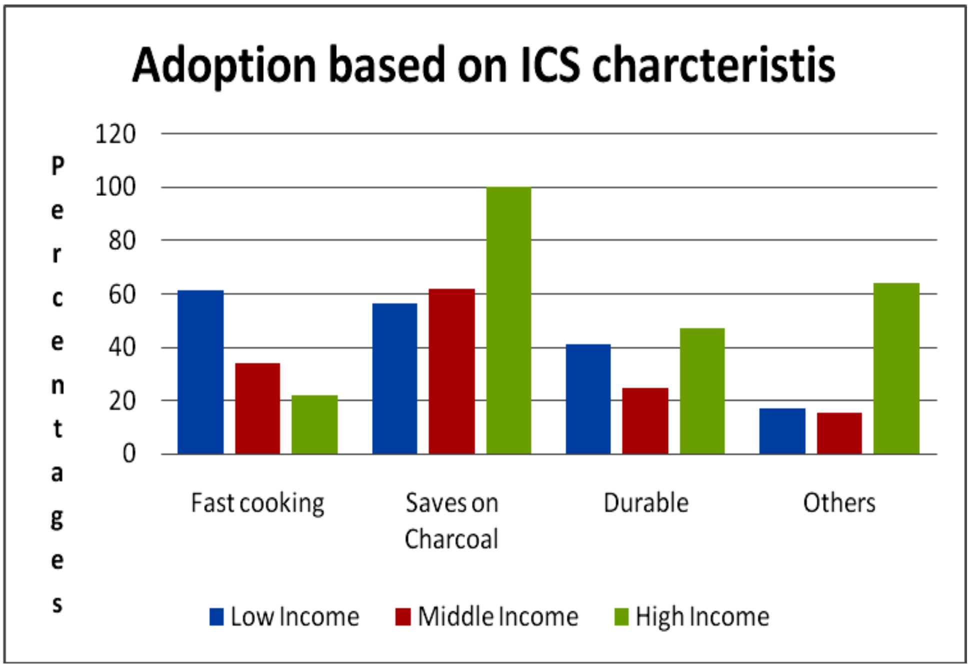


Figure 4. 7: ICS adoption trends based on stove characteristics across income levels

From the results, it was noted that ICS adoption across all the income levels estates, households preferred ICS based on charcoal saving (85.6%), followed by fast cooking characteristic (46.8%), durability being the least with 30.5% adoption levels. The stove's other characteristics like design, stability, heat insulation, and interior environment friendliness, accounted for 45.9% of adoption. Based upon charcoal saving characteristics, high-income estates had the highest adoption (100%), followed by middle (81.3%) and the least adoption was in low-income levels (75.4%) (Figure 4. 7).

4.1.7 Chi-square analysis for factors affecting ICS adoption in households

Appendix Table 1 shows results on chi-square analysis on the factors influencing ICS adoption in Kakamega, Kisumu, and Uasin-Gishu counties. Results revealed that household size in all income levels (χ^2=37.295, df=149, p<0.05), education level

(χ^2=18.367 df=149, p<0.05), awareness of ICS (χ^2=18.2476 df=149, p<0.05), income level (χ^2=14.3024 df=149, p<0.05), ICS characteristics (χ^2=32.8286 df=149, p<0.05) and quantity of fuel wood used per day (χ^2=9.0167 df=149, p<0.05) significantly influenced the adoption levels of households in the three counties (Appendix Table 1).

4.2 The ICS adoption in institutions

4.2.1 Influence of population size on ICS adoption in institutions

Table 4. 6 shows results on the influence of population size served by institutions on the levels of adoption of the ICS among institutions in Kakamega, Kisumu, and Uasin-Gishu counties.

Table 4.6: ICS adoption in Institutions based on population served per day

Population	**Uasi Gishu** (%)	**Kisumu** (%)	**Kakamega** (%)	**Averages**
100-300 (Small)	33.33	33.00	22.22	**29.52**
301-600 (Medium)	37.50	40.00	42.86	**40.12**
601-900 (Large)	33.33	42.85	37.50	**37.89**
>901 (Extra Large)	25.00	37.50	20.00	**27.50**
Averages	**32.29**	**38.34**	**30.64**	

The results revealed that adoption of ICS in institutions was highest in Kisumu County (38.3%), followed by Uasin-Gishu (32.3%) and Kakamega in that order (30.6%). Most institutions that served between 301 and 600 people, on average used ICS more (40.1%), followed by those that served between 601 and 900 people. The least percentage adoption (27.5%) was recorded in institutions that served more than 901 heads per day (Table 4.6).

4.2.2 Education levels of head cook against ICS adoption in institutions

Table 4.7 shows results on the influence of the education level of the institutions head cooks on the ICS adoption in institutions.

Table 4.7: Influence of Education levels of head cooks on ICS adoption

Institution	Uasin-Gishu (%)	Kisumu (%)	Kakamega (%)	Averages
College	68.75	71.43	70.00	70.06
Secondary	60.00	62.50	66.67	63.06
Primary	60.00	50.00	50.00	53.33
Informal	50.00	50.00	33.33	44.44
Percentage Averages	59.69	58.48	55.00	

According to Table 4. 7, the adoption of ICS was highest in establishments where the head cook had a college degree (70.1%), followed by secondary education (53.3%), and the least in informal education (44.4%). High adoption was impacted by the educational background of the institution's head cooks in Uasin-Gishu (59.7%), Kisumu (58.5%), and Kakamega (55%).

4.2.3 Percentage awareness and institutions' ICS adoption

Figure 4.8 shows results on the ICS awareness level among head cooks in institutions in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

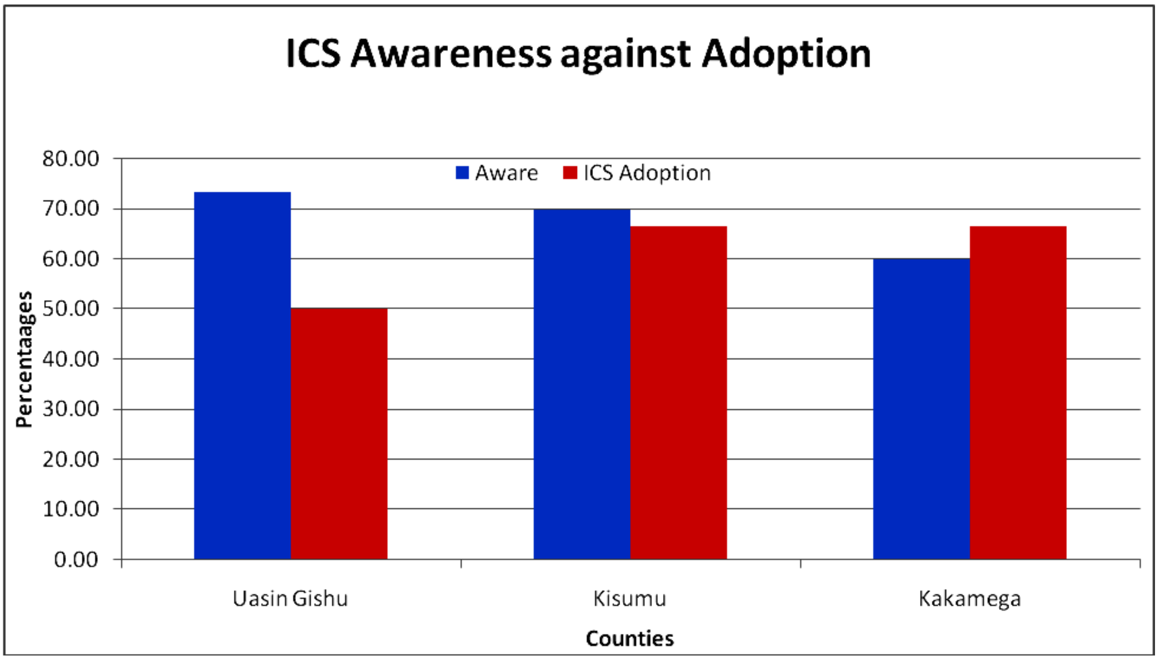


Figure 4. 8: Influence of level of awareness of ICS on adoption

Results showed that Uasin-Gishu (73.3%), Kisumu (70%) and Kakamega (60%) had the highest levels of ICS awareness. However, Kisumu and Kakamega had the greatest ICS adoption rates, each at 66.7%, while Uasin-Gishu had the lowest (at 50%). (Figure 4. 8).

4.2.4 Stove characteristics and ICS adoption in institutions

Figure 4. 9 below shows results on the influence of institution head cooks' perceived ICS characteristics on their use in institutions.

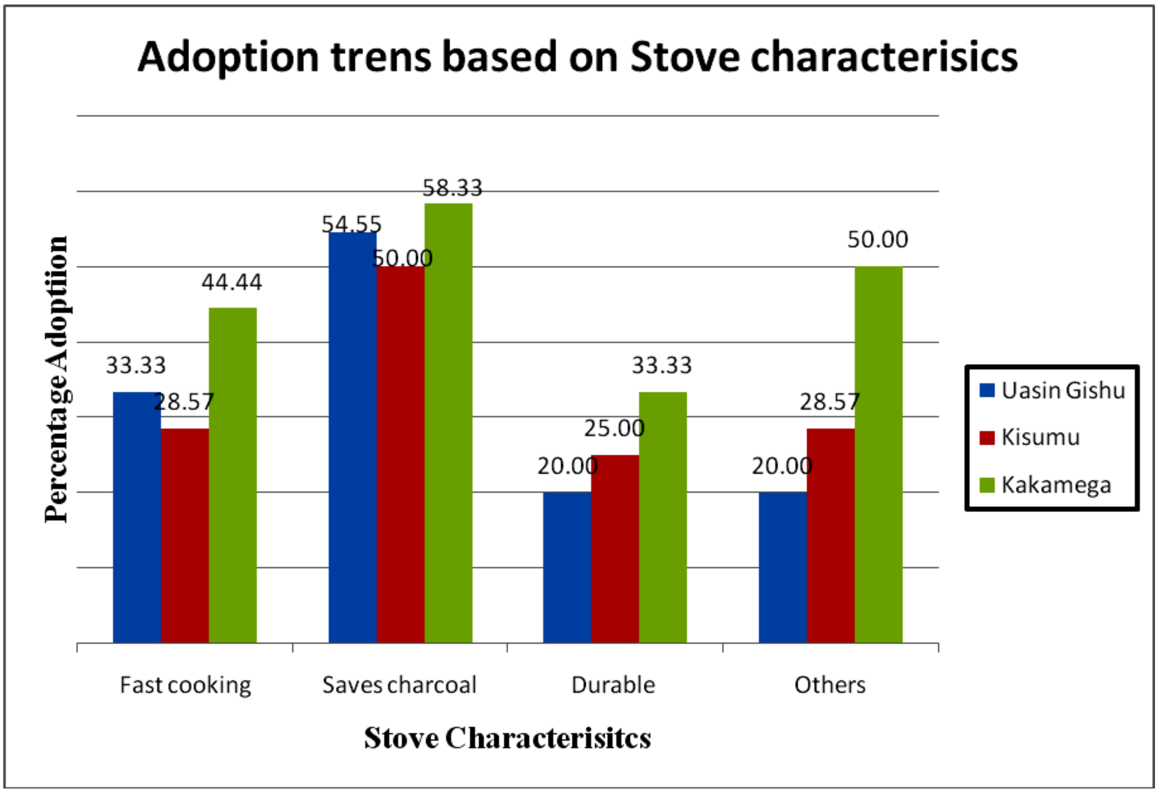


Figure 4. 9: Percentage adoption in institutions based on ICS characteristics

The results revealed that the charcoal saving characteristic of the stove attracted more adopters (Kakamega= 58%, Uasin Gishu= 55%, and Kisumu= 50%).On average**,** the fast-cooking characteristic of the stove accounted for 35.5% across all the counties. Other properties like heat insulation, environment friendliness, and good workmanship accounted for an average of 32.9% across all the counties. The overall adoption based on stove durability across all the counties was the least (26.1%).

4.2.5 Influence of quantity of fuel used on ICS adoption in institutions

Table 4. 8 shows the levels of adoption of ICS based on the quantity of fuel wood consumed per day by institutions in Kakamega, Kisumu, and Uasin-Gishu counties.

Table 4.8: ICS adoption based on the quantity of fuel wood used

Ordinary Jicko Quantity	(%)	ICS (%)	Other (%)
10-50 kg	51.10	27.70	18.65
60-100 kg	25.76	48.09	28.18
101-150 kg	50.55	31.11	26.51
>150 kg	34.07	18.89	26.11
Average	40.37	31.45	24.86

In the three counties, the use of Ordinary Jicko was observed to be high (40.4%) averagely in institutions, followed by ICS (31.5%) and the other technologies least (24.9%). Ordinary Jicko was preferred for both low fuel consumers (10-50 kg/day and high consumers (101> kg/day). On the other hand, medium to large consumers of fuel (60 kg/day and above) adopted the ICS except for institutions that used more than 150 kg/day (Table 4. 8). From the results, it was noted that, as the quantity of fuel wood used per day increased, the adoption of ICS was reduced.

Figure 4.10 shows the result of the levels and trends of ICS adoption in Kakamega,

Kisumu, and Uasin-Gishu counties based on the quantity of fuel wood consumed per day.

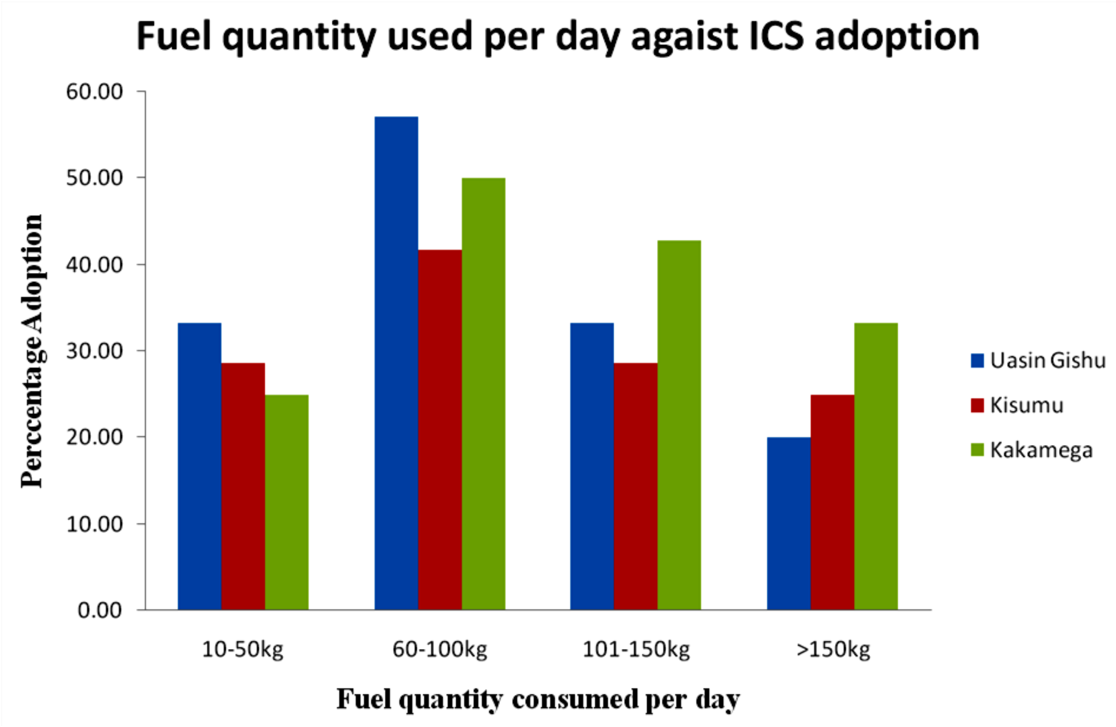


Figure 4.10: Adoption trends based on the quantity of fuel wood used in institutions

Uasin-Gishu had the highest adoption based on high consumers of fuel per day, followed by Kakamega, and least was Kisumu in the second level of fuel wood usage (60-100 kg per day). Generally, ICS adoption increased with an increase in the fuel quantity used per day up to 100 kg/day and declined thereafter (Figure 4. 10).

4.2.6 Chi-square analysis results on factors affecting ICS adoption in institutions

Appendix Table 2 shows results of chi-square analysis on the factors influencing ICS adoption in institutions. According to the results (Appendix Table 2), the number of people served per day (hotel size) significantly influenced the levels of adoption of the ICS in institutions (χ^2=10.0535, df=20, $p<0.05$). However, the education level of the head cooks in institutions (χ^2=0.6622, df=20, $p<0.05$), the awareness level of head cooks

(χ^2=0.5057, df=20, $p<0.05$), stove characteristics (χ^2=2.2622, df=20, $p<0.05$) and quantity of fuel wood used per day (χ^2=3.4796, df=20, $p<0.05$) did not significantly influence adoption in institutions.

Results of chi-square analysis on the variables impacting ICS adoption in institutions are shown in Appendix Table 2. The results (Appendix Table 2) show that levels of ICS adoption in institutions were significantly influenced by the number of persons served each day (hotel size) (χ^2=10.0535, df=20, $p<0.05$). However, there was no evidence of a significant relationship between adoption in institutions and the head cooks' education level (χ^2=0.6622, df=20, $p<0.05$), awareness level (χ^2=0.5057, df=20, $p<0.05$), stove characteristics (χ^2=2.2622, df=20, $p<0.05$), or amount of fuel wood used daily ((χ^2=3.4796, df=20, $p<0.05$).

4.3 ICS adoption in hotels

4.3.1 Hotel sizes and ICS adoption

From Table 4. 9, the overall ICS adoption based on the sizes of the hotels was highest in Kakamega (60.7%), followed by Kisumu (56.7%) and Uasin-Gishu recording the least (49.9%). Medium size hotels, which served 51- 150 people per day, had high levels of use of ICS in all counties compared to small-scale and large-scale hotels. The use of ICS increased with an increase in the population of clients served but declined when the number of the clients served increased above 150 heads (Table 4. 9).

Table 4.9: Influence of hotel size on ICS adoption

Hotel sizes	Uasin-Gishu (%)	Kisumu (%)	Kakamega (%)

10-50 (Small)	33.33	40.00	45.45
51-150 (Medium)	62.50	70.00	70.00
151 and above (Large)	53.85	60.00	66.67
Average	49.89	56.67	60.71

4.3.2 Education level of head cooks and adoption of ICS in hotels

The hotels with higher-educated head cooks had the largest adoption of the ICS (diplomas and above). According to county-level data on adoption, Kisumu had the highest rate at 67.9%, followed by Uasin-Gishu (61.2%) and Kakamega with 55.5%. (Figure 4. 11).

4.3.3 Hotels head cooks awareness level

Figure 4. 11 below presents results on adoption levels as influenced by the level of education of head cooks of hotels in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

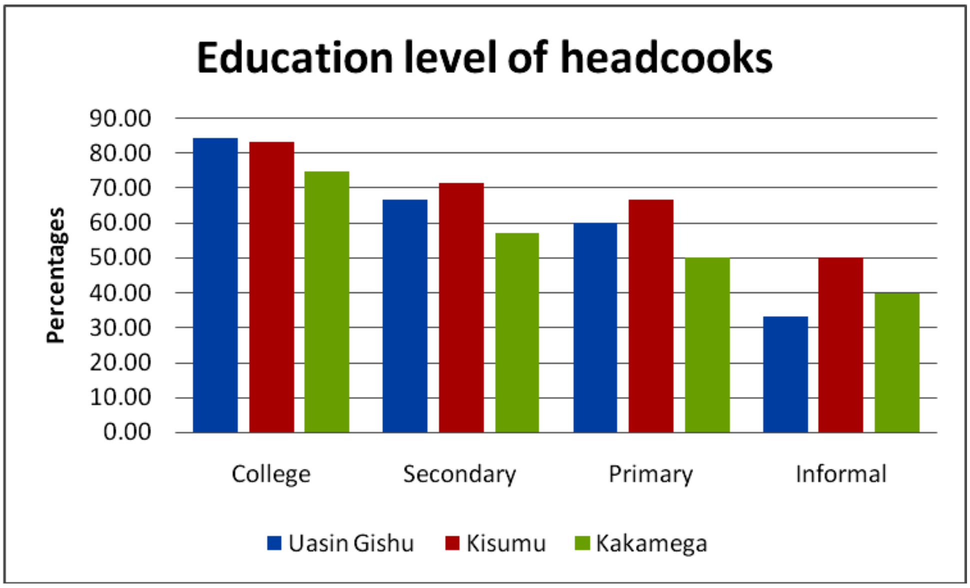


Figure 4.11: Percentage adoption based on the education level of head cooks in hotels

From the results, with majority of hotel head cooks (64 out of 69) were aware of the ICS in Uasin-Gishu, 62 out of 69 in Kisumu, and 62 out of 69 in Kakamega.

According to the results presented in table 4. 10, ICS adoption due to the high awareness level of ICS by hotel head cooks was 34% in Kisumu, 32% in Kakamega, and 30% in Uasin-Gishu counties (Table 4. 10).

Table 4.10: Head cooks ICS awareness and adoption in hotels

	Uasin Gishu					Kisumu					Kakamega				
	Ordinary jiko	**ICS**	**Others**	**Total**	**ICS % adoption**	**Ordinary jiko**	**ICS**	**Others**	**Total**	**ICS % adoption**	**Ordinarv iiko**	**ICS**	**Others**	**Total**	**ICS % adoption**
Aware (%)	5	19	4	64	30	3	21	3	62	34	5	20	2	62	32
Not aware (%)	1	0	1	5	0	1	1	1	7	14	1	0	2	7	0
Total				69					69					69	

4.3.4 Influence of ICS characteristics on adoption in hotels

Table 4. 10 presents the results on adoption of ICS based on hotel head cooks perceived qualities of the stoves in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

Table 4.11: Percentage adoption based on stove characteristics

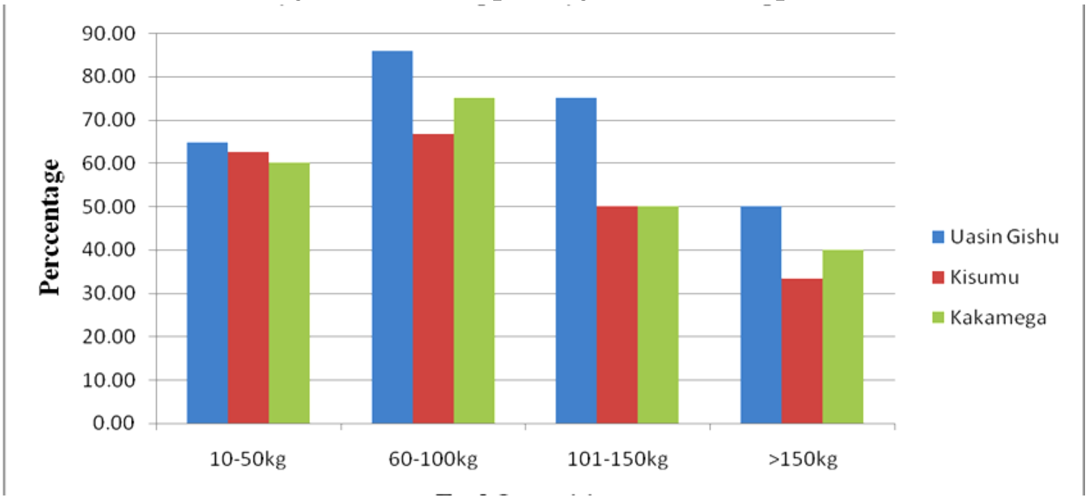
County	Fast cooking	Saves charcoal	Durable	Others
Uasin-Gishu	22.2	72.7	33.3	42.9
Kisumu	42.8	66.7	40.0	44.4
Kakamega	33.3	66.7	40.0	30.0
Average	32.8	68.77	37.8	39.1

The ICS adoption in the three counties was highest considering its characteristic of saving on charcoal (68.8%). Other properties like design, stability, heat insulation, environment friendliness accounted for 39.1%. The durability (37.8%) and fast cooking properties influenced 37.8% and 32.8% of adoption levels (Table 4. 11).

4.3.5. Quantity of fuel wood used after ICS adoption in hotels

Figure 4. 12 represents the results of the influence of the quantity of fuel wood used per day in the hotels on ICS adoption levels in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

Quantity of Fuel used per day and ICS adoption levels



Fuel wood Quantities

Figure 4. 12: Quantity of fuel wood used per day and ICS adoption levels

From the results figure 4.12, Uasin-Gishu had the highest adoption levels (68.9%) based on all categories of the quantity of fuel wood used, followed by Kakamega (56.3) and least was Kisumu (53.1%). It was observed that over 85% of the hotels that adopted ICS used between 60-100 kg/day. Quantities beyond this level resulted in a decline in ICS adoption (Figure 4. 12).

4.3.6 Chi-Square analysis results on factors affecting ICS adoption in hotels

Results of the chi-square analysis on factors influencing the adoption of ICS in hotels in Kakamega, Kisumu, and Uasin-Gishu revealed that adoption of the ICS in hotels within the three counties was not significantly influenced by hotel sizes, head cooks education level, head cook ICS awareness level, stove characteristics and the quantity of fuel wood used per day (χ^2=2.3333, 0.4333, 0.1000, 4.9667 and 0.6667, df=68, $p<0.05$) respectively (Appendix Table 3).

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Socio-economic factors influencing ICS adoption in households

5.1.1 Household size

This study established that household size significantly influenced the levels of adoption of ICS in Kakamega, Kisumu, and Uasin-Gishu counties of Kenya (χ^2=37.295, df=149, $p<0.05$). In low-income estates in the three sampled counties, the average ICS adoption was high in households with low household numbers (1 to 3 members). This implies that ICS use is suitable for small households in rural and urban areas. This finding correlates with observation of Narasimha and Reddy (2007), who argued that residents in rural areas of India preferred traditional stoves for larger households and in cooking traditional meals. According to Andadari *et al.* (2014), larger households in Indonesia preferred ICS with larger pot mouths for cooking large meals. However, households that adopted ICS considered the type of stove suitable for the household size. The only hindrance was that the many kinds of stoves in the market were not very suitable and scarce. Therefore, other means of cooking were adopted for larger households.

In Kakamega, Kisumu, and Uasn-Gishu counties in Kenya, a larger percentage of households with sizes of 4 to 6 members in middle-income estates adopted ICS (average 62.17%). This implies that a high percentage of middle size households preferred ICS for cooking in middle-income estates compared to both low and high-income estates. This was supported by Liu *et al.* (2003) and Carr *et al.* (2005) who stated that middle-income estates preferred fixed ICS because they were affordable and could serve the household’s needs and workers in the compound. This is because ICS saved on fuel wood, an aspect that influenced cooking stove choices. Middle household sizes required more fuel wood compared to small families (Liu *et al.*, 2003; Carr *et al.*, 2005). These households had more demands on their income and thus valued saving their resources for other critical needs. The ICS was affordable and thus useful in saving household income spent on fuel wood. This study observed the same results in the three counties in Kenya. Adoption was also comparably high in middle-income estates because the households used mixed sources of fuel wood (free collection from forests and purchased). In a study conducted by Carr *et al.* (2005) similar results were observed.

5.1.2 Education level of household head

Education level was shown to significantly influence the adoption of ICS in households in the three counties (χ^2=18.367 df=149, p<0.05). From the results, it was observed that in low-income estates, the average adoption levels of households with heads, holding university degrees or diplomas in various fields adopted the use of ICS readily compared to lower education levels. The same results were observed in middle-income estates and high-income estates (66.23%). Average adoption levels were followed by secondary education level in all income estates Lower than primary education level had a low influence on average ICS adoption levels.

According to Okuthe and Akotsi (2014), education helped the household heads understand and interpret information about the importance of clean energy. In their study in Homa Bay, they observed that 27% of the respondents that used ICS had secondary education. Those who had upper primary education and above accounted for 43% while lower primary education accentuated for 25%. These results were comparable with the results obtained in this study. Since ICS was a technology, its use demanded educational awareness to make the informed choice (Bielecki & Wingenbach, 2014). Technical knowledge on the stoves increased the effective use and maintenance of the stoves thus increased the benefits of using the stoves (Tigabu *et al.,* 2017). The results in this study agreed with the observation made by Chitere and Van Doorne (1985), Okuthe *et al.* (2000), and Amudavi (1993). These authors indicated that formal education influenced the use of technology being promoted in their study areas. This implied that formal education increased the decision-making process in favor of innovative and informed practices that maximized the benefits of new technologies (Tomlinson, 2018). It was therefore noted that formal education was necessary in considering the awareness strategies and improvement of households' participation in new technologies aimed at community development (Okuthe & Akotsi, 2014).

In Jan (2012) and Jan *et al.* (2017) noted that education level qualification was measured by the number of years that respondents had attended school in Pakistan. On average 7.3 years were observed. It was, therefore, important to note that long schooling yielded to higher awareness of the new technologies and conceived higher levels of benefits associated with the new technologies compared to individuals with lower education levels. In most households in Kakamega, Kisumu, and Uasin-Gishu, the heads of the households decided on the technology to adopt coking technologies, and therefore higher formal education was vital in making ICS adoption decisions. This was also the case in most literature reviewed by Shen *et al.* (2015) in China.

According to Liu *et al.* (2013), residents in Fujian province did not adopt cleaner high quality cooking fuels because they lacked the necessary information and awareness about them. This agreed with the observation by Wang *et al*. (2012) that limited education on cleaner fuels influenced adoption and sustainable use of the technologies.

A filed survey in nine provinces of Fiji, adoption of cleaner cooking fuel increased by 0.66% with one more year of education (Zhang and Kotani, 2012). In Kenyan rural areas, Pundo and Fraser (2006) found that education increased the chances for choosing cleaner cooking means. This was also observed in eight other developing countries by Heltberg (2004) and in Sudan by Suliman (2010).

According to the observation by Pandey and Chaubal (2011) in India, a higher percentage of educated female members of a household positively influenced the probability of switching to cleaner cooking fuels. Mekonnen and Kohlin (2008) and Gebreegziabher *et al.* (2012) made similar observations in Ethiopia. A study in India by Farsi *et al.* (2007) recorded a similar observation stating that educated household members influenced choices to clean cooking fuels. This study confirmed that higher formal education significantly influenced ICS adoption in all economic classes in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya.

5.1.3 ICS awareness level for households

The study revealed that the level of awareness of the ICS cooking technology significantly influenced its adoption in households in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya (χ^2=18.2476 df=149, p<0.05). Awareness of the technology and knowledge of their use and benefits and availability use is important in influencing its adoption. The level of awareness in the three estates agrees with the observation by Kapfudzaruwa *et al.* (2017), who stated that Kenya had a middle awareness level for the ICS compared to South Africa. According to Fatihiya and Kenneth (2015) and Kumar *et al.* (2016), low awareness of the technology among customers was a key barrier to its adoption. This implied that consumers who had low education levels and limited social networks had limited access to ICS information and thus were less aware of the cumulative socio-economic and health reimbursements of ICS. Kapfudzaruwa *et al.* (2017) stated that low literacy among many women in African countries was the cause of low diffusion and adoption of ICS and other clean fuels in Africa. High awareness among low-income estates implied that the households in the estates were more readily available for new technology awareness programs because they were seeking means that could reduce their spending. According to Rogers (2003), increasing means to diffuse the knowledge of new technologies among rural women in patriarchal societies in Africa could increase the awareness of merits of innovations and thus influence high levels of ICS adoption. High adoption in households was influenced by other socio-cultural factors according to study done in Kilimanjaro Tanzania (Fatihiya & Kenneth, 2015). Diffusion and awareness of products are largely dependent upon social-economic, cultural, and environmental factors to achieve high adoption (Person *et al*., 2012). In this study, increased awareness for the ICS was associated with the high levels of adoption especially knowledge on the benefits of the new technology and practices.

5.1.4 Households income levels

The level of income of each household significantly influenced ICS adoption among households across all economic estate levels in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya (χ^2=14.3024, df=149, p<0.05). This was confirmed by about 98.90% ICS adoption among high-income estates, 81.68% in middle income, and 63.34% in low income estates. However, the average adoption level across household income levels was high for households that earned between Kshs20,001 and 40,000, followed by those earning less than 20,000, and least was households that earned Ksh. 40,001 per month. Financial aspects significantly influenced the implementation of the programs that are aimed at increasing new technology adoption initiatives. In Kapfudzaruwa *et al.* (2017) study, 44% of the respondents cited financial constraints as a barrier to adoption. Finances affected both the price of the commodity and the affordability of ICSs. Various macro-economic environments determine the household's income level (Kapfudzaruwa *et al.,* 2017). The high adoption level in South Africa compared to Malawi was linked to the per capita performance of South Africa relative to Malawi. Households that had higher income were at higher disposal for accessing and affording the ICS in Kenya given the hard financial situations. This was also observed in the study in Kenya that investigated the role of 16% VAT on the use of clean fuels like LPG biogas fuel and ICS, where the levels of ICS increased. This implies that increased prices of ICS lowered the choices for use of ICS among most households (Kapfudzaruwa *et al.,* 2017).

A study in West Africa revealed that high import duties increased the prices of the commodity thus making it cost-prohibitive. Those that adopted ICS in Kenya were noted to be using firewood because other solid fuel wood sources were expensive. The same scenario was observed in Mali where most rural households were pastoralists limited to modern economy cash flow (Johnson & Bryden, (2012). The scenario was different in Addis Ababa and Nairobi urban centers where low-income dwellers relied on charcoal jicko while high-income dwellers modern and durable ICSs. Thurber et al. (2014) discovered that pelletized biomass had the highest levels of ICS adoption, mostly due to lower fuel prices. However, their research also reveals that just 9% of those who bought ICS were utilizing the stove since there wasn't enough fuel. This is true for institutions in the study areas that depend on tenders that might be challenging to get and require considerable amounts of fuel wood (up to half a tone daily). Similar findings were made by Asaduzzaman et al. (2010), who concluded that ICS adoption was constrained by the price of modern fuel and a shortage of supply.

According to Beyene et al. (2013), the cost of the ICS, household income, and wealth all had an impact on whether or not biomass ICS was adopted. The study also discovered that the accessibility of substitute metal and electric cook stoves tended to make ICS less popular. According to a review study by Puzzolo et al. (2011), larger families who used biomass faced barriers from low household income, whereas high household income promoted the adoption of ICS. Household income influences the pattern of spending. According to Andadari *et al.* (2014) the expenditure of most households, changed with a change in income levels and hence the choice of cooking technology adopted in rural and urban areas in India. The observation was incongruous with rural Beijing where an increase in the price of LPG and coal did not influence the use of clean fuels because of diverse income levels, fuel consumption customs, and availability of various energy sources (Jingchao & Koji, 2012).

In Homa Bay, a study by Okuthe and Akotsi (2014) revealed that household income was used to purchase household consumables and thus low income would influence the purchase of ICS. According to this study, over 45% of ICS adopters earned less than Ksh. 6,000 from their firms while only 9% of the adopters earned more than Ksh 6000 from the on-farm sources. Otherwise, high incomes increased affordability and access to various kinds of clean fuels and thus positively influenced the sustainable use of ICS in Kakamega, Kisumu, and Uasin-Gishu counties. Although the increase in income increased the use of clean fuel, the use of fuel wood for cooking tended to decrease with an increase in household income. For instance, in rural India and Pakistan, Bansal *et al.*

(2013) and Chaudhuri and Pfaff (2003) found that clean fuel was preferred against fuel wood when family income increased. A similar observation was made in Guatemala and northern Cameroon by Heltberg (2004) and Nlom and Karimov (2014) respectively. Likewise, the households in Ouagadougou, Burkina Faso behaved in a similar manner
(Ouedraogo, 2006). In Mozambique, an increase in household income increased the probability for a transition from biogas to electricity (Arthur *et al.,* 2010). This implies that government subsidies and tax reduction play a role in household's use of clean cooking technologies. It is therefore imperative to note that higher income in urban areas diversified fuel choices (Mekonnen & Köhlin, 2008).

On the national level, strategies like subsidies and comfortable payment schemes that would make accessibility and affordability of ICS to households would increase ICS adoption. Governments that implemented technology subsidies like Malawi experienced increased levels of adoption of new technologies (Kapfudzaruwa *et al.,* 2017). In China, subsidies and other financial supports promoted the adoption of biogas (Shen *et al.,* 2015) while subsidies increased probabilities of rural households' use of the ICS in Kenya (Akoth *et al.,* 2014). Subsidies offered the household the financial support that made them easily acquire the stoves without straining their financial costs. This was also the case in the Chinese population (Shen *et al.,* 2015). Although Kenyan situation was not highly subsidized, the observation by Agurto-Adrianzen (2013) showed that only 42% of beneficiary households were effectively using ICS despite providing subsidies.

5.1.5 Quantity of fuel used per day

The quantity of the fuel wood used per day in each household significantly influenced the use of ICS in the three counties studied (χ^2=9.0167, df=149, $p<0.05$). The amount of fuel wood used per day in a household depended on the size of the household or the number of people being served in the homestead and other economic activities. In an urban setting, a household may have a high number of people being served per day because of the economic activities and socio-cultural significance of the family. This study indicated that the quantity of fuel wood used per day significantly and positively influenced the choice and sustainable use of ICS (Karanja & Gasparatos, 2019). They also observed that high influence occurred in middle-income estates compared to low income and high income in that order. It was apparent that 73% of the households that adopted ICS in low-income estates used 1 to 5 kg of charcoal or fuel wood per day. This indicated that ICS saved on fuel wood or most households had fewer members.

As observed above, most adopters of ICS (55.17%) had family sizes of 4-6 members in middle and high-income estates across the counties. This is the average size of most of the households accounting for 78% of households in Kenya (World Bank, 2014; Ezzati & Kammen, 2014). Households with members higher than six used other means of cooking like three-stone, kerosene, LPG, and electricity (Sesan, 2012). These findings concurred with Liu *et al.* (2003) observation in China and Carr *et al.* (2005) result in the tropics. The researchers noted that household seizes impacted the amount of fuel wood used per day due to increased demand. In most cases, the choice of cooking means was influenced by the amount of food to be cooked, the method of preparing the meal, and the time taken in cooking the meals. It was also observed that households that prepared cultural meals used traditional stoves more frequently than ICS. This was also observed by Okuthe and Akotsi (2014) in Homa Bay, Akoth *et al.* (2014), in Nyeri, Kakamega, and Maseno, and Nerini *et al.* (2017) in Nyeri County.

Larger households needed large fixed ICS that could sit large pots, which were expensive and unavailable in most areas studied. Increased demand for household fuel wood increased the labor and time for collecting fuel wood (Okuthe & Akotsi, 2014). The study showed that household fuel wood consumption concentrated between 1 kg/L and 10 kg/L per day. Cumulatively, a household would use between 30 kg/L to 300 kg/L of fuel wood in local cooking per month. This reveals that annual consumption in the projected 9.6 million households in Kenya is 3.4 to 34 million tons per year. This agrees with the findings reported by Practical Action East Africa Office (2010) which stated that in year 2000 Kenya was consuming 34.3 million tons of biomass of fuel (firewood and charcoal) (Practical Action East Africa Office, 2010).

5.1.6 Stove qualities

A number of ICS qualities significantly influenced its adoption in Kakamega, Kisumu, and Uasin-Gishu counties (χ^2=32.8286, df=149, p<0.05). The ICS was highly preferred because it saved on charcoal, and thus often used in areas where charcoal fuel wood was purchased expensively. Although the stove design and durability were expected to significantly influence high levels of adoption, results revealed that most households valued it because of charcoal savings. The study revealed that the use of charcoal was predominant in urban areas in Kenya. Observing the trends among income level estates, it is expected that low-income estate dwellers would adopt more of the stoves to economize on household income. However, the opposite was true. Low-income dwellers may want charcoal saving stoves but fast cooking, followed by charcoal saving, durability, and other factors in that order significantly influenced its use.

According to Kapfudzaruwa *et al.* (2017), most peri-urban and urban respondents in African countries highly rated ICS for its aesthetics. This implies that urban dwellers would purchase more of the stoves depending on the general workmanship and finishing rather than economic qualities. Kapfudzaruwa *et al.* (2017) stated that urban and peri-urban dwellers were attracted to the aesthetics of the stove to demonstrate modernity and status of wealth. According to Malla and Timilsina (2014), the property of saving on charcoal was a strong factor in areas where fuel wood was expensive. In Nepal, Sudan, and Kenya, the significant economic benefit of the ICS was fuel wood and time saving

(Malla & Timilsina, 2014),). In Kampala and Malawi, the observation was similar to the above (Habermehl, 2007; Habermehl, 2008). In the western region of Kenya, Djedje (2009) established that private and commercial ICS users saved on the cost of fuel wood and time spent cooking. When translated into monetary terms, it amounted to between Euro 1.1 - Euro 6.6 every day. In Lao, the time spent to collect fuel wood had reduced from 18 minutes to 12 minutes as women switched from using firewood to charcoal in ICS (ASTAE, 2013b).

According to Nerini *et al.* (2017), ICS reduced the cost of cooking compared to traditional methods. The use of the ICS scenario in Nyeri County would result in reduced fuel wood needed for cooking by 40, 000 tons per year (Nerini *et al.*, 2017). The use of ICS resulted in 30% fuel wood saving compared to traditional stoves and this translated to between EUR 5 to 60 per day saved. The stoves also conferred ease use property, suitability to consumer needs, like diverse and cheap domestic institutional stoves

(EnDev Kenya, 2017). According to a review study by Rehfuess et al. (2014), several ICS had unique design flaws that caused users to modify their stoves, reducing their effectiveness and favoring or switching back to traditional stoves. The success of the ICS program, according to Urmee and Gyamfi (2014), also depended on the involvement of local consumers and craftspeople in developing a self-sustaining sector that could adapt to shifting demands for different stove sizes and levels of quality. Ekouevi and Tuntivate (2012) found that lack of communication between manufacturers and consumers was the main cause of lower adoption of ICS for a household that needed over 10 kg/L as most stoves that were available were not suitable for their family sizes with big pots. In recent days, research shows that most urban dwellers are shifting from only energy saving and aesthetics to the environmental friendliness of the stove. According to Ekouevi and Tuntivate (2012), most users valued other characteristics like conditions of the kitchen due to reduced smokiness as well as heating. Due to healthy and environmental concerns, carbon monoxide level was increasingly a concern for users and desired clean indoor air quality especially among those who did not have a separate kitchen (Bailis *et al*., 2010; Ezzati & Kammen, 2014). This study revealed that traditional stoves were preferred due to their durability, heating of the interior house, and sizes flexibility while other means of cooking (Liquefied petroleum gas, paraffin stoves, and electricity) were preferred because of fast cooking, convenience, and indoor air quality
(less polluting). The use of Liquefied petroleum gas, paraffin stoves, and electricity (other cooking means), was high among high-income households compared to low and middle-income households.

The ICS adoption was met with the challenge of meeting the diverse needs of consumers. The diverse needs of the consumers of ICS call for the ICS project implementers to identify a balance between affordability, efficiency, durability, and convenience of the stoves to different socio-cultural and climatic concerns of the adopters (Kapfudzaruwa *et al.*, 2017). This can be done by increasing the designs of the ICS in which case, versatile stoves, which can offer multiple features, are designed and scalability increased for users in the different rural and urban settings in Kenya.

Chi-square analysis results revealed that all the selected socio-economic factors and stove characteristics studied in this research positively and significantly influenced the levels of adoption of ICS in households (χ^2=130.0571, 149, $p<0.05$) in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya. This therefore answered the first research question. According to GVEP-USAID (2012) and Karanja and Gasparatos (2019), policymakers and relevant authorities concerned with the use of clean energy should make strategies that will ensure the needs of the households are suitably and sustainably met to promote ICS in both rural and urban areas of Kenya.

5.2 Factors influencing ICS adoption in institutions

5.2.1 Institutions' population size

The size of the population/heads served per day in the institutions (schools and prisons) significantly influenced the levels of adoption of ICS in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya (χ^2=10.0535, df=20, $p<0.05$). Institutions in Kisumu, Kakamega, and Uasin-Gishu counties varied in the number of persons they serve per day. The study revealed that academic institutions and hospitals that served a population above 51 were higher adopters of fixed ICS. However, as the number of the population increased from medium sizes to extra-large sizes, the use of ICS decreased.

Kisumu County had high overall adoption, followed by Uasin-Gishu and last was Kakamega County. In comparison with the adoption levels in households, the highest adopters were medium size households. The observation above agreed with the findings on the adoption of clean energy by Tidze and Tchouamo (2018) in Sudano Sahelian Camroon. Large fixed ICS had many pot openings and thus could cook more food and thus serve a large population. The prices of the ICS were considerably within their spending budget and thus more medium institutions adopted ICS.

According to Gizachew and Tolera (2018), households' adoption of ICS in the Bale EcoRegion of Ethiopia largely depended on the sizes and condition of the kitchen while cooking. The relationship between household adoption and institutions based on their sizes needs further investigation. This will help correlate the relationships and thus set strategies that are conclusive in marketing ICS in both households and institutions. According to Tigabu (2017), the sizes of the households positively influenced the sustainable use of the stoves. The authors stated that medium institutions used the stoves for a long compared to large institutions.

5.2.2 Education levels of institution head cooks

The education level of the head cooks in institutions variedly affected the adoption of ICS in various levels but was not statistically significant in the three counties (χ^2=0.6622, df=20, p<0.05). The variation was observed to be by chance. In this study, a higher level of education (diploma and above) increased ICS adoption in households in the counties but the levels were not statistically significant. Head cooks in institutions may not influence the adoption of ICS in institutions if the owners of the institutions or governing bodies are not convinced by the perceived benefits of any new technology (Tigabu, 2017). This influences the institutions' choices for clean energy-saving stoves like ICS. Institution's ownership may have a higher influence on the daily operation of the institutions compared to the managers or head cooks. This agrees with the observations by Graves & Waddock (1990), McNulty & Nordberg (2016) and Christensen *et al.* (2018). It is imperative in the management of the institution to consider the environmental benefits of ICS before making decisions on the use of fuel wood. The education level of the head cooks should help the management consider adopting ICS because informed head cooks may input in the decision-making process thus benefiting the institution at large.

According to Jagger and Jumbeb (2016), education facilitates the making of an informed decision in the adoption of clean energy in society. This implies that the decision on the best cooking stoves to use in institutions should be left to the head cooks and not the management. In this case, the adoption of the ICS will increase in most institutions.

5.2.3 Awareness and ICS adoption in institutions

The awareness level of head cooks about ICS did not statistically influence the level of adoption of these stoves in the three counties (χ^2=0.5057, df=20, $p<0.05$). Although the level of awareness of ICS in institutions was found to be high among head cooks in institutions, their adoption due to a high level of awareness did not occur. This could have been the reason behind the low ICS adoption in institutions in the three counties. This implies that most head cooks in institutions do not take part in the important decision-making in institutions like the choice of energy to use. This may be due to the poor evaluation of the budgets and spending of these institutions (Liebman & Mahoney, 2017; Andrews, 2018).

Awareness of a technology increased household use of ICS. This was contrary in institutions. With a clear understanding of the ICS technology, it is imminent to understand its benefits and use. The use of traditional cooking stoves in institutions is prominent because its sponsors introduced it a long time ago. The ICS is a new technology and has not been fully adopted by the households and institutions in Kenya. High awareness by households would influence the institutions and other organizations in the society because the managers of the institutions come from households (Birkland, 2015). However, the relationship between the household level of awareness and institutions' decision-making process needs to be synchronized. High awareness of ICS in Uasin-Gishu head cooks in institutions was contrary to the level of awareness observed in the households. This may be associated with labor mobility. Most head cooks in the Rift Valley institutions were from outside the region (Ambrose, 2017). The level of awareness of improved solid fuel cook stoves in Kenya found that sustainable use of the improved solid fuel cook stoves was significantly predicted by awareness and technology reputation in the community over time.

5.2.4 Stove qualities and ICS adoption in institutions

The stove qualities did not significantly influence the use of ICS in institutions (χ^2=2.2622, df=20, $p<0.05$). The value of ICS was highly tagged on the quality of saving on charcoal/fuel wood. Although the quality did not influence the adoption levels of ICS positively and significantly, high adoption was observed in the institutions whose head cooks valued the stoves based on saving fuel wood. Institutions also valued the stoves for durability, aesthetics, and other qualities. Due to the management issues in the institutions, the adoption of ICS was unpredictable based on the good qualities.

Previous studies revealed that institutions have management structures that influence the adoption of new technologies. Institution's ownership may have a higher influence on the daily operation of the institutions compared to the managers or head cooks. This agrees with the observations by (Graves & Waddock, 1990; McNulty & Nordberg, 2016; Christensen *et al.*, 2018). It is imperative in the management of the institution to consider the environmental benefits of ICS before making decisions on the use of fuel wood. The knowledge of the stoves qualities is influenced by the level of education of the head cooks in the institutions. Training of the head cooks in institutions is rare and thus does not match their work with the level of knowledge about the stoves (Dadzie, 2018). Institutions management need to consider training programs for their head cooks to be aware of new technologies in the market that may increase the efficiency of their operation and save on expenditure. Informed head cooks may improve the process of decision-making in institutions thus help to balance institutions' expenditure and output. According to Dadzie (2018), building awareness on the benefits of using ICS facilitated the making of an informed decision in the adoption of clean energy in society. Tigabua *et al.*, 2017 also observed the same in Rwanda.

5.2.5 Quantity of fuel used against ICS adoption

The study revealed that the quantity of fuel wood used per day in institutions did not influence the use of ICS in the three counties (χ^2=3.4796, df=20, $p<0.05$). However, the quantity of fuel wood used in institutions was relatively comparable with the observed levels in the households. Medium-size institutions that used between 60 kg and 100 kg per day used ICS in cooking. Other cooking methods like traditional/ordinary jickos/stoves and biogas or electricity were used. The variation in the adoption due to stove qualities was observed by chance since the variation was not statistically significant at $p<0.05$. In Kenya, 95% of over 20,000 institutions among them schools, colleges and hospitals used fuel wood for cooking and heating (United Nations Development Program (UNDP), 2013). Compared to institutions, households adopted more ICS based on household sizes ranging between six to nine members. Since household heads had a direct influence on the spending on the cooking means, the qualities that confirmed high value on saving expenditure influenced their probability of using IC stoves. Ownership and management in institutions are different from the households and thus direct correlation may not be possible.

Education on the qualities of the stoves and popularization strategies may increase the management's probability of adopting alternative cooking technologies instead of the influence of knowledge of head cooks (Andadari *et al*., 2014). A knowledge gap on how the head cooks relate with institution's management is lacking to aid understand how their knowledge and ICS liking can be turned into important tools for assisting in increasing the levels of adoption in institutions. It has been observed that most institutions' top management are directly concerned with the daily operations of the kitchens and therefore do not constantly consult nor value the views of head cooks in the choices for the type of fuel wood to use (Dadzie, 2018). Saving on fuel wood has an economic influence on the use of ICS. The existence of other cheap cooking means may also change the levels of adoption in institutions. For instance, Zhang and Kotani (2012) discovered that fuel prices had a strong demand effect, which led to less use of these cooking fuels even though there were no substitution effects between cooking fuels (coal and LPG). Similar findings were found by Takama et al. (2012) who emphasized that institutions that serve large populations are mainly influenced by product-specific characteristics such consumption cost, stove price, safety, and smokiness when choosing fuel and stoves.

In summary, ICS adoption levels in institutions were positively and significantly influenced by the sizes of the institutions at $p<0.05$. This agreed with the observation in households in this study that the number of people being served influenced the use of ICS. Other socio-economic factors and stove qualities were not significantly influential on the ICS adoption. This was contrary to the observations in the households. Since no studies had been conducted on the socio-economic factors that affect ICS adoption in institutions, this study suggested that studies on the same be done in institutions from different regions of the country to gather information necessary to understand how these factors influenced ICS adoption in institutions. In Rwanda, household adoption of ICS was observed to be low at 42% (Jagger *et al.*, 2019). In Kwabenya in the Ga East Municipality, household adoption was 41.2% (Dadzie, 2018). The adoption of biogas in Nakuru was not statistically significant based on socio-economic factors examined at a confidence level of $p<0.05$ (Mwirigi *et al.*, 2009).

5.3 Factors to ICS adoption in hotels

5.3.1 Hotel sizes

In this study, the number of people served by the hotels (hotel sizes) did not significantly influence ICS use in the three studied counties ($\chi^2=2.3333$, df=68, $p<0.05$). However, results revealed that high adoption of ICS in hotels was higher in medium hotels (51-150 heads per day), followed by large (those serving 151 and above heads per day), and the least was in small hotels. This implies that the larger the hotel the higher the levels of ICS adoption. However, the variation in the adoption due to the hotel size was not statistically significant implying that it might have been due to chance. Further investigations need to be conducted to establish to what level does the size of the hotel influence adoption of ICS. Just like the observation in institutions, it can be stated that knowledge of ICS by head cooks does not influence the hotel owners' choice of ICS. This could be the reason why a hotel size does not significantly influence ICS adoption.

Comparatively, high adoption in Kakamega might be due to the combined efforts of the community forest organization that has been fighting to keep the Kakamega forest from depletion and government agencies. Firewood or charcoal in Uasin-Gishu is in plenty and thus low adoption. Most of the fuel wood in the county is collected free or bought at a very low cost and thus lacks high economic implications. The adoption trend in the middle and large size hotels was also observed by Sehjpal *et al.* (2014). They concluded that hotel size was less significant to ICS adoption compared to other social and cultural factors in choosing cleaner fuels/technologies that can be witnessed. A similar trend was observed in household sizes in this study. This implies that medium-size hotels used more of the ICS compared to low and larger sizes. This was supported by Jan (2012) and Pine *et al.* (2011) who made similar observation in rural northwest Pakistan and rural Mexico respectively. In their observations, medium household size significantly affected the household willingness to adopt improved biomass stoves.

According to Nnaji *et al.* (2012), most medium-size households used fuel wood as a major source of energy in rural Nigeria. In Kenya, medium households with six and above members were most likely to use ICS compared to smaller and very larger families in Homa Bay (Okuthe & Akotsi, 2014). This observation in hotels concurs with the household observation and therefore, there is a need to investigate the trend of adoption of ICS in households and hotels among household heads that own hotels.

5.3.2 Education level of hotel head cooks

In general, the level of education of the head cooks did not influence the adoption of ICS significantly (χ^2=0.4333, df=68, p<0.05). The level of ICS adoption was however, high among hotels head cooks with a college education level and higher. The trend showed that Kisumu led, followed by Uasin-Gishu and the least was Kakamega County.

Education was paramount in helping individuals make informed decisions (Suliman, 2010). Although the correlation between the hotel's head cooks and choice of cooking means is not studied, education must have influenced to a certain level the use of ICS in hotels. The influence was however not significant. High adoption in Kisumu might be associated with the high standard of the educational background of the region. In Mongolia and India, high education influenced the probability of business enterprises to use clean fuel wood (Pandey & Chaubal, 2011). The adoption of the ICS in households seemed to correlate with hotels. It, therefore, means that educated hotel owners would prefer clean fuel wood compared to owners with less education (Gebreegziabher *et al.,* 2012). The significance level of adoption is impacted given that hotel management might contend head cooks' decision and thus the insignificant adoption variation in hotels compared to households. Education affected the use of biogas in rural northern Pakistan and Mexico (Jan et al., 2012; Pine *et al.,* 2011).

According to a 2008 study in Nigeria using data from the Nigerian Demographic and Health Survey, the number of urban dwellers and educated household heads with access to electricity and contemporary cooking energy sources dramatically rose (Oyekale, 2012). In Kenya, Okuthe and Akotsi (2014) found that high education level among Homa Bay farmers influenced their decision to use ICSs in their households by 47.7%. This was also observed in Kisumu, Kakamega, and Uasin-Gishu counties in this study. Relating observations in households with hotels, hotel ownership was paramount in adopting ICS.

5.3.3 Awareness levels of hotel head cooks on ICS

The level of awareness about ICS among head cooks in hotels did not significantly influence the use of the stoves in the hotels (χ^2=0.1000, df=68, $p<0.05$). Results revealed that ICS awareness among head cooks in hotels in the three counties was high. However, this did not translate to significantly high ICS adoption in hotels in the three counties. This was contrary to the observation in households where high awareness of ICS among household heads led to high adoption in this study. Despite this, the observation in hotels concurred with the observation in institutions in this study. Other researchers observed that knowledge of the existing technology and information on how to use it and its benefits increased the choices to use it in many ways. For instance, Tebugulwa (2015) observed that in Bunga, Central Uganda, when individuals gained access to information about ICS use and benefit the probability of choosing it increased. Many studies have observed that awareness contributed to the general education about a technology and thus increased the adoption levels. Although that was the case in households, the hotels' adoption level did not correlate with the awareness level of the head cooks. A study to investigate the barriers to adoption due to head cooks awareness and actual adoption in hotels needs to be investigated. However, low adoption level despite high head cooks awareness level might be attributed to the decision-making process in hotels. The owners govern the hotels' operations and therefore, head cooks execute the orders from the owners. This would constitute decision-making competitions and thus management disputes in most hotels if ICS were opted for regardless of the owners' choice (Ngugi *et al.*, 2017).

5.3.4 Stove qualities versus ICS adoption in hotels

According to chi-square results, important stove feature did not significantly influence its use in the hotels (χ^2=4.9667, df=68, p<0.05). However, most hotels that used ICS preferred them due to charcoal saving properties, followed by other qualities like aesthetics, heating, and less smoking. Durability and fast cooking come least. This implies that ICS was not good for hotel business based on durability and fast cooking, characteristics that make hotel business boom. Kisumu County led in overall ICS use in hotels meaning that generally, the ICS qualities were appealing in Kisumu County compared to other counties studied. However, the overall variations due to stove qualities were not statistically significant at p<0.05. A similar observation was observed in households and institutions which preferred the stove for its ability to save on charcoal. On the contrary, saving on charcoal was statistically significant in the household than in institutions and hotels. Management issues could be tagged to the low use of ICS in hotels despite their head cooks knowledge of the stove's ability to save on charcoal. Altin *et al.* (2017) stated that business owners are likely to make the final decisions in the choice of cooking methods as long as they perceive that it is profitable contrary to the opinion of their head cooks.

According to Gizachew & Tolera (2018), the use of ICS saved 29% firewood. Comparatively, they stated that this was equivalent to a reduction of 0.494 tons of CO_2 per ICS computed annually. Although diverse needs of the society affected specific designs needed by users (Rehfuess *et al*., 2014), hotels did not prefer portability as an issue but smokelesness and fast cooking. In Bangladesh, Mongolia, and rural India the ability of the stove to save on fuel ranked high (Gordon *et al.,* 2007; Chowdhury *et al.,* 2011; Anderson, 2014). In Mongolia, fuel-saving was highly beneficial because fuel wood was mostly purchased (Gordon *et al.,* 2007). Fast cooking and saving on fuel wood collection time property was highly valued in Mexico (Troncoso *et al.,* 2007).

According to Gordon *et al.* (2007), ICS reduced the workload of women in cooking activities. The fixed stove's characteristic of having numerous cooking potholes increased adoption in Bangladesh, Nepal, Mexico, and India (Troncoso *et al.,* 2007; Gordon *et al.,* 2007; Chowdhury *et al.*, 2011; Anderson, 2014). In Mexico and India, stove durability and design influenced adoption. In Uganda, most users valued it based on saving charcoal. Person *et al.* (2012) found that fuel-saving property was a significant motivator in the ICS adoption decision in Kenya. Cooking in hotels in Kenya is often indoor. The heating property of the stove could also influence its use. This could be the reason other properties ranked high compared to the durability and fast cooking. Preservation of the heat to continue cooking was observed to favor its adoption in the study by Tebugulwa (2015) in Bunga, Central Uganda.

5.3.5 Quantity of fuel wood used per day in hotels

The amount of fuel wood used per day in hotels did not significantly influence ICS use in hotels in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya (χ^2=0.6667, df=68, p<0.05). It seemed to be by chance, that hotels that used between 60-100 kg/day preferred the ICS since the variation was not statistically significant at $p<0.05$. Larger quantities reduced the levels of use of ICS as well as very small fuel wood quantities. A similar trend was also observed in both households and institutions in this study.

Although a study to detail the relationship between the management and employees and correlation in making decisions like choices of cooking methods do not exist, it is apparent that there might be a gap (Wasike & Ndivo, 2015). The head cooks evaluate the fuel wood use and quantify it but may not decide to save it using energy-saving means like ICS. This was also observed among institutions management in Kenya (Dadzie, 2018). In households, the head cooks were more involved in decision-making based on their perceived saving on money used to purchase fuel wood. However, in households where the head did not involve in the kitchen decision-making adoption of ICS was low despite the benefits. Alternative cooking means influenced clear computation of the fuel wood used in hotels because most hotels oscillated between firewood, electricity, and charcoal use. This affected the levels of ICS adoption observed by Zhang and Kotani (2012) in rural Beijing.

In summary, all the socio-economic factors and stove qualities studied did not significantly influence ICS adoption. This implied that head cooks were not directly involved in the decision-making process on the choice of cooking modes they use in hotels. Although there were observed variations in the use of traditional stoves and other means compared to ICS, the overall adoption of ICS was based on the management rather than head cooks. Hotel management will tend to use cooking options that are fast and less costly but will not easily yield to external influence from their head cooks because they may fill less in-charge (Ngugi *et al.,* 2017). This is the case in institutions but contrary to households in Kenya.

5.4 Conclusions

The study made the following conclusions. One, the number of the members in the households, household income, education levels of the household heads, household heads awareness level, and quantity of fuel wood used per day positively and significantly influenced the levels of adoption of ICS in Kakamega, Kisumu, and Uasin-Gishu counties in Kenya. In institutions, only the size of the population served per day positively and significantly affected ICS adoption and use. At $p<0.05$, neither socioeconomic considerations nor the characteristics of the stoves substantially or favorably influenced the adoption of ICS in the Kenyan counties of Kakamega, Kisumu, and Uasin Gishu. Although the respondents to this study had a typically high level of ICS awareness, they nevertheless had a low level of grasp of its advantages. Despite this, a larger percentage of medium-sized households with 6-9 members used ICS. The same applied to mediumsize institutions. The ICS knowledge of head cooks did not influence the adoption of ICS in hotels.

5.5Recommendations

The study recommended that ICS awareness creation through training and workshops among other was important to influence ICS adoption in households, institutions, and hotels. More campaigns on the health benefit of ICS are recommended to increase their value due to lack of awareness and to reduce the perception that cleaner cooking devices are expensive. Making affordability of ICS and flexibility of pay using many methods should be considered in low to middle-income level estates that have income that fluctuates with seasons to enable potential users adopt ICS. Stronger marketing efforts that will drive high sales of ICS may be more fruitful than promotions on ICS throughout the year. This will ensure more users have access to ICS. Flexible financing options for the stoves with a flexible repayment structure should be implemented for fixed stoves that are available to the entire supply chain to help encourage ICS use by energy-based entrepreneurs. Investigation and thorough understanding are required in order to maximize the market potential for clean cooking fuels and technologies and to increase the number of actors in the energy conservation and utilization field that contribute to ICS distribution. To encourage energy entrepreneurs throughout think about stove distribution and marketing as a business enterprise, financial assistance requirements should be made available to the whole supply chain. Even though markets are inherently divided into income-based segments, there is a need to lessen distortions in both traditional and contemporary fuels. Another suggestion is that the energy requirements of homes, institutions, and hotels should be taken into account when designing stoves, as well as any other cultural or practical considerations. Good designs that would increase the proper function and efficiency of stoves should be considered. To ensure the longevity and effectiveness of the stoves, follow-up activities and ICS maintenance services should be implemented together with ICS stove advertising. Reliable and credible sources for ICS should also be introduced. The relationship between ICS use in households and institutions should be investigated further, with a particular focus on how understanding of ICS benefits and how it affects ICS usage among hotel and institution owners and senior management.

The results indicate that rules and procedures must be created to make Kenya a global source of clean cooking fuel. Integrated approaches and stakeholder collaboration may be part of such policies. They may also increase awareness-raising efforts regarding the use and advantages of ICS, expand access to financial aid and economic incentives to encourage the purchase of clean fuel and stoves, and support research and development for technical empowerment.

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APPENDICES

Appendix I: Household Questionnaire

BARRIERS TO IMPROVED COOK STOVES ADOPTION IN UASIN GISHU, KISUMU, AND KAKAMEGA HOUSEHOLDS

1.1 Tick appropriately in the box

RESPONDENT'S GENERAL DETAILS **County of residence…**Kisumu☐…Uasin Gishu☐…Kakamega☐**…**

Indicate whether the house is rented or owned rented owned ☐

1. Level of education attained by the most educated member of the household.

   University and over☐ Diploma ☐ Secondary ☐ Primary ☐

2. What type of fuel wood does the household use to cook?

   Wood fuel☐ Charcoal ☐ Farm residue ☐ other biomass (name)………….

3. Where does the household obtain its wood fuel?

   Collect for free ☐ Purchase from sellers ☐ ☐ Grown in own farm Obtained from others

4. Does the household own a ceramic stove? Yes ☐ No ☐

   The number of persons that eat and sleep in the home?

   One ☐ Two ☐ Three ☐ Greater than three ☐

5. What is the amount of fuel wood used in the home to cook one meal?

   Less than 1-5Kg☐ 5-9Kg ☐>10Kg☐

6. How many meals do you cook per day in the home?

   One ☐ Two ☐ Three ☐ greater than 3 ☐

7. What is the average monthly income that is for the food budget?

   Below 10000 between 10000-50000 ☐50000-100000 ☐> 100000 ☐

8. Indicate the number of dependents on this income

No dependents One dependent less than 3 Greater than 3

9. Do you consider the price of a new ICS to be affordable? Yes No

Have you experienced any significant difference in the fuel savings with the improved cookstoves? Yes No

10. Is the improved ceramic cook stoves acceptable to you based on the following conditions?

The stoves designed is according to the cooking needs Yes No

The stoves meet your general needs for heating Yes No

The sitting posture and stability when in use Yes No

Aesthetics (looks good in the kitchen). Yes No

11. How would you assess the ICS models in your kitchen terms of:

Quality of steel used to construct it. Good Bad Fair

Durability of the ceramic lining. High Low Fair

Size of the fire chamber. Adequate Not adequate

12. Size of the grate compared to cooking vessels in the home. Adequate Notadequate

13. How long does the new improved cook stoves last in the home?

Less than 3 months Less than 6 months Less than 1 year Not sure

14. Which one of the following would you say was most important to you when choosing a stove to purchase?

beautiful finishing

perceived fuel savings quality of workmanship

Size of stove compared to cooking vessels

Appendix II: Institution Questionnaire

BARRIERS TO IMPROVED COOK STOVES ADOPTION IN UASIN GISHU, KISUMU, AND KAKAMEGA INSTITUTIONS

1.2: TICK APPROPRIATELY IN THE BOX

RESPONDENT'S GENERAL DETAILS **County of the Institution…**Kisumu ☐…Uasin Gishu☐…Kakamega☐**…**

1. Indicate the type of institution.

   a) Higher learning institution☐ b) Hospital☐

   c) Prison☐ d) Hotel☐

2. What is the level of education attained by the most educated member of the cooking staff?

   a) University ☐ b) College ☐

   c) Secondary school and below ☐ d) Informal training ☐

3. Where does the institution obtain its fuel?

   a) Collected for free ☐b) Grown in the institution's farm ☐

   c) Purchased from sellersd) Obtained from others related to the institution ☐

4. What type of biomass does the institution use to cook?

   a) Wood fuel ☐ b) Charcoal ☐c) Farm residue ☐ d) Animal dung & biogas ☐

5. What quantity of fuel wood does the institution use to cook meals daily?

   a) More than a 50 kg☐ sack b) Less than a 50 kg sack ☐

   c) Less Half of a 50 kg sack ☐ d) Less than a Quarter of a 50 kg sack ☐

6. What is the average number of people served by the cafeteria?

   a) < 100-300 ☐ b) 301-600 ☐

   c) 601-900 ☐ d) >900 ☐

7. Is the improved ceramic cook stove acceptable to you based on the following conditions?

   The stoves designed is according to the cooking needs ☐

   The stoves meet your general needs for heating ☐

   The sitting posture and stability when in use ☐

   The stove meets your needs in terms of aesthetics (looks good in the kitchen). ☐

8. How would you assess the ICS models in your kitchen terms of:

   Quality of steel used to construct it. Good ☐ Low ☐ Bad ☐ Fair ☐

   Durability of the ceramic lining. High Fair ☐

   Size of the fire chamber. Adequate ☐ Not adequate

   Size of the great compared to cooking vessels in the home.

   Adequate ☐ Not adequate ☐

9. How long does the new improved cook stoves last in the home?

   Less than 3 months ☐ Less than ☐ 6 months

   Less than 1 year ☐ Not sure ☐

10. Which one of the following would you say was most important to you when choosing a stove to purchase?

    Beautiful finishing ☐ perceived fuel savings ☐ quality of

    workmanship ☐ Size of stove compared to cooking vessels ☐ **Appendix**

III: Hotels Questionnaire

BARRIERS TO IMPROVED COOK STOVE ADOPTION IN UASIN GISHU, KISUMU, AND KAKAMEGA INSTITUTIONS

1.3: TICK APPROPRIATELY IN THE BOX

RESPONDENT'S GENERAL DETAILS **County of the Institution…**Kisumu ☐… Uasin Gishu☐…Kakamega☐**…**

1. Indicate the type of hotel.
2. What is the level of education attained by the most educated member of the cooking staff?

a) University ☐ b) College ☐ c) Secondary school and below ☐

c) Informal training☐

3. Where does the institution obtain its fuel?

a) Collected for free ☐ b) Grown in the institution's farm ☐

c) Purchased from sellers d) Obtained from others related to the institution ☐

4. What type of biomass does the institution use to cook?

a) Wood fuel ☐ b) Charcoal ☐c) Farm residue ☐ d) Animal dung $ biogas ☐

5. What quantity of fuel wood does the institution use to cook meals daily?

a) More than a 50 kg sack☐ b) Less than a 50 kg sack ☐

c) Less Half of a 50 kg sack ☐ d) Less than a Quarter of a 50 kg sack ☐

6. What is the average number of people served by the cafeteria?

a) < 10-50 ☐ b) 51-100 ☐ c) 101-150☐ d) >151☐

7. Is the improved ceramic cook stoves acceptable to you based on the following conditions?

The stoves designed is according to the cooking needs ☐

The stoves meet your general needs for heating ☐

The sitting posture and stability when in use ☐

The stove meets your needs in terms of aesthetics (looks good in the kitchen).☐

8. How would you assess the ICS models in your kitchen in terms of:

Quality of steel used to construct it. ☐ ☐Good ☐

☐ ☐ ☐

Bad Fair

Durability of the ceramic lining. High Low ☐ Fair

Size of the fire chamber. Adequate ☐ Not adequate

Size of the great compared to cooking vessels in the home.

Adequate ☐ Not adequate ☐

9. How long does the new improved cook stoves last in the home?

Less than 3 months☐ Less than 6 months ☐ Less than 1 year ☐

Not sure ☐

10. Which one of the following would you say was most important to you when choosing a stove to purchase?

Beautiful finishing ☐ perceived fuel savings ☐ quality of

workmanship☐ Size of stove compared to cooking vessels ☐

Thank you

Appendix IV: Chi-Square Analysis Results for Households

Appendix table 1: Chi-square results for ICS adoption in households.

Parameters	*Df*	$\chi^2 =\sum(O-E)2/E$	F-statistic ($p<0.5$)
Household size	2	37.2952	5.991*
Education level	2	18.3667	5.991*
Income Level	2	14.3024	5.991*
Awareness of ICS	2	18.2476	5.991*
Cook stoves properties	2	32.8286	5.991*
Quantity of fuel wood/day	2	9.0167	5.991*

Key: *= Statistically Significant difference

Appendix table 2: Chi-square analysis for ICS adoption in institutions.

Parameters	***Df***	$\chi^2 =\sum(O-E)^2/E$	**F-statistic (*p<0.5*)**
Number of People Served	2	10.0535	5.991*
Education Level of Head Cook	2	0.6622	5.991^{ns}
Awareness of ICS	2	0.5057	5.991^{ns}
Stove Characteristics	2	2.2622	5.991^{ns}
Quantity of fuel wood/day	2	3.4796	5.991^{ns}

Key: *=significant ^{ns} =not significant

Appendix table 3: Chi-square results of ICS adoption in hotels.

Parameters	***Df***	**$\chi 2 = \sum(O\text{-}E)^2/E$**	**F-statistic (p<0.5)**
Number of people served	2	2.3333	5.991^{ns}
Education level of head cook	2	0.4333	5.991^{ns}
Awareness of ICS	2	0.1000	5.991^{ns}
Stove characteristics	2	4.9667	5.991^{ns}
Quantity of Fuel wood/day	2	0.6667	5.991^{ns}

*=significant ^{ns} =not significant

Appendix V: Income Quintiles

Appendix table 4: Income Quintiles adopted

Income Bracket	**Category**
Income Quintile 1	Households living below the urban poverty line Ksh. 2913 per month
Income Quintile 2	Households living above the urban poverty line Ksh. 2913 per month
Income Quintile 3	Income levels between Ksh. 9320 and Ksh. 13015
Income Quintile 4	Income levels between Ksh. 13016 and Ksh. 20408
Income Quintile 5	Income levels above Ksh. 20409

Source: KNBS, 2007

Appendix VI: State of Income in Estates Sampled

Appendix table 5: Indicators of social status during the project

i.Low-income Estates	Shared resources like water wells and water meters, toilets/latrines, bathrooms, and electric meters. Small houses and even respondents, who live in temporary, carton, iron sheet, and semi-permanent housing. Poor garbage and sewage disposal in the area with littered streets and small compounds. Presence of pubs and recreation areas close to or even sharing walls and compounds. Poor and temporary access roads in the area. Small compounds, poor access roots with shared walls.
ii.Middle-income estates	Self-contained houses of low to average rent with some residence even of high income. Permanent housing that may be small to average with compounds even fences some residents own vehicles. Littered streets with good garbage and sewage disposal. Presence of pubs and recreational areas located an appropriate distance from residential areas. Presence of some poorly and even well-maintained marram roads within the estate. Average-sized compounds, with fair access roots and stand-alone houses.
iii.High-income estates	Most residents own one or more vehicles. Spacious compounds that are well maintained with some form of landscaping. Estate has its supermarkets, hospitals, and even recreational centers situated away from people's compounds. Excellent road network with municipality garbage trucks that make rounds to collect garbage and litter along the street.

Appendix VIII: Originality Report

Turnitin Originality Report

SOCIO-ECONOMIC FACTORS INFLUENCING THE ADOPTION OF IMPROVED COOK STOVES IN KISUMU, KAKAMEGA AND UASIN GISHU COUNTIES IN KENYA by Stephen Apondo

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