DETERMINANTS OF ADOPTION OF RENEWABLE ENERGY IN KENYA

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DECLARATION

This thesis is my original work and has not been presented to any university for any award or anywhere else for academic purposes.

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This thesis has been submitted for examination purposes with my approval as University Supervisor.

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DEDICATION

I dedicate this research project to my mother, Mary and my late dad, Reuben Gitone for their relentless efforts to have me get quality education despite many challenges.

ABSTRACT

Kenya being on the equator experiences enough solar energy of between 4-6 KWh/M2 which provides excellent opportunity for solar energy development. Nonetheless, the cost of acquiring it is becoming an inhibiting factor as demonstrated by the slow adoption of the technology despite the huge potential the country possesses. Moreover adoption of biogas as a source of energy is also very low. Therefore, this study sought to investigate the determinants of adoption of solar and biogas using cross sectional data collected from 70 districts across the country. The study used bivariate probit model so as to account for interdependence in adoption decisions. However, the results indicated that decisions to adopt solar and biogas are independent. Thus the study used separate probit equations to investigate the impact of household head characteristics, household characteristics and economic factors on adoption of both solar and biogas. The result revealed that household heads with secondary and post secondary education and household size significantly influence adoption of solar energy while gender of the household head and household size significantly influences adoption of biogas. The study recommended that government and other stakeholders should create awareness and sensitize the learned people regarding the benefits of adopting solar energy so as to increase adoption of solar energy among the educated people. Further, government should create incentives to encourage men to adopt biogas by sensitizing them on the importance of biogas a source of renewable energy.

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LIST OF ABBREVIATIONS

CO_2	:	Carbon Dioxide
KIHBS	:	Kenya Integrated Household Budget Survey
Kw	:	Kilo Watts
MW	:	Mega Watts
PV	:	Photovoltaic
RETs	:	Renewable Energy Technologies
SHSs	:	Solar Home Systems
UNEP	:	United Nations Environmental Programme
US	:	United States

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Energy is not regarded as a basic necessity, but it is a basic ingredient in the successful satisfaction of almost all basic human needs (Yuko, 2004). The level and intensity of energy use is an important indicator of a countryợs economic growth. The main sources of energy are divided into two main categories: conventional and renewable energy sources. Conventional sources such as energy from non renewable resources have numerous challenges that include pollution and global warming; this has made countries change policies to encourage adoption of greener technologies in renewable energy sources.

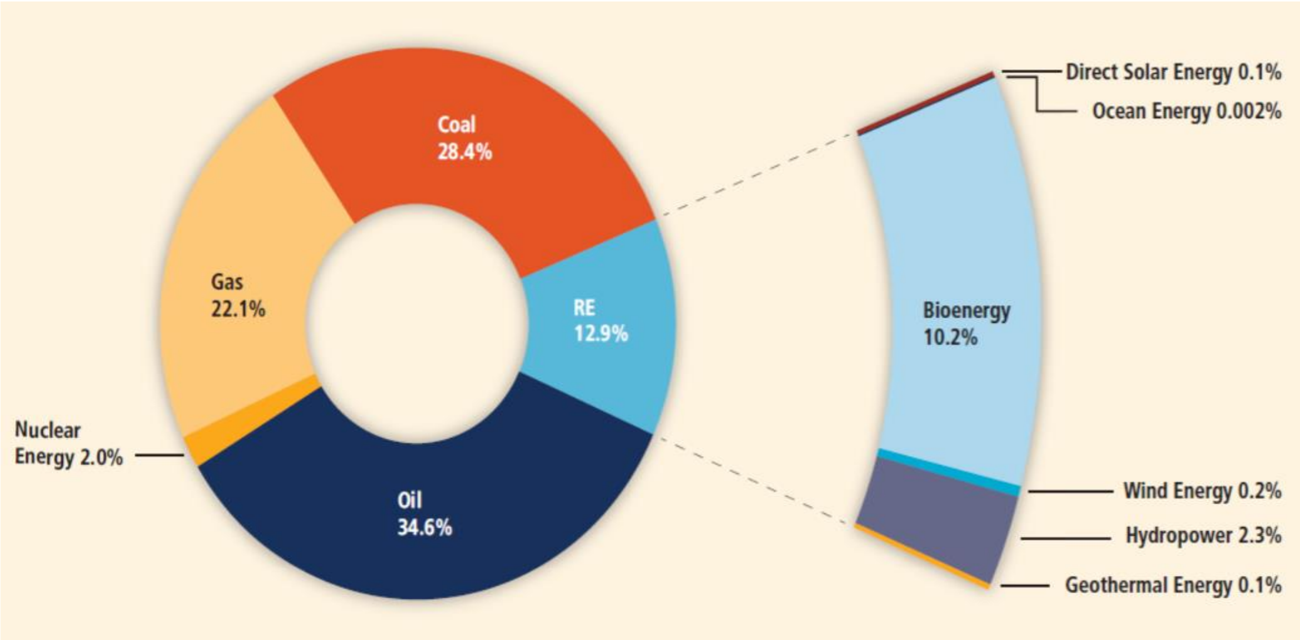
Renewable energy can in general terms be defined as energy that can be derived from resources which are naturally replenished on a human continuance, for instance sunlight, biogas, wind, hydropower, tides, waves and geothermal heat. Renewable energy sources can substitute conventional energy sources in four distinguishable areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services (Wikipedia, 2014).

Fossil fuel which includes coal, oil and natural gas led world economic growth, but this fuels release of carbon dioxide (CO2) into the earth atmosphere, is regarded as the main driver of global warming and climate change (Stern, 2006). The increased concern over effects related to energy use and global warming hints that there will be more reliance on renewable energy sources in future which includes wind, solar, geothermal, hydro, biogas, wave and tidal. Additionally, with increasing energy prices, more attention is being shifted to further exploration of renewable energy sources as an alternative to fossil fuels. As a result, academics and industries from various parts of the world have begun to envision renewable energy driven future in the pursuit of a sustainable energy system (IPCC, 2007).

1.1.1 Renewable Energy in the Globe

Approximately 80 % of all energy consumed in the world is utilized by the first twenty large economies commonly referred as G20 in 2010 (Schmidt and Haifly, 2012). According to this statistics this group of countries is important in shaping renewable trend since this is where most energy demands are happening. Overall about 16% of world energy consumption comes from renewables; with 10% from traditional biogas, used majorly for heating and about 3.4% from hydroelectricity. New renewable energy sources including small hydro, modern biogas, solar, wind, geothermal, and bio-fuels contribute about 2.8% (UNEP, 2011). Figure 1.1 shows the world energy sources as of the year 2011.

Figure 1: Total Global Primary Energy Supply



Source: Adapted from IPCC (2012)

The world has witnessed a rapid growth in new renewables due to increased uptake of the relevant technologies. Investments in renewable energy have increased by 32% in 2010, to a record US$211 billion. The increase in investments was as a result of wind farm development in China and small scale solar photovoltaic (PV) installations in Europe (UNEP, 2011). Africa attained the biggest gain in investment in renewable energy sources among developing countries excluding South Africa. Africa total investment rose from US$750 million to US$3.6 billion, majorly due to strong performance in Egypt and Kenya.

World annual percentage increase for 2008 depicts significant achievements with all forms of grid connected solar PV capacity growing by 70%, wind power grew by 29%, solar hot water gained by 15%, and small hydro increased by 8% (El-Ashry, 2009). Additionally, Renewable energy Global Status Report (2009) gives a ranking of the top five renewable energy investor economies together with rankings of top five states depending on their investment and capacity of renewable energy until 2008. It shows that countries with emerging economies such as Brazil, China, Indonesia, India, Philippines and Turkey are investing significantly in different sources of renewable energy.

1.1.2 Renewable Energy in Africa

African continent is gifted with huge renewable and non-renewable energy sources. Some estimates show that the continent has 1,750TWh potential of hydroelectric power and 14,000 MW of geothermal energy potential. It receives enough solar radiation throughout the year, and several studies have confirmed the availability of immerse wind energy resources in several areas of the continent. Nevertheless, these energy endowments are largely underutilized (Daly, 2012). For example, only about 5% of the continentés hydroelectric power potential has been exploited, whereas the same figure for geothermal is 0.6%. Energy poverty in Africa remains a serious impediment to human and economic development in many parts of the continent.

Africa as a region continues to face critical challenges in its energy sector characterized by inadequate access to modern energy services, low purchasing power, poor infrastructure, low investments and over reliance on traditional biogas to satisfy their basic energy requirements. Comparing Africa with other parts of the globe, the lack of access to energy is most pronounced in the continent. In most Sub-Saharan countries access to the electricity grid is less than 1% (Daly, 2012).

Recent trends show that by 2020 still over 60% of Sub-Saharan Africans will not have access to electricity. In spite of the environmental, social and health challenges associated with its use, traditional biogas still remains the major source of energy for the majority of the poor. Biogas accounts for about 70-90% of primary energy supply in some economies and about 86% of energy consumption. Moreover, adoption of renewable energy is limited due to high initial transition costs (Love, 2012). There are however distinct variations within the continent, with biogas energy accounting for only 5% of energy consumption in Northern Africa and 15% in South Africa.

1.1.3 Renewable Energy in Kenya

Kenya as a country is aspiring to become energy secure, with only about 6% of the rural population with access to grid electricity. Decentralized renewable energy systems have enormous potential in meeting immediate energy requirements for isolated institutions, businesses and households in remote areas (Wanjiru and Ochieng, 2013). Prohibitively high connection costs and low incomes among majority of people in developing countries such as Kenyans accelerate low access to energy in spite of the government efforts under the rural electrification programme (Love, 2012). For instance, the cost of rural electrification is estimated to be between US$ 30 to US$ 40 per kWh, compared to an amortized life-cycle cost of solar and battery operated systems of US$ 1 to US$ 2 per kWh (Kiplagat, Wang and Li, 2011).

Even though Kenya has vast renewable energy resources including solar, wind, bio-fuel, biogas, geothermal and hydropower, their application has been limited. The expansion of the renewable energy is being catalyzed by the increasing demand and price of electricity, growing world oil and gas costs and environmental pressure. Biogas energy makes over 70% of total energy consumption in Kenya. Petroleum and electricity, account for approximately 22% and 9% respectively (Mwakubo et al., 2007). The Kenyan energy sector is characterized by the heavy dependence on biogas, low access to modern energy, frequent power outages, over dependence on hydroelectricity and high reliance on imported oil. Renewable energy sources adoption is, hence, significant means to meet the challenges of increasing demand and dealing with the related environmental pressure.

According to Kimuyu, Mutua and Wainaina (2012), installed electric power capacity in Kenya was 1,412.2MW as of December, 2010. This installed capacity could not to meet demand; therefore the government contracted 60MW of emergency power to bridge the deficit. This was necessary so as to meet the increasing demand and cut down on load-shedding, especially during peak periods. Hydroelectric power is the leading source, accounting for 51.55% of total installed capacity. Thermal (petrol), geothermal, co-generation and wind contribute 33.2%, 13.38%, 1.84% and 0.36% respectively. Therefore, renewable energy accounts for approximately 67.1%, thus Kenya power generation is now majorly ógreenô.

1.1.4 Overview of Renewable Energy Sources

Solar energy

Solar energy technologies harness the energy of direct solar irradiance to create electricity using photovoltaics cells and concentrating solar power to create thermal energy to meet direct lighting requirements as well as to produce fuels that might be used for transport and other purposes which might include heating and cooling (Hemmen, 2011). Kenya has a high solar energy potential since it receives daily insolation of between 4-6kWh/m2. Solar use in Kenya is majorly for photovoltaic systems, drying and water heating. The Solar photovoltaic systems are used mainly in telecommunication, lighting and water pumping. Currently the country has installed capacity of approximately 4 MW. In addition, the country currently has approximately 140,000 solar water heating systems installed.

Wind energy

Wind energy utilizes the kinetic energy of moving air. Electricity is produced from large wind turbines located either onshore or offshore. Electricity from wind is both variable and, to some extent, unpredictable, but experience and elaborate studies from many regions shows that integration of wind energy do not pose insurmountable technical barriers (Belward et al., 2011).

Kenya has estimated average wind speeds of between 3-10 m/s and this is a huge potential for production of wind energy. Areas with highest potential are northern and eastern parts of the country.

Biogas energy

Biogas energy can be derived from diverse biogas feedstock, including forest, agricultural and livestock residues; the organic constituent of municipal solid waste among other organic waste sources. Although with different processes, these feed stocks can be used directly to give out electricity or heat, or can be utilized to make gaseous, liquid, or solid fuels. The variety of biogas energy technologies is wide and the technical maturity varies considerably (Belward et al., 2011).

Kenya Biogas density is moderate but there is a lot of potential to produce biogas energy for modern production. The Kenyan government has identified significant potential for power generation using forestry and agro-industry residues including and not limited to bagasse.

Geothermal energy

Geothermal energy harnesses the thermal energy from the Earthọs interior. Heat is usually extracted from geothermal reservoirs underground using wells. These reservoirs are either naturally sufficiently hot as well as permeable or are sufficiently hot but improved with hydraulic stimulation. The hot fluids produced with various temperatures can be utilized to generate electricity or be used more directly for applications that utilize thermal energy, including heating, geothermal heat pumps or cooling applications (International Energy Agency, 2009).

In Kenya geothermal resources are located within the Rift Valley with an approximate power generation potential of between 7,000 MW to 10,000 MW spread over 14 prospective places. Geothermal is a very reliable way to produce energy, since it is not affected by climatic variability and it does not require transported fuels. Therefore, it is the most suitable source for base load electricity generation in the Kenya (IPCC, 2012).

Hydroelectric power

Hydropower utilizes the energy of water moving from higher elevation to lower elevations, mainly to generate electricity. Most hydropower projects involve construction of dams with reservoirs, run-of-river and in-stream projects. Hydropower technologies are now mature. The hydropower reservoirs are often used for multiple uses, for instance, they are used to provide drinking water, irrigation, flood and drought control, navigation, in addition to energy supply (International Energy Agency, 2009).

1.2 Statement of the Problem

Though the renewable energy sector is not relatively new, its growth in the country is at a low pace as compared to the other developing countries (SREP, 2011). Deficiency of market analysis has in many cases hampered the uptake of product development (Wanjiru and Ochieng, 2013) as shown by poor market understanding regarding stakeholder mapping, technology mapping and promotional schemes. High costs of products often lead to market stagnation further discouraging the technology uptake (Love, 2012).

Currently in Kenya, most renewable energy systems technology is available although market penetration is notably low and existence of these technologies is rarely known by potential users (Mwakubo et al., 2007). In addition, very few studies have sought to investigate determinants of renewable energy adoption in Kenya. For instance, Lay et al. (2012) found that income and education influence adoption of solar home systems (SHSs) but the authors did not thoroughly investigate the effect of household characteristics and other economic factors on adoption of SHSs. Though this paper provides useful insights there is need to conduct a thorough investigation into how individual, household and economic factors influence adoption of renewable energy so as to provide relevant information that can be used to formulate policies that promote adoption of renewable energy.

1.3 General Objective of the Study

The general objective of this study is to examine factors that determine adoption of renewable energy among Kenyan households.

1.3.1 Specific Objectives of the Study

i. To investigate the effect of characteristics of the household head on adoption of solar and biogas energy.

ii. To examine the effect of household characteristics on adoption of solar and biogas energy.

iii. To analyze the effect of economic factors on adoption of solar and biogas energy.

1.4 Hypotheses

The following are the null hypotheses:

i. Characteristics of the household head have no effect on adoption of solar and biogas energy.

ii. Household characteristics have no effect on adoption of solar and biogas energy.

iii. Economic factors have no effect on adoption of solar and biogas energy.

1.5 Research Questions

i. What is the effect of household head characteristics on adoption of solar and biogas energy?

ii. What is the effect of household characteristics on adoption of solar and biogas energy?

iii. What is the effect of economic factors on adoption of solar and biogas energy?

1.6 Contribution of the Study

This study has several contributions as indicated below:

1.6.1 Renewable Energy Sector market players

Companies and dealers of renewable energy products need to align their business activities and products with the consumersô preferences to be more appealing to the society they serve. However, to increase the uptake of solar energy in Kenya, it is imperative to understand the factors that affect its adoption and development. Thus, this study will provide insights into the determinants of solar energy adoption and development in Kenya. The study findings will be used to further increase engagement of potential consumers into adoption of renewable energy for economic empowerment.

1.6.2 Scholars

Scholars interested in studying the use of renewable energy can use the study findings as entry point in understanding the determinants of adoption of renewable energy. The study will provide the most up-to-date data on determinants of adoption of solar energy in Kenya. This study will therefore, significantly enrich and broaden existing literature on renewable energy.

1.6.3 Policy Makers

The findings of this study will provide relevant and valuable information on how best to streamline renewable energy sector. The study will provide information that can be used to come up with policies that enhance renewable energy development and access thereby contributing to achievement of Kenyaôs Vision 2030.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter investigates the background information needed to give a general understanding of determinants of adoption of renewable energy with emphasizes on adoption of solar and biogas energy. The chapter looks at the theoretical literature review focusing on behavioral economics theories that best explain determinants of renewable energy adoption. In addition, the review discusses empirical literature focusing on the determinants of adoption of renewable energy. Finally, the chapter is concluded in section 2.4, summarizing findings from this chapter and how they will link up to the remainder of the study.

2.2 Theoretical Literature Review

Behavioral economics is a comparatively new field of study but has accrued information at a speedy pace, borrowing to a greater extent from psychology and neuroscience. In economics, consumer behavior assumptions are necessary so as to model the actions and purchasing habits of large populations. The assumptions evolve over a period of time.

Various classical models of the 19th century involved imperfect decision devising, but they had limited efforts at quantifying it. Neoclassical economic movement followed, focusing on objective and testable questions. As a result of the nature of decision making, which can be messy and unpredictable, economists inclined to the assumption that on average consumers will arrive at rational decisions. These rational decisions of the neoclassical movement were grounded on utility maximization, where the alternative chosen gives the most net gains (Simon, 1986). Users may on an individual basis make a mistake because of uncertainty or imperfect information, but since these basics are defined through chance, substituting choices will take place with the same frequency and the mean result will be the right, or most beneficial, result (Muth, 1961).

Presumption of rational decision models is that systematic bias does not occur, where wrong decisions will be made repeatedly in a certain direction. Instances of rational assumptions of this period included rational choice theory on a scale of microeconomics and rational expectations theory for macroeconomics (Muth, 1961). However, in the 1960s, economists began to comment on how primitive the behavioral assumptions of neoclassical models were (Akerlof, 2001).

In the late 1960ǿs came the birth of behavioral economics. This field tries to reflect real decisions that consumers make by drawing on available data about making decisions that come from psychology as well as from neuroscience lately. The described work below highlights notable contributions from behavioral economics that can be applicable to solar adoption. Theory of bounded rationality, introduced by Herbert A. (Simon, 1982) is one of the first and most influential modifications of rational decision making. It suggested that economic models required broadening the scope of rationality and including psychological concepts. It introduced the keywords satisficing and approximate optimizing, which reflect the thought that consumers make selections when an acceptable alternative is available, instead of completing an entire analysis of all alternatives (Simon, 1972).

Distinctively, the theory of bounded rationality tries to let in limitations on awareness, cognitive abilities and time. These restrictions may surely be applicable to the adoption of solar panels since the type of the decision to adopt needs high degrees of all three of the named restraints. Cognitive powers within this study are assumed to be a constant for all economies. Nevertheless, degrees of awareness and free time are researched through proxy variables. Economies that have either naturally greater levels of awareness and free time, or else economies that develop plans to minimize these limitations on solar adoption, should be anticipated to have greater levels of adoption.

Leon Festingerœ theory of cognitive dissonance (Festinger, 1957) may also be used to explain the varying solar energy adoption. This psychological instrument is used to warrant making the ñincorrectò choice internally. It entails the diminution of mental discomfort (dissonance) about selecting the non-optimal alternative by falsifying facts and analysis to suit the decision made. Here is one of Festingerœ famous instances, where a smoker may cut down his psychological discomfort regarding smoking by convincing himself that the damaging health effects of smoking are pompous, or even that giving up on smoking would bring about weight gain that would be equally as damaging to health (Festinger, 1957).

This particular concept has seen increasing use in behavioral and ecological economics, especially concerning the acceptance of climate change (Hulme, 2009). It points to the fact that those who stand to lose the most by adopting environmental friendly practices to curb climate change are potentially to reject the scientific facts of climate change so as to reduce the dissonance of continuing environmentally damaging exercises. This concept may be applicable to solar energy adoption when a country has carbon dioxide intensive industries, or even greater amount of oil reserves. When such a scenario occurs, it may be psychologically easier to disregard environmentally friendly products like Photovoltaic modules.

Cognitive dissonance has its origin in the thought that people like to imagine of themselves as moral and thus, they must convince themselves that climate change is not human-centered so as to preserve their good self-image in spite of continuing practices that harm the environment. It may also be thought of in regards of social identity. Instead of changing their entire worldview as a result of addition of new knowledge, individuals are likely to selectively prefer situations and data that suit their general perspective on matters (Festinger, 1957). Thus, just as economies that have environmentally damaging practices may assure themselves that solar energy adoption is not worthy, an economy that affiliates themselves with environmental wholeness may be more likely to adopt solar energy use. Likewise, countries with high social equality may experience greater solar panel and biogas adoption because of the social implications.

Heuristics is another significant concept in behavioral economics. Its application to economics work was started by Daniel Kahneman and Amos Tversky (Kahneman and Tversky, 1974) and much further research has been carried out since then. Heuristics are particularly useful in circumstances where the choice is not apparent (Kahneman, 2003). Whenever uncertainty or complexity comes up, rational choice theory assumes that people would take the time to make fully informed decisions by exploring the alternatives exhaustively and imagining deeply about the potential results and their chance.

In real sense this would symbolize a huge cost in regards of cognitive effort. Alternatively, consumers frequently use shortcuts called heuristics. Thus these decision making proficiencies are founded on educational guesses and past experiences, and need a lot less cognitive effort to come up with a decision (Kahneman and Tversky, 1974). Considering solar energy adoption, the utilization of heuristics signifies that families are not likely to do an actual cost-benefit analysis of installing solar panels in their homesteads. To salvage cognitive energy and time, people may dismiss solar panels installation by linking them with high-priced environmental measures or excessive complex technology. As an alternative, a rule of thumb in decision making may be that products on sale are ever a good buy and as a consequence, homesteads may be willing to adopt solar energy in excess if incentives given by the government are available and publicized. The familiarity heuristic also may be relevant with solar energy adoption. As a rule, items or technologies look more familiar to the consumer are most likely to be adopted for use. The ground for this originates from another heuristic formulated by Kahneman and Tversky known as the availability heuristic, and it says that concepts that are more easily available to the mind incline to get amplified weightings in regards of sensed frequency and importance (Kahneman and Tversky, 1974). Thus, we may expect those who are more familiar with scientific technology to be more likely to weigh solar energy adoption.

Another heuristic known as social proof may as well influence solar energy adoption, which results from the introductory concept of conformity. It occurs when an uncertain consumer grounds his/her determinations on the arrived at by others around him by making an assumption that others have better know how of the various alternatives. Solar exposure can be as a result of great density of installations or else by high profile installations. For instance, Barack Obama the US President has vowed to install solar panels on the White House, which may result in considerable ripple effects (Executive Office of the President, 2010). This suit Rogersộs thought of community leaders having a huge influence on the acceptance of new technology (Rogers, 2003).

Status quo bias is another concept from heuristics that prevails in decisions with uncertainty (Samuelson and Zeckhauser, 1988). When individuals are uncertain of the yields of various alternatives and do not need to exert effort into researching them, they incline to go for the default. This frequently takes place whether or not it is the optimal outcome. An instance of status quo bias regards watching television. Most individuals will continue to watch a particular TV station after their program stops instead of switching the channel merely due to the cognitive effort related with surfing channels (Sunstein and Thaler, 2009). Status quo bias also associates back to the time restrictions of bounded rationality, as the consumers incline toward the alternative which needs less of a time commitment. The status quo heuristic, therefore, has effects for solar and biogas energy adoption as the switching from the default grid power to solar energy uses much more cognitive effort than just switching a TV channel.

If research substantiates this concept has a major influence for solar energy adoption, governments may suggest legislation and policies that makes solar energy installations the default for new homesteads. Thus, the public would be provided the alternative of energy sources, and the cognitive effort employed in procuring solar panels for their homestead would be tremendously decreased.

Held up results may as well play an important role in the adoption or rejection of solar energy technology. A good example of this type of irrational behavior is obesity. Whereas overweight people are aware that eating beyond normal limits is not to their self-interest, they frequently dismiss their future health in place of immediate satisfaction (Loewenstein, 1996). Considering the case of solar energy adoption, it may be applicable because the switch involves a very costly initial investment in regards to resources and time, followed by benefits considerably into the future.

2.3 Empirical Literature Review

2.3.1 Financial

Funding plays a great role in the formulation of Renewable Energy Technologies (RETs) policies. Researchers have shown that one of the primary obstacles to carrying out renewable energy projects is frequently not the technical feasibility of these projects instead it is the absence of low cost, long term funding. This situation is complicated more by competition for limited financing by the various projects and gets critical if the nation is running under unfavorable macro-economic circumstances. Therefore, the governments and private firms must find creative means of funding RETs projects. The main challenge of funding RETs projects is to come up with models that can give these technologies to consumers at affordable costs while securing that the industry stays sustainable. There is limited policy support for RETs as shown by minimum budget allotment to renewables at government level. As a result, the private sector is left to bear the weight of funding RETs.

Majority of advanced and electric RETs are not affordable to most of the population in Africa who are poor, with poverty degrees of between 50 to 70% (World Bank, 1996). This is true particularly for RETs that have huge cost of imported parts, than those that can be locally produced and assembled utilizing locally available parts. The RETs with huge cost of importing parts put an extra burden on foreign exchange reserves of African economies, which are frequently little and approaching exhaustion, and needs expensive funding strategies and huge subsidies (Karekezi and Kithyoma, 2002). The subsidies are unsustainable in the long term, except when the technologies given are planned to include income generation.

Banks have unfavorable demands for RETs funding. They usually make strict terms for RETs investors and this discourages potential consumers. The terms needed include a feasibility study carried out at the applicantøs costs, because of the limited know how on renewables by banking institutions. Additionally, the banking institutions require title deeds as collateral, portfolios of project sponsors and directors, information on past and current activities, a valuation report, estimate value of existing investment, raw material procurement strategy, and the marketing plans for the final product (Karekezi and Turyareeba, 1995).

In instances where funding mechanisms are offered for consumers, they are in many times not within the reach of the most of the population. For instance, the UNDP/GEF Photovoltaic (PV) project in Zimbabwe profited mainly the wealthy rural households, due to the fact that over 80% of rural consumers could not afford the smallest unit even at the cheapest prices. Rigorous requirements for funding applications kept out the majority of the rural consumers from qualifying (Mapako, 2000). Another research carried out in Manicaland, Zimbabwe on the viability of PV, 65% of the rural population could not be able to pay up the solar service fee, whereas 91.5% could not be able to pay for a credit scheme (Teferra, 2000)

2.3.2 Institutional

Experience in the country, points that the establishment and success of any renewable energy technology is dependent to a great extent, on the government existing policy. These policies are significant factor in conditions of their power to create an enabling environment for RETs public exposure and mobilizing resources, in addition to supporting private sector investment (Sampa, 1994).

Early policy initiatives on renewables in the country were as a result by the oil crisis of the 1970s. As a result to the crisis, governments launched either an autonomous Ministry of Energy or a department committed to the advancement of good energy policies, including the development of RETs. For instance, Zambia reacted by drafting policy proposals in its Third National Development Plan (1979-83) to develop alternative kinds of energy as partial substitutes for conventional energy sources. Regrettably, when the energy crisis lessened, government funding for energy development and RETs practices decreased significantly. Majority of African governments do not have a laid out policy on the development and support of RETs, which proceed to be undertaken without the necessary energy planning and policy. As a consequence, RETs development follows an unplanned route, with no clear association to national power master plans, which are seldom accessible or are outdated (Karekezi and Ranja, 1997).

A research done in Botswana showed that about 57% of the respondents did not know their government policies planned to support the use of RETs (Sampa, 1994). In Malawi, lack of policy meant that the majority of RETs diffusion efforts have not only been unplanned, but have been practiced mostly as informal sector operations beyond the government machinery framework, therefore unable to mobilize the fiscal support of the government and its great donors. A research on wind energy done in Kenya established that Dutch aid officials would have been interested in funding wind projects if there was an official policy on wind energy powerfully supported by the Kenyan government (IT Power, 1988).

Policy support for renewables is limited as shown by the low budgetary allotment to renewables in most economies. Majority of the countries laid more significance on the petroleum and power sectors, which supply a low percentage share of the population, than on renewables which provide energy or has potential to supply to a large percentage of the population.

Very small expenditure is allotted to small and medium scale RETs in comparison to the conventional energy sector. For instance, Ethiopiaûs investment trends in energy sector show huge investments in the electricity and petroleum sub-sectors. Investments in petroleum quadrupled between 1990 and 2000, whereas investments in electricity nearly tripled in the same period. In direct contrast, expenditure on traditional and alternative energy (which includes solar energy) has steadily reduced from around 1% of entire expenditure in 1990, to about 0.1% of full expenditure in the year 2000 (Teferra, 2000).

About 2.9% of entire anticipated expenditure for the energy sector in Kenya was allotted to renewable energy. Additionally, the public investment program shows that only about 1% of the priority project investment for the energy sector was allotted to small and medium Renewable Energy Technologies in 1999/2000 (Kiplagat et al., 2011).

According to AFREPREN (2002) the policy programs should be planned to show the economic and environmental gains of RETs to Africaôs poor and suggest short and medium term policy initiatives that would make large-scale diffusion of renewables. Emphasis should be devoted to bringing out the real and tangible economic gains, like job creation and income generation, which renewable energy projects can achieve to the area at both the micro and macro levels. For instance, RETs are usually more labor intensive compared to the conventional and centralized energy projects and therefore can help to deal with troubles of employment of the urban and rural poor.

Of interest to sub-Saharan policy-makers in Africa are revenue neutral policy and institutional measures. For instance, there is potential to make the scenario that the reduced revenue linked with the removal or reduction of duties and taxes on renewable energy technologies such as solar panels can be recovered from the long-time savings in imports of petroleum products that need rare convertible currencies in addition to the income and sales tax remittances from a large and functional solar industry (AFREPREN, 2000).

So as to improve access to credit, banking institutions should seek alternatives to strict demands e.g. the collateral requirements. Since banking policies are not likely to vary in the near future, a possible action is to recommend potential end users to create self-help groups or cooperatives to be able to acquire loans through cooperative banks, majority of which do not have strict collateral demands. Additionally, small credit or micro-finance institutions can provide financing for RETs investors and users at less costly and accessible terms. These institutions are important in making sure projects continue even when external support stops.

2.3.3 Technological

To introduce unknown technologies like RETs need the development of technical skills. The importance of technical knowledge in the enhanced uptake of RETs has been realized in the region, but despite of attempts by governments, there is a continuing deficit of qualified force (Baguant, 1992). Technical knowhow is crucial in order to form over the long term, a critical mass of professional African policy analysts, economic leaders and engineers who are capable of managing all facets of the RET development work and to make sure effective use of already trained African analysts and managers (World Bank, 1996). Trained workforce which is able of designing and manufacturing renewable energy technologies is a requirement for their productive diffusion.

African Government and ministries experience a shortfall of qualified RETs personnel. In Kenya, for instance, there is inadequate general expertise in all facets of solar pumps in the applicable ministries and NGOs (IT Power, 1988). At one time, in Zambia only one engineer was responsible for organizing all renewable energy operations of the government (Sampa, 1994). A project financed by Britain to map out the wind energy in Seychelles was not successful because of lack of trained personnel (Razanajatovo et al., 1994). This lack is to a large extent to blame for the usually under-developed research and technological ability and the inadequate management of renewable energy plans.

Provided that there is inadequate technical knowledge in the formal sector, the state of affairs in the informal sector poses a major challenge. In the informal sector, technical skills are mainly mechanical. As a result, electrical technologies are not easy to comprehend for artisans in the informal sector, as well as most consumers, particularly in rural areas. This can be used to explain the low intake of electrical RETs such as solar PV. The technology is pretty complex, and with inadequate technical skill, result in the dependence on expatriates or technicians established in urban areas. When the outsiders leave in most cases leads to the stopping of the RETs projects. A good example is a case in Kenya, where an expatriate designed a low-cost, locally built control unit for PV lighting systems; when he left, production halted and has not re-started since (Karekezi and Kimani, 2002). Therefore the level of technical knowledge and expertise currently in existence in African economies is a key requirement for the successful execution of RETs.

The options of renewable energy technologies for diffusion and development in Kenya should take into consideration the available technical expertise and local industries. Technologies that build on available methods and improve already established manufacturers are likely to be successfully diffused. Additionally, these technologies can in the long-term get self-sustainable. Renewable energy technologies used to produce electricity (e.g. solar PV) are not likely to be widely diffused in the region, because of the inadequacy of technical knowledge locally on their functioning. A significant percentage of conventional energy projects have been wasted chiefly because of the big emphasis on electricity and on imported technology. Additionally, a large part of the constituents in electrical technologies are sourced abroad. This results in high costs and minimizes the chances for the local technological growth.

When RETs build on local knowledge and skills, there are fewer problems with maintenance, which brings in greater and more sustainable diffusion. Additionally, these technologies are can be increased gradually over time, and can be produced locally. This results in more opportunities for employment and local enterprise creation. Given enhanced funding support at national and international levels for RETs, it would be possible for countries in Africa to be a major participant in the world renewable energy industry. For example, with the exclusion of solar PV technologies, over 60% of the parts needed in most renewable energy technologies can be obtained locally (Karekezi and Kithyoma, 2003). Long-run renewable energy training programs formulated to nurture a critical mass of locally-trained work force with the needed technical, economic and social-cultural skills are desperately required. Most engineering and technical programs offered currently at local universities and colleges in Africa give small exposure to energy technologies. Minor shift in the curricula of existent universities and colleges could to a large extent improve the provision of skilled renewable energy engineers, policy analysts and technicians.

Capacity and demand for the local analytical expertise to give comprehensive analysis of available renewable energy resources and alternatives for using them are required in Africa. NGOs and independent research institutions and networks are in a better position for carrying out such studies. Furthering the growth of human resources and promoting their utilization is a valuable field for committing donor support, as it immediately equips receiver countries with skills for handling resources on their own. From experience it can be proved that majority of RETs need government subsidies only in the initial levels, and can get financially sustainable in the short to medium term after a particular level of technology diffusion has been achieved. After achieving a diffusion of certain critical mass number of units and producers, the renewable energy industry can get self-sustaining and government subsidies can be slowly be withdrawn without any major consequences on continued diffusion of renewable energy technologies (Karekezi and Kithyoma, 2003).

2.4 Overview of Literature

This chapter has covered two main areas. First, it has defined and looked at the theories that explain consumer behavior when making economic decisions. Second, it has presented a discussion regarding empirical research literature, with emphasis on factors affecting adoption of renewable energy. Several factors has been identified and discussed and include technological, intuitional and financial determinants. This gives a good basis for the study since it provides the background information on the adoption of renewable energy. However, there a gap that exists in understanding how individual and household and economic factors influence the decision to adopt renewable energy. This study seeks to fill this research gap.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the, model specification and estimation, definition of variables and sources of data.

3.2 Model Specification

To analyze factors that influence adoption of renewable energy this study follows Simon (1982) and Rogers (2003) theories. In addition, the study takes into account that households adopt renewable energy so as to satisfy their needs. However, this satisfaction is based on the choices made thus the study uses Random Utility Theory developed by (McFadden, 1981). Random Utility theory assumes that individuals are rational decision makers who seek to maximize utility relative to their choices. A consumer, in this case a household, assigns perceived utility to each alternative and chooses the alternative that maximizes his or her utility. This utility depends on the attributes of the consumer and the alternative itself (Rogers, 2003; Simon, 1982). Thus utility can be expressed as shown in Equation 3.1.

$$U_{ij} = U(X_{ij}) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.1)$$

Where; U_{ij} is the utility of individual i derived from alternative j, X_{ij} is a vector of characteristics of both the decision maker and the alternative j.

Since the researcher does not observe utility U_j^i it is therefore necessary for him/her to represent utility as a random variable. Therefore, the choice that a household makes can be expressed as the probability of choosing alternative j conditional to the choice set. This implies that a household will choose alternative j if it gives higher utility than all other available alternatives (equation 3.2).

$$P^i(J|I^i) = Pr\{U_j^i > U_k^i \forall_k \neq j, k \in I^i\} \ldots \ldots (3.2)$$

Based on equation 3.2 it is possible to derive a statistical model by specifying a particular distribution of the disturbances. According to Greene (2012) there are two commonly used distributions for the disturbances namely; normal and logistic distributions which result to probit and logit models respectively.

3.3 Model Estimation

As illustrated above, a household will choose from a number of renewable energy sources that gives him/her the highest utility. This implies that the utility U_{ij} of household i resulting from adoption of renewable energy source j is composed of deterministic component (V_{ij}) and stochastic error component (ε_{ij}) as shown in equation 3.3.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \ldots \ldots 3.3$$

Households are assumed to adopt multiple renewable energy sources. This study focus on two renewable energy sources namely, solar energy and biogas energy. We use a latent variable (Y_{ij}^*) since the decision to adapt renewable energy is observable but the householdsô utility is unobservable (equation 3.4).

$$Y_{ij}^* = \begin{cases} 1 & if\ Y_{ij}^* > 0 \\ 0 & otherwise \end{cases} \ldots \ldots (3.4)$$

The Y renewable energy source adopted by a household and is denoted by $j = 1,2$ that is, solar energy and biogas energy. The relationship between adoption of renewable energy and its determinants can then be specified as shown in equation 3.5.

$$Y^*_{ij} = X_i \beta_j + \varepsilon_{ij} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3.5$$

Where X is a vector of covariates that include; individual (I), household (H) and economic (E) factors, β_j are parameters to be estimated and ε_{ij} denotes the errors term that are assumed to follow multivariate normal distribution and are correlated across choices. Equation 3.5 can be expanded as:

$$Solar_i = \beta_0 + \beta_1 Gender_i + \beta_2 Age_i + \beta_3 Pedu_i + \beta_4 Sedu_i + \beta_5 PSedu_i + \beta_6 HS_i + \beta_7 LT_i + \beta_8 CA_i + \beta_9 IT_i + \mu_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3.6$$

$$Biog_i = \alpha_0 + \alpha_1 Gender_i + \alpha_2 Age_i + \alpha_3 Pedu_i + \alpha_4 Sedu_i + \alpha_5 PSedu_i + \alpha_6 HS_i + \alpha_7 LT_i + \alpha_8 CA_i + \alpha_9 IT_i + \varepsilon_i \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 3.7$$

Where solar denotes adoption of solar energy by household i, gender denotes gender of the household head, age denotes age of the household head, Pedu, Sedu and PSedu denotes primary, secondary and post secondary education level of the household head respectively, HS denotes household size, LT denotes land tenure, CA denotes credit access and IT denotes income transfers. Biog denotes adoption of biogas, β and α are parameters to be estimated and ε are the error terms.

As argued before, households decision to adopt multiple renewable energy sources maybe simultaneous. This implies that the error terms are interdependent due to complimentarity or substitutability of different renewable energy sources, in our case, solar and biogas energy. Therefore, it calls for a model that can account for this interdependence in the errors. Belderbos et al. (2004) argue that multivariate regression model has the capability of simultaneously modeling the effect of a set of independent variables on adoption of each technology while allowing for correlation between error terms. Given that our study focuses on two renewable energy sources, the study then models equation 3.5 as bivariate probit model.

3.4 Definition of Variables

This subsection defines the variables to be used in our analysis.

3.4.1 Dependent variable

The dependent variable is the adoption of renewable energy sources which is measured by a dummy variable. Adoption of solar energy is measured as 1 if a household uses solar energy and zero otherwise while adoption of biogas energy is measured as 1 if a household uses biogas energy and zero otherwise.

3.4.2 Independent Variables

The independent variables of this study are classified into three categories namely; individual characteristics, household characteristics and economic factors. Individual characteristics include age of the household head, gender of the household head and highest education achieved by the household head while household characteristics include household size and land tenure. Economic characteristics of the household include income transfers and credit access.

From the literature reviewed it is expected that the coefficient for male headed households will be positive while age of the household head will have negative effect on adoption of both solar and biogas energy. Education is expected to positively influence adoption of solar and biogas energy but household size would influence adoption of solar and biogas energy. Land with title deeds, access to credit facilities and income transfers are all expected to positively influence adoption of solar and biogas energy. The summary of the variables used in the analysis and their expected signs is presented in table 1.

Table 1: Definition and Measurement of Variables

		Expected Sign	
Variables	**Definition of variables**	**Biogas**	**Solar**
Individual Household Head Characteristics			
Gender	Gender of the household head (1 male, 0 otherwise)	+	+
Age	Age of the household head	-	-
Primary education	Primary education of the household head (1 primary education, 0 otherwise)	+	+
Secondary education	Secondary education of the household head (1 secondary education, 0 otherwise)	+	+
Postsecondary education	Postsecondary education of the household head (1 postsecondary education, 0 otherwise)	+	+
Household Characteristics			

Household size	Number of members of the household	-	-
Land tenure	Household own land with title deed (1 land with title deed, 0 otherwise)	+	+
Economic Factors			
Credit Access	Household accessed credit facility (1 accessed credit, 0 otherwise)	+	+
Income Transfers	Household head received cash transfers (1 received cash transfers, 0 otherwise)	+	+

3.5 Data Sources

Data on renewable energy sources, individual, household and economic factors was sourced from the Kenya Integrated Household Budget Survey (KIHBS) 2005/2006. This data set includes a wide spectrum of socio-economic indicators that collected information on demographics, housing, education, health, agriculture and livestock, enterprises, expenditure, consumption and energy among others. The survey covered all the 70 districts both in rural and urban areas and in all arid and semi arid areas across the country.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents the findings of the study where section 4.2 presents descriptive statistics and section 4.3 presents bivariate regression results and their interpretation.

4.2 Descriptive Statistics

The descriptive statistics shows that the average number of households that used biogas and solar energy were 0.13 and 10.8 percent respectively (table 2). This suggests that adoption of renewable energy in Kenya is still very low. The results show that about 71 percent of the household heads were male while the average age for the household head was 44 years. The youngest household head had 15 years while the oldest had 99 years of age. Regarding education level, about 22, 14 and 16 percent of the household heads had primary, secondary and post secondary education respectively while the rest had no education. The average family size was 5 people with the largest household having 29 members.

Households that received income transfers were 70 percent of the total number of households under the study. Additionally, 37 percent of the household had title deeds for their land. This reflects a low number of people who could use their land as collateral for borrowing funds to invest in renewable energy. This is reinforced by the small proportion (34%) of households that accessed credit facilities.

Table 2: Descriptive Statistics of variables used in the analysis

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Dependent Variables					
Biogas	14189	0.0013	0.0356	0	1
Solar	2641	0.1075	0.3099	0	1
Independent Variables					
Gender of the household head	14189	0.7052	0.4560	0	1
Age of the household head	14189	44.2288	15.6405	15	99
No education	14189	0.2401	0.4272	0	1
Primary education	14189	0.2185	0.4133	0	1
Secondary education	14189	0.1402	0.3472	0	1
Postsecondary education	14189	0.1578	0.3646	0	1
Household size	14189	5.0444	2.8128	1	29
Income transfers	14188	0.7045	0.4563	0	1
Title deed	6089	0.3736	0.4838	0	1
Credit access	14149	0.3412	0.4741	0	1

4.3 Regression Results

The study estimated the determinants of adoption of renewable energy using bivariate probit model. The study presents the two models for adoption of solar energy (model 1) and adoption of biogas (model 2) as shown in table 3. However, before running these two models, the study tested for multicollinearity and found that there was no severe multicollinearity since all the correlation coefficients were less than 0.8 (see appendix 1). The results from bivariate probit model presented in table 4.2 report a Chi Square of 2.52 with a P value of 0.11 indicating that the two models (solar and biogas) are independent. This suggests that the decision to adopt solar and biogas are not interrelated. This calls for running separate probit model for solar energy and biogas energy. The regression results for solar and biogas energy are presented in table 4 and 5 respectively.

Table 3: Bivariate Regression Results for Adoption of Biogas and Solar

	Biogas		Solar	
Variables	**Coefficient**	**Robust Standard Errors**	**Coefficient**	**Robust Standard Errors**
Individual household head characteristics				
Gender of the household head	-0.2308	0.4529	0.0377	0.1251
Age of the household head	-0.0565***	0.0195	-0.0009	0.0035
Primary education	-4.7116***	0.3918	-0.1163	0.1433
Secondary education	0.3437	0.5735	-0.6983***	0.1720
Postsecondary education	-4.8254***	0.3351	-0.2578	0.1604
Household characteristics				
Household size	0.0709**	0.0304	-0.0327*	0.0196
Land tenure	0.3016	0.4925	0.0451	0.1183
Economic Factors				
Credit access	-4.7350***	0.5979	0.0596	0.1239
Income transfers	4.6841***	0.4875	-0.0483	0.1244
Constant	-5.3969***	0.2367	-0.6435**	0.2765
athrho	-0.5818	0.3666		
Observations	929		929	

Wald Test Chi Square= 2.5188, P value =0.1125, ***, ** and * denote significance at 1%, 5% and 10% respectively, no education is the reference category.

4.3.1 Regression Results for Adoption of Solar Energy

The regression results for adoption of solar energy is based probit model since the dependent variable (adoption of solar energy) is binary. The results in table 4 indicate that the Wald Chi

Square is 21.16 with a P value of 0.0120. The significant value of Wald Chi Square imply that gender, age and education level of the household head, household size, land tenure, credit access and income transfers jointly influence adoption of solar energy in Kenya. The influence of each of these independent variables is discussed as follows.

The household head characteristics that were considered in this study were gender, age and level of education. Among these variables only secondary and primary level education significantly influence adoption of solar energy. Gender and age of the household head did not significantly influence decision to adopt solar energy (table 4).

Table 4: Regression Results for Adoption of Solar Energy

Variables	Coefficient	Robust Standard Error
Individual household head characteristics		
Gender of the household head	0.0367	0.1116
Age of the household head	-0.0009	0.0032
Primary education	-0.1166	0.1290
Secondary education	-0.6992***	0.1650
Postsecondary education	-0.2582*	0.1362
Household characteristics		
Household size	-0.0328*	0.0177
Land tenure	0.0460	0.1049
Economic Factors		
Credit access	0.0595	0.1075
Income transfers	-0.0482	0.1147
Constant	-0.6413***	0.2456
Observations	929	

Wald Chi Square=21.16, P value 0.0120, Pseudo R Square=0.0313, ***, ** and * denote significance at 1%, 5% and 10% respectively, no education is the reference category.

The coefficient for secondary and post secondary education are -0.6992 and -0.2582 and are significant at 1 and 10 percent respectively. This implies that household heads with secondary and post secondary education are less likely to adopt solar energy as compared to household heads with no education. Household heads with secondary education have 0.7 lower chances of adopting solar energy as compared to their counterparts with no education. On the other hand, household heads with post secondary education had 0.3 lower chances of adopting solar energy as compared to those with no education. This suggests that as household heads get more education they are likely to be exposed to more information such as adoption of other sources of energy.

This study considered two variables as indicators of household characteristics. These variables include household size and land tenure. The results indicate that household size had a negative but significant influence on adoption of solar energy. The coefficient for household size is -0.0328 and is significant at 10 percent level. This implies that as family size increases there would be lower chances of adopting solar energy. This could be explained by the fact adoption of solar energy requires investment and as such households with large families may be spending most of their resources in the upkeep of the children other than investing in solar energy. Other factors such as land tenure, credit access and income transfers did not have a significant influence on adoption of solar energy in Kenya.

4.3.2 Regression Results for Adoption of Biogas Energy

The study estimated the probit model for adoption of biogas and found that the Wald Chi Square was 196.03 with a p value of 0.0000 implying that jointly gender, age and education level of the household head, household size, land tenure, credit access and income transfers significantly influence adoption of biogas in Kenya. Among the independent variables used in the analysis for adoption of biogas, age and education of the household head, land tenure, credit access and income transfers have no significant impact on decision to adopt biogas energy. However, gender of the household head and household size significantly influences adoption of biogas energy. The results of adoption of biogas energy are presented in table 5. The study found that the results for primary and post secondary education were omitted due to prediction failure.

Table 5: Regression Results for Adoption of Biogas Energy

Variables	Coefficients	Robust Standard Error
Individual household head characteristics		
Gender of the household head	-0.3830*	0.2237
Age of the household head	-0.0072	0.0075
Secondary education	0.1533	0.2538
Household characteristics		
Household size	0.0513*	0.0285
Land tenure	0.0842	0.2451
Economic Factors		
Credit access	-0.1687	0.2581
Income transfers	0.2159	0.2909
Constant	-2.8413***	0.2612
Observations	3,730	

Wald Chi Square=196.03, P value 0.0000, Pseudo R Square=0.0503, ***, ** and * denote significance at 1%, 5% and 10% respectively, no education is the reference category.

The coefficient of gender of the household head is -0.3830 and is statistically significant at 10 percent level. This implies that male headed households are less likely to adopt biogas as compared to their female counterparts. This finding suggests that female headed households are likely to adopt biogas so as to reduce time spent looking for firewood.

The coefficient for household size is 0.0513 and is statistically significant implying that as family size increases the household is more likely to adopt biogas energy. This is generating power from biogas is labor intensive and as such family labor could be used in making biogas. Thus increase in family size leads to increase in supply of family labor that could be used to invest in biogas.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY IMPLICATION

5.1 Introduction

This chapter presents summary, conclusion, policy implications and areas for further research. Section 5.2 presents summary of the study, section 5.3 presents conclusion and section 5.4 presents policy implications while section 5.5 presents limitations of the study and areas of further research.

5.2 Summary

This study sought to investigate the determinants of adoption of solar and biogas energy in Kenya. The study used cross sectional data collected in 70 districts located across the country. The data comprised of demographic characteristics of the household, sources of energy and economic characteristics among other variables. The study sought to examine the effect of household head characteristics, household characteristics and economic factors on adoption of solar and biogas energy. The household head characteristics considered were gender, age, education while the household characteristics were household size and land tenure. In addition, the study used credit access and income transfers as economic factors.

The study used bivariate probit model since it accounts for interdependence in decision making (Belderbos et al., 2004). This implies that the interdependence could be as a result of biogas and solar energy been complementary or substitutes of each other. However, the study tested for interdependence in adoption decisions and found that decision to adopt biogas and solar are independent. This necessitated the use of separate models for adoption of biogas and solar energy. The study found that adoption of solar energy was negatively influenced by secondary education, post secondary education and household size. On the other hand, adoption of biogas energy was negatively influenced by gender but positively influenced by household size.

5.3 Conclusion

The study sought to investigate the effect of characteristics of the household head, household characteristics and economic factors on adoption of solar and biogas energy using bivariate probit model. The bivariate regression results reported a Chi Square of 2.52 with a P value of 0.11. This implied that the Chi Square was statistically insignificant suggesting that the two models (solar and biogas) were independent. This called for use of separate regressions for adoption of biogas and solar energy.

Probit model was used to estimate the determinants of adoption of biogas and solar. The regression results for adoption of solar energy reported a significant Wald Chi Square of 21.16 implying that all independent variables jointly influence adoption of solar energy. The study found that household heads with secondary education had 0.7 lower chances of adopting solar energy while household heads with post secondary education had 0.3 lower chances of adopting solar energy as compared to those with no education. The coefficient for household size was -0.0328 and was significant implying that as family size increases the chances of adopting solar energy decreases.

The regression results for adoption of biogas reported a significant Wald Chi Square of 196.03 implying that all independent variables jointly influence adoption of biogas. The coefficient of gender of the household head was -0.3830 and was statistically significant suggesting that male headed households were less likely to adopt biogas as compared to their female counterparts. However, as family size increases the chances of adopting biogas energy increases.

5.4 Policy Implications

The study found that secondary, post secondary education and household size negatively influenced adoption of solar energy. This finding suggests the need for government and other stakeholders to create awareness and sensitize the learned people regarding the benefits of adopting solar energy. This would ultimately increase adoption of solar energy among the educated people.

Moreover, adoption of biogas energy is negatively influenced by gender of the household head. Male headed households were less likely to adopt biogas as compared to their female counterparts. Thus the policy makers should devise ways of creating incentives for men to adopt biogas by sensitizing them on the importance of biogas a source of renewable energy.

5.5 Areas of Further Research

This study used cross sectional data to examine the effect of household characteristics, characteristics of the household head and economic factors on adoption of solar and biogas. However, the study did not analysis adoption decisions over a period of time. Further research may investigate determinants of adoption of biogas and solar energy using dynamic models in order to understand how householdsô adoption decisions change over time.

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APPENDICES

Appendix 1: Multicollinearity Test Results

	Gender	Age	Primary education	Secondary education	Postsecondary education	Household size	Income Transfer	Title Deed	Credit Access
Gender	1.0000								
Age	-0.0883	1.0000							
Primary education	0.0043	0.0031	1.0000						
Secondary education	0.0012	0.0144	-0.2228	1.0000					
Postsecondary education	0.0224	-0.0130	-0.2316	-0.1657	1.0000				
Household	0.1874	-0.0501	0.0018	-0.0156	0.0011	1.0000			

size									
Income Transfer	-0.0751	-0.0103	0.0029	-0.0386	0.0123	0.0079	1.0000		
Title Deed	0.0208	0.1903	0.0175	0.0213	0.0416	-0.0240	-0.0346	1.0000	
Credit Access	-0.0264	-0.0559	0.0090	0.0232	0.0124	-0.0162	0.0531	-0.0049	1.0000