EX-ANTE ANALYSIS OF RURAL ELECTRICITY DEMAND AND ENVIRONMENTAL BENEFITS: THE CASE OF GURA SMALL HYDRO POWER PROJECT, NYERI-KENYA

by

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DECLARATION

This thesis is my original work and has not been submitted to any university for any degree.

Signed______________________________ Date 17TH / AUGUST/2009

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This thesis has been submitted with my approval as the University supervisor:

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Signed______________________________ Date 17 / 08 /2009

DEDICATION

To my lovely family: Dad (Jason Munyua M'Migwi), Mom (Jennifer Naitore Munyua) siblings (Kithinji, Makena and Kathambi), and nieces (Nana, Florida, Ashley and Natalia) who value and appreciate education-matters as the drivers for success.

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My parents, for their continuous support on so many levels, the encouragement and example they have set to me all my life.

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Opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to UNEP or EATTA.

Finally, to the almighty for giving me the inner strength and wisdom to complete this study.

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List of Acronyms

CO_2	Carbon Dioxide
CS	Consumer Surplus
CV	Contingent Valuation
CVM	Contingent Valuation Method
EATTA	East African Tea Trade Association
EC	European Commission
ES	Equivalent Surplus
FSP	Full Size Project
GEF	Global Environment Facility
GHG	Greenhouse Gas
GOK	Government of Kenya
GTIEA	Greening the Tea Industry in East Africa
IEA	International Energy Agency
IED	Innovation Energie Developpement
IPCC	International Panel on Climate Change
KPLC	Kenya Power & Lighting Company
KTDA	Kenya Tea Development Authority
KW	Kilowatt
KWH	Kilowatt Hour
LPG	Liquefied Paraffin Gas
LRMC	Long-Run Marginal Costs
MC	Marginal Costs
MOE	Ministry of Energy
MW	Mega Watt
MWH	Mega Watt Hour
OLS	Ordinary Least Square
ORNL	Oak Ridge National Laboratory
PMO	Project Management Office
REEPS	Residential End-Use Energy Planning System
RFF	Resources for the Future
UNEP	United Nations Environment Programme
UK	United Kingdom
US	United States
WTA	Willingness to Accept compensation
WTP	Willingness to Pay compensation
SHP	Small Hydro-Electric power
SRMC	Short-Run Marginal Costs

Abstract

"Greening the Tea Industry in East Africa" (GTIEA), a global environmental facility (GEF) funded 4-year project, was officially started in August 2007. Its objectives are to increase investments in small hydro-power development projects and reduce energy costs in the tea industry in countries covered by the East Africa Tea Trade Association (EATTA), improve reliability of power supply, increase power supply for rural electrification, and reduce greenhouse gas (GHG) emissions.

GTIEA project supports potential small hydro-power developers (tea factories) by conducting feasibility studies and produce bankable reports on the basis of which these projects are expected to be funded by financial institution and the developers' equity contributions. One such study, feasibility study on Gura small hydropower project in Kenya-March 2008, was carried out on the Gura River in the Aberdare Mountains, Nyeri District by IED. Gura small hydropower project is expected to serve four KTDA managed tea factories: Chinga, Iriaini, Gitugi and Gathuthi in the project area.

In the Gura SHP feasibility study a finding was made to the effect that the actual household electrification rate was not known but was probably below 50%. The study also reached a conclusion that there was no demand for rural electrification even though KPLC's had planned to expand 11kV-lines to remote tea buying centres (TBC) by 100% by December 2007. These two findings of this study contradicted the Ministry of Energy rural electrification master plan of 2008 which found that the Kenya's central region had an unmet electricity demand. The MOE rural electrification master plan of 2008 also found the mean monthly household electricity consumption to be 70kWh. The IED study did not quantify the expected environmental benefits of the reduced GHG emissions when the SHP project is completed from the society's point of view, nevertheless.

In view of these shortcomings of the Gura SHP feasibility study report, this study aimed at analyzing the rural electricity demand and the indirect environmental benefits of the project. A total of 212 households, approximately 50 each from a 20km^2 area (or a radii distance of 2.5km) surrounding each of the four tea factories, were randomly sampled for the survey. The mean monthly electricity consumption and load demand was calculated from the data. The analysis of the factors that influence rural electricity demand was carried out using a double–logarithm demand model that was able to calculate own and cross elasticities of that demand. The double-logarithm demand model was ran using the two-stage Heckman selection model to first determine the factors that influence the probability of electricity connection and second the factors that influence electricity demand. Contingent valuation method (CVM) was used for valuation of the environmental benefits. Central tendency mean was used to elicit the willingness to pay (WTP) value for the environmental benefits. Ordinary Least Square (OLS) model was used to determine the variables that influence the communities' WTP for the small hydro-electric power (SHP) project construction in view of the perceived environmental benefits.

The monthly current and projected rural electricity demand were found to be approximately 105MW and 543MW respectively. Total household's income and the price of kerosene were found as the probable factors that would increase new electricity connections. Connection fee amongst households not connected to the national grid, the number of electric appliances amongst household on the national grid, price of electricity and the age of the household head were identified as the main factors that directly influence electricity demand. Other factor found to negatively influence electricity demand were the number of people living in the household and education level. Out of 212 respondents, 193 were willing to contribute monthly for 2 years towards the project implementation for the perceived environmental benefits. The household's mean WTP value for two years was KShs 4552 which translated to Kshs1399/tCO2 or US$20/tCO2 assuming that Gura SHP would install a 2.8 MW capacity power plant. Income and employment status were found to affect the WTP positively.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Climate change and alleviation of poverty are the most critical global challenges and also quite relevant in Kenya where 56% of people live below the poverty line and 80% of the population rely on agricultural production and processes for livelihood (UNDP and GEF, 2004). An agricultural commodity that is very important in tackling these challenges through livelihood improvement in Kenya is tea. Tea is the second largest sub-sector to horticulture in the agricultural sector and is the second leading export commodity in terms of foreign exchange generation, accounting for almost 20% of Kenya's total export earnings (Government of Kenya, 2003). Kenya has 91 tea factories across the country which contributes 10% of total global tea production and commands 21% of all global tea exports (Gesimba et al., 2005). The tea industry is the largest employer in the private sector, with more than 800,000 people working on the estates and over three million Kenyans, 10% of the population, earning their livelihoods directly and indirectly through the industry (Gesimba et al., 2005). Table 1 shows the production level trends of green tea and made tea of an average tea factory in Kenya from the year 2002 to 2005.

Table 1: Production levels of an average tea factory in Kenya

Production (tons)	2002/2003	2003/2004	2004/2005
Green Leaf Production	17,797	16,067	15,658
Made Tea Production	4,581	4,082	3,954

Source: KTDA, December 2005.

The made tea is the final product of the green leaf after the production process. Tea processing requires huge amounts of energy and factories have substituted amongst three energy sources, fossil fuels (diesel and furnace oil), wood fuel and electricity for the process (KTDA, 2005). Tea processing is a major contributor to the green house gases (GHG) emissions due to the use of unsustainable fossil fuel sources (UNEP, 2006). GHGs lead to global warming (UNDP and GEF, 2004). The government of Kenya's strategy to tackle these challenges is documented in the National Energy policy that seeks to encourage private investors to produce electricity, a clean source of energy, for their own use and sell the surplus to nearby communities (Government of Kenya, 2002). While operating under this National Policy Framework of 2002 and motivated by the process of transforming production process into being more environmentally friendly, a process also known as "greening", EATTA and UNEP launched the "greening the tea industry in East Africa (GTIEA) project" in 2007 (EATTA, 2008). GTIEA project sought to tackle several issues and key amongst them, the negative externalities associated with fossil fuels use during tea processing. Tea production process and the associated negative externalities are discussed in the following section.

1.2 Tea production and the energy requirements

1.2.1 Tea production energy requirements

Tea processing requires a substantial amount of energy (KTDA, 2005). Analysis of 91 Kenyan tea factories over the years indicate that an average of 3, 572 tonnes of tea is produced annually by each tea factory. The energy requirements of an average factory are as represented in Table 2. The Table indicates that fossil fuels (diesel and furnace oil) are used in substantial amounts in the production process. Burning of fossil fuel, which is an exhaustible resource, is the major contributor of GHG (Dasgupta and Heal, 1979).

Table 2: Energy consumption of an average tea factory in Kenya from 2003 to 2005

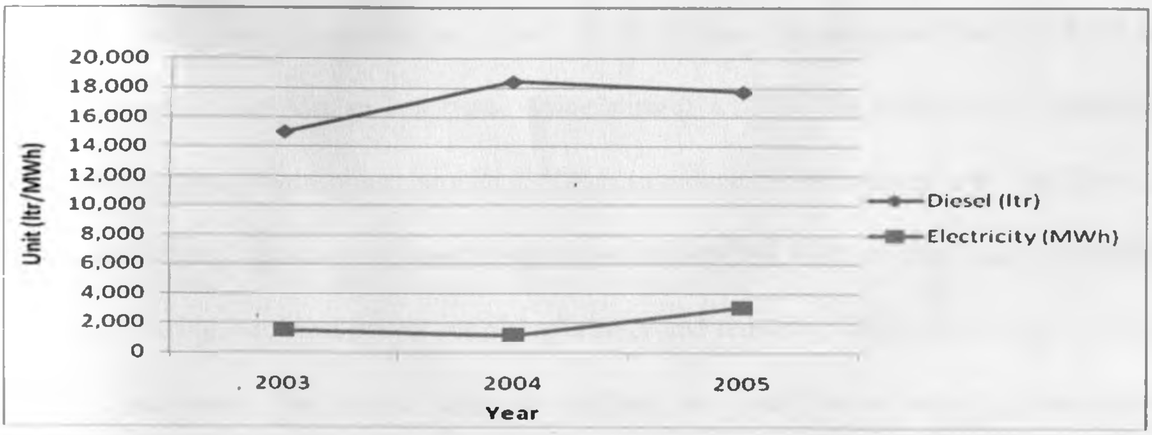
Year/Energy amounts consumed	2003	2004	2005	Mean
Furnace oil (litres)	517,261	1,114,380	267,888	633,176
Diesel (litres)	15,011	18,414	17,715	17,047
Wood (m^3)	1,635	1,745	6,813	3,398
Electricity (kWh)	1,507,040	1,195,338	3,042,358	1,914,912

Source: KTDA, December 2005.

1.2.2 GHG emissions as a negative externality in tea processing

The use of fossil fuel leads to a negative externality due to the GHGs emissions associated with its use. Specifically, it is documented that 0.8 tons of GHG are emitted for every ton of burnt diesel (IPCC, 1996). Figure 1 below shows the relationship between the diesel (a fossil fuel) and electricity use in tea processing.

Figure 1: Relationship between diesel and electricity consumption in an average tea factory in Kenya from 2003 to 2005



Source: KTDA, 2005

The figure shows an inverse relationship between the two energy sources indicating that the two energy sources substitute each other. That is, diesel is used in plethora whenever there is shortage of electricity and vice-versa. From this observation a direct relationship is expected between diesel use and GHGs emissions such as Carbon Dioxide-CO_2-(Dasgupta and Heal, 1979). The burning of fossil fuels leads to almost equivalent units of CO_2 emissions (IPCC, 1996) The amount of CO_2 expected to be emitted from the use of diesel per tea factory is expected to be high and this is likely to have adverse health effects on the environment and human beings (Freeman, 1993). This poor health can eventually lead to low labour productivity in on-farm and non-farm activities to the communities surrounding the tea factories since most rely on family labour for productivity (Gesimba et al., 2005).

1.3 Small hydro power in tea estates

1.3.1 Greening the tea industry in East Africa project

This study is based on the benefits of the "Greening the Tea industry in East Africa" (GTIEA) project. Greening the Tea Industry in East Africa, a small hydropower initiative, has recently been approved by the Global Environmental Facility (GEF) Council. The project is being co-implemented by UNEP & the African Development Bank (AfDB) and executed by the East African Tea Trade Association (EATTA). The objective of establishing the proposed small hydropower project (SHP) is to reduce thermal energy and fossil fuel use in tea processing industries in member countries of the East African Tea Trade Association while increasing electrical power supply reliability and reducing GHGs emissions (EATTA, 2008). Specifically, the project aims to establish six small hydro power demonstration projects in at least four of the EATTA member countries, preferably with an attached rural

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1.3.2 Environmental and economic benefits of the GTIEA project

The GTIEA project anticipates that around 10 MW of power will be generated within the full size project (FSP) period from six pilot small hydropower projects (UNEP, 2006). The FSP report continues to state that if it is assumed that this 10 MW of power would replace diesel powered electricity generation and using IPCC emission factor for diesel of 0.8 ton CO_2/MWh this would result in a mitigation of some 42,048 tons of CO_2 per year at the end of the FSP period.

Table 3 below gives the expected emissions abatement over the life of the pilot projects using the assumed load factor[1] of 0.6. The table shows that roughly 168,192 tons of CO_2 would be abated at the end of the FSP period (assuming that on average hydropower plants start abating CO_2 half way through the FSP Project), growing to around 6,895,872 tons of CO_2 abated within the 20 year period (UNEP, 2006).

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[1] **Load factor** is the actual amount of kilowatt-hours consumed by tea factory in a day as opposed to the total possible kilowatt-hours that could be delivered to the factory during that day.

Some of the perceived direct and indirect economic benefits of the SHP include but not limited to improved health out of the reduced GHG which will in effect cut down on the expenses of the health bills.

Table 3: Emission abated over 20 years life of GTIEA project

End of years	4	10	20
Cumulative MW installed	10	32	82
Cumulative MWh generated	210,240	1,681,920	8,619,840
Total CO_2 abated (cumulative tons)	168,192	1,345,536	6,895,872

Source: UNEP 2006.

Non-farm productivity will also be expected to increase due to setting up of home industries and businesses (Government of Kenya, 2003). This will in effect open up new employment opportunities because a sizeable number of the locals remain unemployed (Government of Kenya, 2003). A study on the energy demand from the government in 2002 also showed that agricultural productivity is partly related to energy in some parts of rural areas near water sources but limited by energy to draw the resource (Government of Kenya, 2002). In effect the provided power in the surrounding communities is expected to boost agricultural production and livelihoods due to the opportunity costs of time saved from the new convenient energy source.

The government policy on rural electrification is to generate as much hydro-power as possible to help in job creation in the rural areas (Government of Kenya, 2002). To enable this policy the government has embarked on protection and development of water catchment areas, which will eventually improve precipitation and water flow, that is, climate change mitigation measures (Government of Kenya, 2002). Electricity is also expected to improve security and education standards since lighting availability has been found to be inversely and directly related to the two activities respectively (Barnes et al., 2002; Longo et al., 2008).

1.4 Statement of the problem

The demand for electricity in areas vicinity to Gura River is demonstrated by the feasibility study conducted by Innovation Energie Developpement-IED-in 2008 (EATTA, 2008). In the IED study, it has been shown that more than 50% of the population surrounding the proposed Gura SHP was not connected to the national grid and that there was no rural electrification potential (EATTA, 2008). This finding however, is contradictory for it is not supported by the current national electricity demand status as documented by the Ministry of Energy (Government of Kenya, 2002). Specifically it is documented that there is an average national demand of 544 kWh per household per annum for the households on the national grid with projected 2.5% annual increase in demand (Government of Kenya, 2002). The rural electrification Master Plan (2008) found the central regions mean monthly household electricity energy demand to be 70kWh but did not determine the region specific factors that influenced electricity demand.

The benefits of the reduced negative externalities associated with Gura SHP have also not been quantified in developing world context, nevertheless. Several studies have been carried out to assess externalities of various electric power productions during the 1980s and 1990s in Europe and the US (Scuman and Canavagh, 1982; Rowe et al., 1995; ORNL and RfF, 1994, 1998). Application of the findings and policy recommendations of most of these studies however have been found useful in specific areas and cannot easily be generalized (Sundqvist. 2002). Sundqvist (2002) further notes that most of the studies have been carried out in the developed world (mostly Europe and US) and rarely in developing countries. where the need for additional power is greatest. The quantified environmental benefits generated in developed countries are often transferred for use in a developing country's context without considering the fact that those benefits and externality estimates differ substantially between these two broad economies. Report by the International Energy outlook not only supports this idea. but also argues that since developing countries incomes are lower. the environmental effects of hydro-power production may be fundamentally different (IEA. 1998). Thus the need to assess externalities. such as reduced GHG emissions and their conditioning factors, specifically associated with the Gura SHP cannot be over-emphasized. Since SHPs produce less GHG emissions than diesel engines. assessment of externalities in this case is synonymous with quantification of the environmental benefits accruing to the society as a result of adopting more environmental friendly energy source.

This study therefore sought to address the knowledge gap associated with the contradictory findings on the current and projected electricity demand status and the lack on information on the perceived environmental benefits associated with the Gura SHP in a developing world context.

1.5 Objective of the study

1.5.1 Overall objective

The overall objective of this study was to analyze rural electricity demand and the environmental benefits of the Gura SHP Project.

1.5.2 Specific objectives

1. Assess current and projected rural electricity demand in the areas surrounding the Gura SHP Project.
2. Determine the factors that influence the current rural electricity demand.
3. Determine local communities' valuation for the environmental benefits of the Gura SHP.
4. Identify factors that influence local communities' valuation for indirect environmental benefits.

1.6 Research questions

1. What is the current and projected rural electricity demand status amongst the community along Gura SHP?
2. Which are the social and economic factors that affect the current electricity demand?
3. What is the local communities' valuation of the environmental benefits associated with the Gura SHP?

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3. What is the local communities' valuation of the environmental benefits associated with the Gura SHP?

4. What social and economic factors influence the local communities' perception of environmental benefits?

1.7 Justification of the study

The National and Global policy of clean development technologies such as SHP will be better understood and enhanced by this study's broad outputs of rural electricity demand analysis and quantification of environmental benefits of Gura SHP. The governments National Energy policy strategy is to encourage private investors to produce electricity for their own use and sell the surplus to nearby communities (Government of Kenya, 2002).

The study findings on the rural electricity demand analysis will provide better understanding of the demand status and factors that limit rural electrification expansion plan. This will assist the Kenyan government policy objective of provision of electricity to all parts of the country and to as many people in the cheapest way possible. On the other hand, quantification of the reduced GHGs will fit with global and countries environmental policies that are geared towards mitigating the effects of climate change. When appropriately quantified the weight of those benefits will reflect on their impact on every level of institutions (and here its impact on tea factories and surrounding communities).

These study findings therefore, will document the rural electrification potential and the environmental benefits of the Gura SHP. The findings could also be extrapolated to national and global levels and will help in formulation and recommendation of better policies geared towards economic and environmental friendly (welfare improving) energy investment technologies in the tea sector.

CHAPTER TWO

2.0 LITERATURE REVIEW

This literature review is divided into two broad categories; Section 2.2 and Section 2.3. The first part is on rural electricity demand and consists of literature on methodologies and shortcomings, results and findings for electricity demand studies in developed countries. Kenya and other developing countries. The second part reviews literature on the environmental benefits and is based on the valuation of the positive externalities studies' that have that have used Contingent Valuation Method (CVM). Selected studies are reviewed in terms of their methodologies and shortcomings. results and findings where applicable.

2.1 Electricity demand

Electricity demand can be distinguished from two categories; the short-run demand and long-run demand. Unlike the short-run demand which includes the immediate electricity needs. long-run demand includes the demand for new connections (clients) as well (Taylor. 1975). Most energy demand studies arose from the energy crises of the 1970s (McFadden et al., 1977) and mainly addressed the short-run demand. While guided by the demand theory, these studies shared a common purpose. which was to measure how total energy demand. or one particular energy source. responded to price and income changes (Hartman. 1983: Houthakker, 1980; Hsiao and Mountain, 1985).

2.1.1 Short-run and long-run demand for electricity

As the basis for the analysis of electricity demand. Taylor (1975) compared 11 studies that were carried out on the residential, industrial and commercial electricity demand to critique the econometric literature and distinguished short-run and long-run demand for electricity in the US. The analysis would help in pricing, electricity tarrifs and project electricity production investments.

Electricity does not yield utility in and of itself but rather is desired as an input into other processes (or activities) that do yields utility (Taylor, 1975). Thus electricity demand is a derived demand from all the processes that utilize a capital stock of some durability (lambs, stoves, water heaters). The author continued to note that since durable goods are involved, there was need to distinguish between a short-run demand for electricity and long-run demand for electricity, and he defined the two categories as follows;

> *"The short run demand can be defined by the condition that the electricity-consuming capital stock is fixed, while the long run takes the capital stock as variable. In essence, therefore, the short-run demand for electricity can be seen as arising from the choice of short-run utilization rate of the existing capital stock, while the long-run demand is tantamount to the demand for the capital stock itself."* (Taylor, 1975, pp 80).

2.1.2 Factors that determine electricity demand

Analysis of electricity demand has been riddled by theoretically implausible demand functions because demand for electricity has always been carried out in isolation from its close substitutes and the fact that electricity consumers do not face constant prices (Taylor. 1975). The author describes the parlance theoretically plausible demand equation as one derived from the classical theory of consumer behaviour where an individual or household is assumed to maximize a utility function over the n goods subject to the budget. The issue of electricity pricing arose from the question of what price to be used to avoid problems of simultaneity and identification. This was after analysis of earlier electricity demand studies generated biased estimates as discussed below in the review that tries to trace the evolvement of electricity demand analysis from 1965. The author noted that simultaneity and identification arose when the independent variable (electricity demand) is correlated with the price (tariff schedule). The author continues to describe marginal price as the last block consumed in. while the average price as the price per kWh of the electricity consumed up but not including the final block or as the total expenditure on electricity up to the final block.

Analysis of electricity demand studies can be traced back to Nelson's (1965) study titled "the elasticity of demand for electricity by residential consumers in Nebraska." While guided by the classical demand theory Nelsons (1965) study only involved the price elasticity in the analysis. Nelson (1965) found that demand reacted in a manner expected from the economic definition of elasticity but the conclusion was rather antithetic to preconceived notions concerning consumer attitude toward electricity demand. Nelson's (1965) concluded that the demand problem was not price alone but also of other variables. Nelson's (1965) study findings led to other authors' extending his notion by including income as a determinant for demand since changes in this variable determined the ability of households to realize change in accumulation of electricity-using capacity (Houthakker, 1980; McFadden and Dubin, 1980). Various studies then analyzed the effect of both income and increased capacity in conjunction with price simultaneously (Balestra and Nerlove, 1966; Nerlove, 1967, 1971; Wallece and Hussain, 1969; Maddala, 1971; Houthakker, 1980; McFadden and Dubin, 1980; George, 1980). All these studies however, carried out electricity demand analysis in a rather aggregate level by sector such as residential, commercial and industrial and were also found to generate estimation biases in price and income elasticity's (Hsiao and Mountain, 1985).

More recent studies have incorporated the aspect of social demographic factors and developed micro-simulation models to solve the problem of biases in a disaggregate way (Barnes et al., 1981; Hsiao and Mountain, 1985). This traditional point of departure in applied demand analysis assumed that the quantity consumed of the good is a function of the level of income, the price of the good, and the price of the other goods that are consumed in a disaggregate way. Westley (1984) specified structural models at the level of a firm or a household in order to describe all components leading to a decision upon durable holdings and usage.

2.1.3 Applications of double-logarithm model for electricity demand analysis

Several studies have used double–logarithm model to estimate the residential electricity demand while using different price categories. However, most of these studies have been undertaken in developed world. Houthakker et al., (1973) used the marginal price on double-logarithm model for electricity demand analysis in US. This study used aggregate price and found own price of electricity to exhibit normal goods properties at -0.90. Fisher and

Kaysen (1962), Houthakker and Taylor (1970) and Mount et al., (1973) used the average price on double logarithm model to determine the electricity demand in United States. The studies found own price of electricity to be -0.15, -0.13 and -0.14 respectively. The results also indicated electricity as being considered as a normal good. Wilson (1971) used the double logarithm model to analyze the residential demand for electricity and also the residential demand for different categories of households. He used both the average and marginal prices in analysis to correct for biases involved with usage of one price. Anderson (1973) analyzed residential long-run demand for electricity using the double-logarithm function of income, prices of various sources of energy and demographic quantities and found own price of electricity to be greater than one implying that when time is factored in demand analysis an increase in electricity prices would see household's tend to limit consumption and consider it as a luxury good.

No study amongst the above literature has used the double-logarithm model for demand analysis was faced with a situation where the data set had many zero variables, nevertheless.

2.1.4 Applications of double-hurdle (two-stage) model for demand analysis

Analysis of studies with a data set with many zero variables have been known to generate biases associated with analysis with many zeros (Heckman, 1976). The model that has been able to address the biases associated with decision and usage of a commodity is the two-stage Heckman selection (or double-hurdle) model (Heckman, 1976). The Heckman model involves the use of a two-stage (or double-hurdle model); the decision stage and the usage stage to correct for biases associated with analysis of the anticipated many zeros in the decision stage (Heckman, 1976). The first-stage is the hurdle that eventually influences the actual consumption demand. The actual consumption demand is the second-stage. While acknowledging that this study might be limited by literature sources, no study has applied double-logarithm model while using two-step procedure for demand analysis for electricity demand analysis. This section therefore reviews demand studies for other commodities that have used double-hurdle model for demand analysis. These studies have been considered based on their two-stage consumption likeness properties with electricity.

Mar ıa Ana et al., (2001) used the double hurdle (DH) to analyze the main determinants of alcoholic beverages consumption at home in Spain since the data set contained many zeros. The authors' expenditure elasticities were found to be positive and own-price elasticities to be negative. The authors also found that socio-economic variables; education level of the household head, number of people living in the household, household composition as playing an important role in explaining consumer purchase and consumption decisions. Household size increases lead to more likelihood of consuming wine and other alcoholic beverages while reducing spirits consumption. Mocan H. Naci (2007) used DH model and a discrete factor model in the estimation of the demand for Medical Care in urban China and found that medical care was considered as a normal good since price elasticity was found to be around 0.3. The authors also found that medical care demand price elasticity for poorer household was larger in absolute value than those of the well-off households.

Basani et al., (2008) evaluated the determinants of water connection and water consumption in Cambodia using DH model to estimate both an access-to-water network equation and a water demand equation. The authors found that the connection elasticity with respect to the one-off initial connection fee was 0.39 and the price elasticity of water demand for the connected households lying in between 0.4 and 0.5 implying that the community in the study area considered piped water as a normal good. Since electricity consumption involves connection and consumption like that of water, this study adapted Basani et al., (2008) study methodology for the analysis of electricity connection and demand.

2.1.5 Electricity demand studies in Kenya

Three major countrywide studies have been carried out in the Kenya by the government to determine the energy demand and supply status (Government of Kenya, 2008). The first and the second studies were carried out in 1980 and 2002 respectively while the third study was carried out in 2008. The first two studies were for all the general forms of energy use and both found that there was generally an unmet demand for electricity because the current electricity generation capacity was inadequate, with demand regularly exceeding supply during peak periods.

The two earlier studies also found that the overall price of electricity was high relative to households' income. The studies also noted that electricity appliances were costly and hence many households would not afford initial investments even when they could afford recurrent costs. This phenomenon shows that the long-run electricity demand is only dependent on new connection and not on new appliances. The connection fee was found to be quite high for most households.

However, based on these observations, the 2002 study did not go further to quantify the projected electricity demand nor address the impeding inefficiencies in the connection but recommended lowering the price of electricity connection as an incentive of attracting more consumers. This recommendation made the concerned Ministry to review the prices downwards (Government of Kenya, 2005). Report on the Gura SHP study indicated responsiveness to this price-cut in the last five years with up to just less than 50% of clients being connected to the national grid (EATTA, 2008). The report however noted that the demand for national grid electricity connection stagnated at that percentage and that the remaining population had no prospects of demanding the electricity connection despite the connection fee price-cut (EATTA, 2008). The study also did not go further to understand the underlying factors that inhibited the potential in line with other demand studies that have been carried in the world. nevertheless. The rural electrification Master Plan (2008) tried to quantify the regional electricity demand and found the central regions mean monthly household electricity energy demand to be 70kWh but did not determine the region specific factors that influenced electricity demand. This study therefore sought to determine the short-run demand for electricity along the Gura SHP and the factors that influence that demand.

2.1.6 Assessing electricity demand in other developing countries

The literature on residential electricity demand in developing countries is small and mainly focused on the price and income elasticities but hardly on other social-economic variables. Lyman (1994) determined electric demand and equivalence scales in Philippines and found that easy availability of substitute fuels in rural settings than in urban settings generally lowered the price elasticity of electricity demand. However, the author found income elasticity to be greater than one implying that electricity demand was highly responsive to income changes. UN ESCAP (2000) study on household energy consumption in the Asian recommended lowering the price of electricity connection as an incentive of attracting more consumers. This recommendation made the concerned Ministry to review the prices downwards (Government of Kenya. 2005). Report on the Gura SHP study indicated responsiveness to this price-cut in the last five years with up to just less than 50% of clients being connected to the national grid (EATTA, 2008). The report however noted that the demand for national grid electricity connection stagnated at that percentage and that the remaining population had no prospects of demanding the electricity connection despite the connection fee price-cut (EATTA, 2008). The study also did not go further to understand the underlying factors that inhibited the potential in line with other demand studies that have been carried in the world. nevertheless. The rural electrification Master Plan (2008) tried to quantify the regional electricity demand and found the central regions mean monthly household electricity energy demand to be 70kWh but did not determine the region specific factors that influenced electricity demand. This study therefore sought to determine the short-run demand for electricity along the Gura SHP and the factors that influence that demand.

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2.2 The valuation of environmental benefits as a positive externality of electricity

Sundqvist (2002) critically evaluated past research efforts and found that the last decade's policy makers had shown an increasing interest in the general recommendations found in the environmental literature. The author notes that according to this strand of research the answers to the environmental valuations lie in applying economic non-market valuation techniques to the specific environment (and non-environmental) impacts that can be labelled as externalities. An externality is present whenever some individual's (say A) utility or production relationship include real (non-monetary) variables whose values are chosen by others (persons, corporations, government) without particular attention to the effects on A's welfare subject to the proviso that the decision maker, whose activity affects other's utility levels or enter their production function, does not receive (pay) in compensation for this activity an amount equal in value to the resulting benefits (or costs) to others (Baumol and Oates, 1988).

In early 1980s studies that explicitly attempted to assess and value externalities in the power sector began to emerge (Scuman and Canagh. 1982). During the 1990s there was a surge in the number of externality analysis conducted in large part due to the increased attention from policy makers in Europe, with the ExternE Project (EC, 95; 1999) and in the US (Rowe et al., 1995; ORNL and RfF, 1994, 1998). The results and the methods of many of these externality studies have been utilized as important modelling work and have served as vehicles in developing additional methodological work in the environmental and energy field (Krewitt, 2002).

2.2.1 Non- market valuation of environmental benefits of electricity

Non-market valuation approach can be divided into two categories: revealed preference and stated preference methods (Longo et al., 2008). Revealed preference methods such as the travel cost and hedonic pricing method infer values from data on behavioural changes in actual markets, with actual purchase and consumption of marketed goods and services related in some way to the missing market of a non-market resource (Mitchell and Carson, 1989).

Stated preference methods, such as conjoint analysis, choice experiments, and contingent valuation, attempt to solve the problem of non-market valuation of resource and pollution by capturing benefits and costs that may be neglected by the other methods. These methods are commonly used to estimate the non-use value of the environment by directly surveying consumers on their willingness-to-pay (WTP) or willingness to accept (WTA) for existing or potential environmental attributes in a hypothetical, constructed market.

The most commonly used form of questioning on hypothetical features is the contingent valuation method (CVM). According to Mitchell and Carson (1989). the advantage of CVM to other valuation methods is that it does not require the conceptual linkage between market prices and a non-market resource. since the researcher elicits information on the value of the amenity directly by using a questionnaire or interview to create a hypothetical market or referendum in which individuals reveal the values they place on the resource. This study did not have any conceptual linkages with market goods for it was an ex-ante study and therefore opted for CVM method.

2.2.2. Applications of CVM in valuation of environmental benefits

CVM has principally been applied in highly industrialized economies (Ojeda et al., 2007). However, in the last decade, the method has also been increasingly applied in developing countries for valuation of environmental quality and for measuring the WTP for public projects aimed at providing services such as safe drinking water and sanitation (Briscoe et al., 1990; Whittington et al., 1991; Choe et al., 1996; Lauria et al., 1999; Johnson and Baltodano. 2004; de Oca and Bateman. 2006). Much less attention has been paid in developing countries to measuring the value of ecosystem services in complex natural systems such as the atmosphere (ambience pollution) and rivers, especially the indirect use values and non-use values (Venkatachalam. 2004). A few studies have been carried out to value environmental services in tropical forests (Hodgson and Dixon. 1988; Shyamsundar and Kramer, 1996), in wetlands (Windevoxhel, 1993), and in other applications in Mexico (Sanjurjo. 2004; Lara-Dominguez et al., 1998), but no previous CVM study to my knowledge has focused on quantification of the environmental benefits or damages associated with the externalities of agro-industries located in rural areas of developing countries such as tea factories in Kenya.

CVM has also been used by decision makers to compare the benefits generated by different environmental services, and to management of scarce resources under long-term sustainable approaches (Ojeda et al., 2008). While estimating the economic value of environmental services provided by restored stream flows in the water-scarce Yaqui River Delta in Mexico, Ojeda et al., (2008) found that 148 interviewed households indicated that they would pay an average of 73 pesos ($5.15) monthly. The authors also found WTP related to key variables suggested by economic theory and contingent valuation studies elsewhere: income, educational level, number of children in the household and initial bid amount which would be targeted by the resource managers.

Wiser (2007) used dichotomous choice contingent valuation survey of 1574 U.S. residents to explore willingness to pay (WTP) for renewable energy under collective and voluntary payment vehicles, and under government and private provision of the good. The author found some evidence that, when confronted with a collective payment mechanism, respondents stated a somewhat higher WTP than when voluntary payment mechanisms are used. Similarly, the author found that private provision of the good elicited a somewhat higher WTP than does government provision. In conclusion the authors remarked that CVM responses are strongly correlated with expectations for the WTP of others. This finding, the author noted, shed light on strategic response behaviour and the incentive compatibility of different CV designs, and offered practical insight into U.S. household preferences for how to support renewable energy.

Longo et al., (2008) study on WTP for attributes of a policy for renewable energy internalization of externalities' in the UK found that costs of energy, security, climate change and air pollution caused by the production of electricity were some of the factors that significantly influenced consumers willingness to pay a higher price for electricity.

CHAPTER THREE

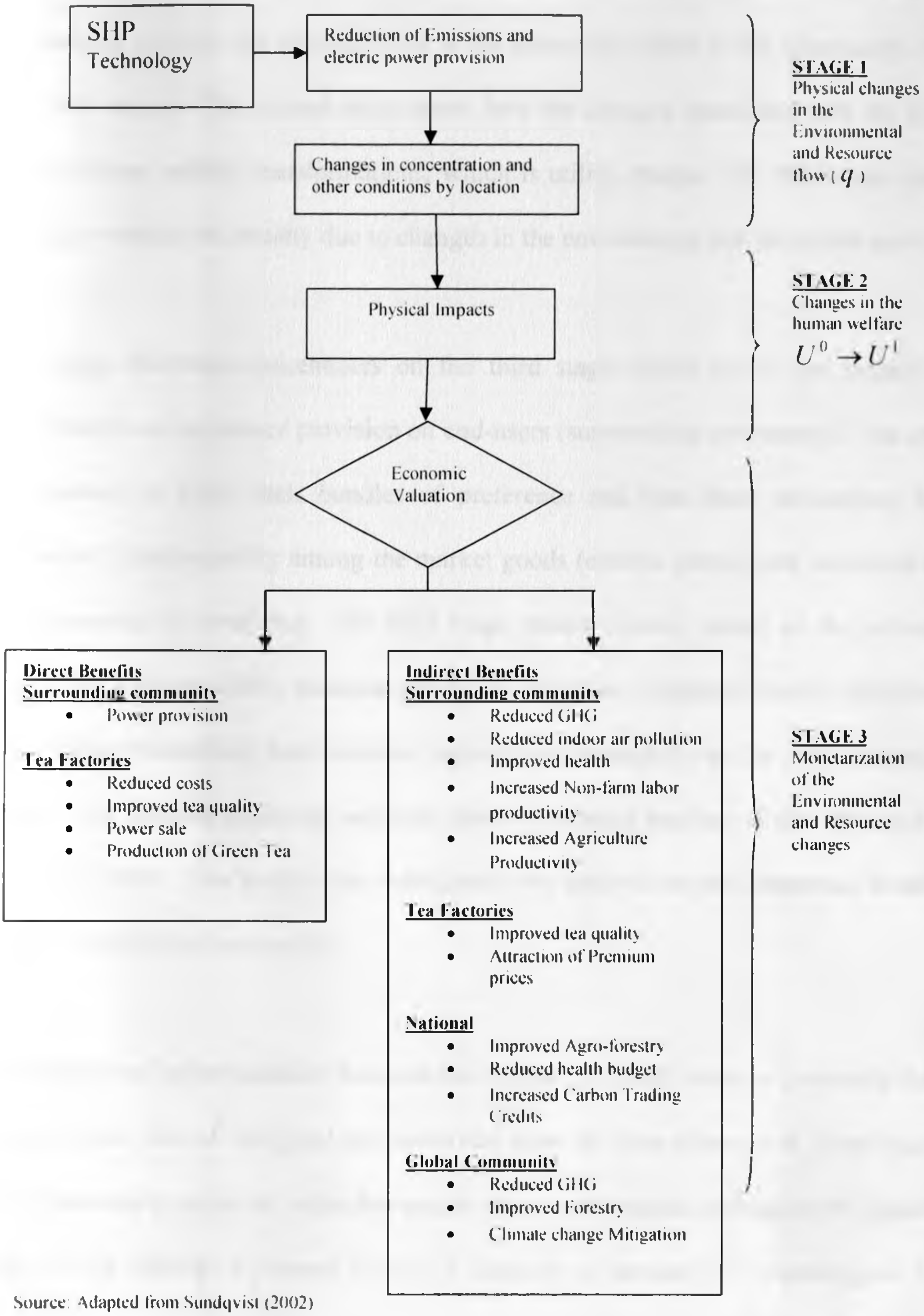
3.0 METHODOLOGY

The methodology is broken down into three major sections: the conceptual framework, theoretical framework and the empirical framework. Section 3.1 shows the conceptual framework that marries the two concepts of electricity demand and environmental valuation through the use of the explicit bottom-up (demand curve) approach. Section 3.2 gives the theoretical framework that the study objectives are based upon and also gives equations that have been applied for the two broad objectives albeit with a few modifications. Sections 3.3 to 3.9 give the empirical framework starting with the sampling techniques applied for the study and ending with the methods of analysing the tested hypothesis for the four research questions.

3.1 Conceptual Framework

The conceptual framework (Figure 2) is adapted from Sundqvist (2002) and is based on the bottom-up (demand-curve) economic valuation of the change in the human welfare out of changes in the environment and resource systems. The bottom-up approach enables one to trace the changes in human welfare out of the demand or consumption of these goods explicitly, that is, from the consumer's point of view (Sundqvist, 2002). In this study, Gura SHP doubles both as the resource system through provision of power and the environmental system through generation of the positive externalities associated with that power production.

Figure 2: Conceptual framework for the analysis of the total benefits of SHP technologies.



Source: Adapted from Sundqvist (2002)

The first stage of the framework shows how Gura SHP causes physical changes in the environment and resource flow. The environmental physical changes are captured as externalities whereas the resource flow is the power provision to the community from the Gura SHP project. The second stage shows how the changes associated with the first stage lead to human welfare transformations, which is utility change. The third stage shows the economic value to the society due to changes in the environment and the power provision.

This study, therefore concentrates on the third stage which shows the impacts of the environment and the power provision on end-users (surrounding community). The end-users are assumed to know their bundles of preference and that these preferences have the property of substitutability among the market goods (electric power) and non-market goods (environmental externalities). The third stage shows electric power as the private good bundle and reduced GHG, reduced indoor air pollution, improved health, increased non-farm labour productivity and increased agriculture productivity as the environmental good bundle. The reduced indoor air pollution leads to reduced number of sick days per annum (Freeman, 2003). This implies that individuals who enjoy these environmental benefits will be more healthy and productive.

The property of substitutability between the bundles of goods invokes trade-offs that make people choose less of one good and substitute more of some other good. These trades-offs reveal something about the value that people place on the goods making up the bundle. This value can be captured by money price and elasticity of demand for a market good (electric power) and willingness to pay (WTP) or willingness to accept (WTA) for non-market goods (the environmental changes).

3.2 Theoretical framework.

The theoretical framework that captures both the environmental benefits and rural electricity demand analysis is based on the classical theory of consumer choice whereby an individual is assumed to demand goods n that maximizes his utility subject to his level of income. The n goods are broadly categorised into private and public goods (Freeman, 2003). Electric power is a private good whereas the environmental services are public goods. Therefore, the theory of attaching value to public goods and the theory of demand for private goods are considered in the following model.

On the assumption that individuals in the study area are utility maximisers from consumption of private goods, electric power (x) and environmental good (q) this study adopts Freeman (1993) model on individual i utility U_i defined as,

$$U_i = U_i(x, q)\text{....................}(i)$$

Where,

U_i -individual i utility which depends on,

x -vector of private goods consumed and

q -vector of environmental goods consumed.

If the environmental good q is assumed as having a positive price presented by vector r, then the individual i will be faced with a consumption constraint budget M.

$$M_i = px + rq\text{......................}(ii)$$

Where p is the vector of prices of the private good x.

Individual i is assumed to maximize utility subject to the budget constraint.

The first order conditions for the maximization problem implies that the individual conditional demand function (that is, conditioned upon the imposed the environmental good q), x_i for the marketed good can be written as.

$$x_i = x_i(p, M_i - rq, q) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Equation (iii) implies that the individual i demand for the private good (in this case power) is a function of the provision price p, income less the price of other environmental goods imposed on him $(M_i - rq)$ and the environmental good q. Demand function such as Equation (iii) derived through the classical theory of consumer behaviour in current parlance is said to be theoretically plausible (Taylor, 1975).

Guided by earlier studies of the residential demand for electricity, this study modified Equation (iii) to derive a demand function for the private good facing the individual. The study adopted Baxter and Rees (1968), Wilson (1971) and Anderson (1973) Cobb-Douglas type function to model electric power demand. The study assumed that the individual i public good price imposition $(M_i - rq)$ as the price for any other commodity that complements or substitutes the private good and denoted it as price p_i. The study then took the budget facing the individual's as M. The environmental good q and social economic factors that affect the demand of the private good were denoted as Z. Individual i adopted Cobb-Douglas form demand function therefore becomes.

$$x_i = \alpha p^{\beta_1} . p_i^{\beta_2} . M^{\beta} . Z_i^{\beta} \text{.....................}(iv)$$

Analysis of Equation (iv) is carried out through linearization to get the resultant double-logarithm model as applied by Baxter and Rees (1968), Wilson (1971) and Anderson (1973). The analysis will be examined in the section on methods of analysing the rural electricity demand: Section 3.9. In summary, demand is commonly treated as a function of current budget, prices and other household's inherent factors that would affect that consumption demand (Taylor, 1975).

Non-Market valuation for the environmental good

For the valuation of the non-market good q, Equation (iii) was inserted into Equation (i) to get the conditional indirect utility function v, for the individual i,

$$v_i = v_i(p, M_i - rq, q) \text{...................}(v)$$

The use of indirect utility function enables welfare measure to be expressed in monetary metric terms (Varian, 1992). This measure will be used for the valuation of the environmental good.

Assuming that the private good x is the numeraire (that is, the element can be expressed in monetary price which fixed at one) and that q is an environmental good consisting of one element, ceteris paribus, individual i would choose more of q if given the option. A project like Gura SHP will cause the environmental quality to improve from q^0 to q^1 (that is, $q^1 > q^0$). Gura SHP project will cause a positive change in individual i indirect utility (or welfare) so that,

$$\Delta v_i = v_i(p, M_i - rq^1, q^1) - v_i(p, M_i - rq^0, q^0) \succ o \ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

Given the presence of the project, individual i is thus better off by Δv_i. However, since utility is not directly observable and since environmental goods are not part of a market transaction alternative ways of assessing the value of this welfare change were sought. The two standard monetary measure of quality based welfare change are WTP and WTA.

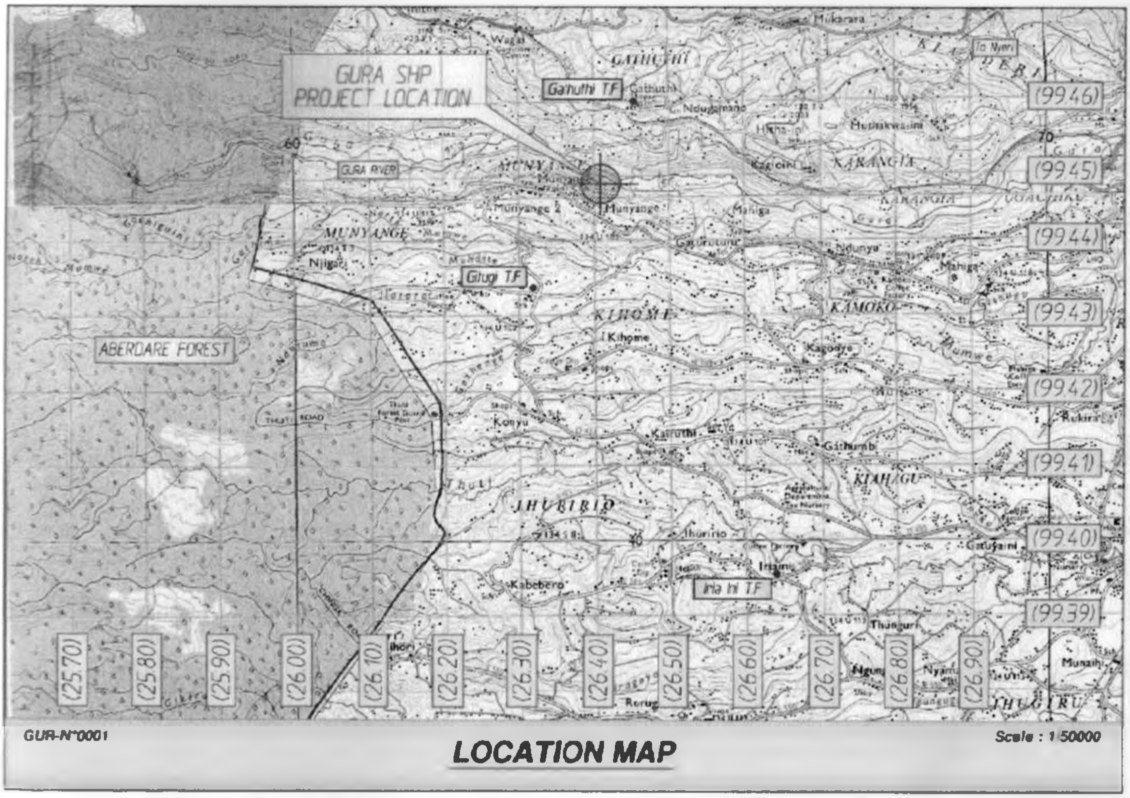
WTP and WTA measures can be defined in terms of any good that the individual is willing to substitute for the good being valued (Freeman, 2003). WTP is the maximum sum of money the individual would be willing to pay rather than do without an increase in some good such as an environmental amenity. This is the amount of money that would make the individual indifferent between the options of paying for and having the improvement and foregoing the improvement while keeping the money to spend on other things. WTA is the minimum sum of money the individual would require to voluntarily forego an improvement that would otherwise be experienced. It is the amount that would make the person to be indifferent between the options of having improvement and foregoing the improvement while getting extra money. Both value measures are based on the assumption of substitutability and preferences, but they adopt different reference points for levels of wellbeing (Freeman, 2003). WTP takes absence for improvement as its reference point whereas the WTA takes the presence of the improvement as the base level of welfare (Freeman, 2003).

Empirical studies have shown that WTA measure tend to be substantially higher than WTP measure for the same change (Kahnmann et al., 1990). This could be attributed to the fact that WTA is not being constrained by income which creates an incentive problem (Hanemann, 1991; Arrow et al., 1993). The authors therefore advocate for WTP as the best welfare measure. In eliciting WTP, the environment is essentially treated as any other private commodity and people are willing to consider trade offs in relation to the quantity and quality of the environmental goods as well as the private good (electric power).

3.3 Study area

The study area was purposively selected to cover an approximate $20km^2$-area (or 2.5 km radii distance) surrounding each of the four tea factories under the Gura SHP project (see location map, Figure 3).

Figure 3: Study Location Map



Three of the locations; Mahiga. Iria ini and Chinga are located in Othaya Division $(00^{\circ}33'S,36^{\circ}57'E)$ while one Thegenge is located in Tetu Division $(00^{\circ}31'S,36^{\circ}56'E)$ in Nyeri district (Google Earth, 2008). Iria ini and Chinga locations have tea factories of interest under the same name while Mahiga and Thegenge locations have Gitugi and Gathuthi tea factories respectively (KTDA, 2005).

Othaya and Tetu divisions share a common border and lie about 220 kilometres north of Nairobi, the capital city of Kenya. The 1999 Kenya census survey gave Othaya division a population of 88,291 while that of Tetu division at 80,000 with an annual population growth rate of 1.8% (Government of Kenya, 2007). The population in tea growing areas of Kenya is usually of a dispersed yet relatively dense nature and People tend to live in small plots of lands (Gesimba et al., 2005).

The two divisions lie between 1600 to 1800m above the sea level. The areas mean annual precipitations range from 1,150mm to 1,450 mm with two rainy seasons per year: the long rains (March 15th to May 30th) and short rains-October 15th to December 30th (Google Earth, 2008).

3.4 Data sources and structure of the questionnaire

This study used primary data. Primary data was collected by interviewing selected households in the study area. Data for the two broad objectives of rural electricity demand and environmental benefits was collected through a semi-structured questionnaire based on previous energy demand and CVM questionnaires from past studies. The semi-structured questionnaire had two sections; one on rural electricity demand analysis and the other on the environmental benefits.

The rural electricity demand section had questions on all the common energy types, uses, availability and costs. The environmental section was patterned based on previous CVM questionnaires in terms of introductory questions, background information and WTP questions. The WTP section consisted of a single-bound dichotomous choice (DC) bid followed by an open-ended question eliciting maximum WTP. CVM surveys conducted in developing countries have, from the most part used a DC format, with one or more follow-up questions (FAO Information Division, 2000). Open-ended question improves the likelihood of receiving bid amounts that would provide a more precise estimate of the individual's WTP (Ojeda et al., 2007).

3.5. Survey design and administration

An aggregate total of 212 households were interviewed from a sample of approximately 8000 households in the four purposively selected locations. The members of the four tea factories were the sampling frame. An average total of 50 households were randomly picked from a sampling frame of around 2000 households in each of the four locations. This is because according to the central limit theorem sample sizes in excess of 30 are adequate for virtually all populations unless the distribution is extremely skewed (Greene, 1993).

A draft questionnaire was pre-tested with five-trained university graduates and students interviewers in Othaya town which is 10km from the nearest study location. The final survey was administered through face-to-face interviews through the randomly sampled list in the four selected locations in the second week of July, 2008. Random sampling minimizes biased sample (Ojeda et al., 2007).

3.6. Methods of analysing the rural electricity demand

3.6.1 Current and projected rural electricity demand

The current and projected rural electricity demand in the areas surrounding the Gura SHP project involved tabulation of the gross electric energy and peak load demands from the collected data. The current gross electric energy demand was calculated from aggregation of electric power consumption for all households connected to the national grid in the month of June, 2008. The current gross peak load demand involved aggregation of the highest power demand for all households connected to the national grid within a period of 24 hours (a day). The projected gross electric energy and peak load demands involved aggregation of the electric energy and peak load demands for the households that would be willing to pay for connections to the national grid at different discounted connection fees (that is, of Kshs 1,000-5,000; 5,001-10,000; 10,001-15,000; 15,001-20,000; 20,001-25,000 and over 25,000).

3.6.2 Determinants of rural electricity connection and consumption

The rural electricity demand analyses involved determination of the effects of prices (of electricity and close energy substitutes), income and other social economic factors on electricity demand. The analysis was conducted by the linearized version of the Cobb-Douglas type demand Equation *iv*) which gave the double-logarithmic demand equation (vii) below.

$$\ln x_i or(kWh) = \ln \alpha + \beta_1 \ln p + \beta_i \ln p_i + \beta \ln M + \beta_i \ln Z_i \text{.....................} (vii)$$

All variables are as described in equation (iv) above.

Thus, in an econometric model (vii) energy consumption (kWh) was expressed as a function of its relative price p, the price of close substitutes p_i and a set of other independent variables, including household's income M and a variety of other household-level characteristics Z.

Analysis of the double-logarithm demand Equation (vii) above has been conducted through the use of OLS method for its suitability in giving the Best Linear and unbiased estimates-BLUE (Greene, 1993). Most studies have applied relative average or marginal electricity as provision prices (Taylor, 1975). However, in analysis of this study, two problems are bound to occur if the relative KPLC electricity prices and OLS were to be applied in analysing Equation (vii). The first problem is that of getting biased price elasticity estimates caused by exogenously determined price tariffs that are independent of the quantity (previously) consumed or Block Pricing (Taylor, 1975; Dalhuisen et al., 2001). The second problem is associated with censored data problem due to the anticipated high percentage of non-electrified rural population in central region of Kenya (Heckman, 1979; Government of Kenya, 2008). This study examines the methodologies of overcoming the anticipated biases below.

3.6.3 Overcoming biasness associated with electricity tariffs

The issue that electricity energy demand economists have grappled with is biasness associated with the use of fixed tariffs. Kenya Power and Lighting Company (KPLC), like other residential electricity tariffs around the world, are categorized in three major blocks (based on monthly electricity energy consumption as; category 1 for households consuming less than 50kWh, category 2 for households consuming between 51kWh and 300kWh and category 3 for households consuming more than 300kWh but not more than 3000kWh). This kind of block pricing has both the average pricing effect in each tariff block and the marginal effect pricing effect between each block. The use of one price in absence of the other would lead to an upward bias in the estimate of the price elasticity because the average and marginal prices are positively correlated, as would likely be the case here (Taylor, 1975). To factor in both the marginal and average prices this study used dummies for the three price blocks with the lowest tariffs being the base case. The dummy variables measured the income effect arising from intra-marginal (average) price changes thus leaving the price effect to be measured by the marginal price (Taylor, 1975).

3.6.4 Overcoming biasness associated with missing and zeros observations

The percentage of rural electricity connection in areas surrounding the central region of Kenya is less than 20% (Government of Kenya, 2008). Analysis of rural electricity demand for such a population therefore, would be characterised by many zero variable. Analysis of such a data set would lead to censored data problem due to a large number of households that were expected not to be connected to the national grid. The rural electricity demand is a two stage process since it involves the rural electricity connection in the first stage and electricity consumption in the second stage. There are a number of challenges in empirically estimating the parameters of this type of model (Johnston and DiNardo, 1997). The electricity provided by the national grid is not universal and households who wish to connect pay a connection fee. Thus, while common information is observed for all households, electricity consumption levels are only reported and observed for those households who are connected to the national grid and have paid the relevant connection fee. The foregoing of the first stage creates a censored data problem for the dependent variable in an electricity demand, and the application of ordinary least squares (OLS) to the full sample may lead to potentially biased estimates (Johnston and DiNardo, 1997).

Since one observes electricity consumption only for households that are connected, using the observations on the connected households to estimate electricity demand relationship may be affected by a selection bias problem. The selection problem can be viewed as a problem of missing observations (Heckman, 1979). Heckman two-step procedure allows for the separate estimation of the selection (electricity connection) and consumption (kWh) equations, and explicitly deals with the selectivity bias problem as noted above. This two-step procedure corrects for selectivity bias through insertion of a proxy variable—a correction term known as the Inverse Mills Ratio—to capture the selection effect. However, in order to identify, *inter alia*, the correction term's parameter, it is crucial to have available identifying variables that shift the probability of household connection but not the level of household electricity consumption (Heckman, 1979). The econometric approach used in this study (two-step Heckman selection analysis model) thus provided a framework for the estimation of both an access-to-electricity connection probability equation and an electricity demand equation and this helps inform this study's two research questions: what are the key household's and other characteristics that influence electricity connection (including the connection fee), and how sensitive is the electricity demand of households to a change in price of electricity? The adopted two-step Heckman selection analysis model is thus,

1st Step (Probability to electricity connection): Probit Model

$$\Pr ob(P=1)=\Pr ob(kWh>0)$$

$$=F(\alpha_m Z_m)+\varepsilon_1, \quad \varepsilon_1 \sim N(0,1)\ldots\ldots\ldots\ldots\ldots(viii)$$

Where.

P takes the value of one if the household is connected to the national grid and zero otherwise;

kWh is total electric energy consumed;

Z_m is a vector of explanatory variables;

α_m is a vector of coefficients to be estimated and

ε_1 is a random error term with zero mean and unit variance.

2nd Step (Electricity Consumption): OLS Regression Model

A regression model of electricity demanded can be given as

$$\ln kWh = \beta_m' \ln X_m + \gamma_m \lambda_m + \varepsilon_2, \qquad \varepsilon_2 \sim N(0, \sigma^2) \ldots\ldots\ldots\ldots\ldots\ldots (ix)$$

Where,

X_m is a vector of explanatory variables

β_m is a vector of parameters to be estimated

λ_m is the inverse Mills' ratio calculated as,

$$\lambda_m = \frac{\phi(\alpha_m' Z_m)}{\Phi(\alpha_m' Z_m)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (x)$$

to account for sample selection in electricity demand analysis,

where ϕ is the probability density function and Φ is the cumulative distribution function

γ_m is the associated parameter to be estimated and

ε_2 is a random error term with zero mean and variance σ^2

In summary the two-step Heckman procedure comprised estimation to electricity connection probability equation (a probit model on the probability of using the connected electricity) in the first step, and then electricity demand equation (OLS regression model) for the connected households in the second step. The probit model estimates were used in conjunction with the electricity demand equation to provide the basis for a test of selectivity bias while using the inverse mills ratio. This single analysis for the combined two steps was provided for by *Stata Pack 9.0*.

3.6.5 Factors influencing rural electricity demand

To determine the specific variables that influenced that demand, this study made some hypotheses that were subjected to t-tests. The variables hypothesized to explain electricity demand were identified from the conceptual framework, theoretical framework and on past empirical work on electricity demand which were mostly reviewed under the studies that have used the double-logarithm demand models and two-step Heckman selection model for demand analysis in the section on literature review. Based on the econometric model Equations (*viii*) and (*ix*) above, the following hypotheses were tested in the analysis (Refer to Table 4).

Taylor (1975) study on electricity demand in US found that the cross elasticities of energy substitutes to be inversely related to the electricity energy. This study therefore hypothesised that the cross price elasticity of other energy sources in the household (firewood, woodwaste, charcoal, kerosene, and LPG) to electricity would be inversely related to each other. This study also hypothesised that electricity demand would be inversely related its price. This is because the economic theory of demand assumes that the quantity demanded is inversely related to price

(Varian, 1992). The income elasticity was hypothesised to be directly related to the electricity demand. Studies on cross sectional data have been found to have positive short-run income elasticity of demand (Hsiao and Mountain, 1985). Other economic and social factors such as education level, age and employment status were expected to take any direction depending on the respective household's characteristics. Table 4 summarises the tested hypothesis.

Table 4: Hypothesis of the explanatory variables used in the analysis of eletricity demand model.

Variable	Apriori sign
Monthly costs for other (substitute) energy types, *j* = Firewood, Woodwaste, Charcoal, Kerosene, LPG, Drycell battery, Vehicle battery	(-ve)
Own Price	(-ve)
Number of years schooled	(+ve)
Age of household head	indeterminate
Employment status	(+ve)
Total Monthly Household income	(+ve)

Source: Author's Conceptualization

3.7 Methods of analysing the environmental benefits

3.7.1 Amount of WTP for the environmental benefits associated with Gura SHP

Central tendency theorem was applied to determine the society's mean WTP for the environmental benefits associated with Gura SHP. Elicitations of WTP values, however, have been riddled by many biases associated with poor CVM survey designs (Arrow et al., 1993). In this respect and before WTP elicitation exercise, all anticipated biases associated with CVM surveys were re-evaluated: a plausible payment vehicle was identified and a clear hypothetical market formulated. The approached methodologies for mitigating the anticipated biases are discussed below.

3.7.2 Anticipating potential CVM biases of the survey

It is well known that many sources of bias can occur in a poorly designed and administered CVM survey (Mitchell and Carson, 1989). Sponsor bias was minimized by informing potential respondents that the research was sponsored by a university. This is because respondents in developing countries consider university, a neutral body (Navrud and Mungatana, 1994). This also minimized interviewer bias since respondents do not feel the need to either please or gain status in the eyes of the interviewer. The questionnaire, scenario misspecification biases was avoided by training of all interviewers to conduct the CVM-format embedded surveys, which prepared them to answer the questions that respondents would likely have (Whittington, 1998).

3.7.3 Payment vehicle

Definition and selection of the appropriate payment vehicle on the environmental valuation component depend on the resource to be valued, the socio-economic characteristics of the sample, and the institutional structure governing the area (Arrow et al., 1993). Since the resource to be valued was the effects of reduced GHGs emissions on human health, this study used money (saved annual health bills) as the payment vehicle. The study hypothesised that the reduced emissions leads to reduced sickness that would reduce health bills and also improve productivity, all of which translate to money.

3.7.4 Hypothetical market

The following summarized hypothetical market was formulated.

...Small Hydropower Projects (SHP) produce power in small quantities and could be used by tea factories in reducing operating costs, increasing power supply reliability for rural electrification and reducing GHGs emissions during tea processing. The perceived environmental benefits of the reduced emissions include but are not limited to;

1. Improved Health
2. Increased Non-farm productivity
3. Increased Agriculture productivity
4. Improved precipitation and water flow (climate change mitigation)

Assume that the project will be collectively financed by a fund which all the stakeholders (tea factories and farmers and surrounding communities) who support the implementation of this project will have to pay. The project would be realized by an independent organization and it would be financed exclusively by means of the fund. The fund works by pass and fail principle: Either there is enough money for implementation of the project, or the money does not suffice for the envisaged benefits. In this case the project will not be realized and each proponent of the project gets his money back. Under those circumstances, would you be willing to contribute to have the project implemented? If yes, what is the maximum amount would you be willing to pay for two years as your contribution into such a fund to have that project implemented out of these perceived environmental and economic benefits?

3.7.5 The central tendency theorem

The mean WTP value was calculated from the formula.

$$WTP = \frac{1}{N}\sum_{i=1}^{N} X_i y_i \text{...} (xi).$$

Where N is the total number of responses, X_i is the WTP bid and y_i is the number of "yes" responses. The mean value was chosen because of its ability to capture the disparaging social set-up of the study area (Greene, 1993; Government of Kenya, 2002).

3.7.6 The determinants that influence the WTP value

Multivariate Model

To determine the extent to which social-economic factors influence the WTP the study adopted a multiple variable econometric model as previously used by Aballa (1984) and Tulyenge (2002). The WTP value depends on a number of social-economic variables and is given by Equation xiv.

$$WTP = f(Awr, Y, Age, Ed, hhh, Ar, Ds, Und, Emplsts, fin, hhxt, u) \ldots\ldots\ldots\ldots (xii)$$

Where the variables are as described in Table 5.

The multivariate model Equation (xii) sought to inform research question four (that is, what factors influence the society's perception of environmental benefits?) and applied OLS regression for analysis. An F-test was applied to test the robustness of all variables in answering the research question. However, to determine the specific variables that influenced that perception, this study made some hypotheses that were subjected to t-tests. The variables hypothesized to explain WTP were identified from the conceptual framework, theoretical framework and on past empirical work on non-market valuation which were mostly reviewed under the studies that have applied CVM.

Different non-market valuations studies have come up with region specific findings regarding the factors that influence the WTP. The CVM concept is relatively new in developing countries and has generated varying results regarding the factors that influence WTP value. For example, while having high level of education should suggest a positive WTP for environmental programs (Wiser, 2007) previous research on the effects of education on WTP have found mixed results. Blomquist and Whitehead (1998), Witzke and Urfei (2001), Li et al., (2004) have found that the level of education as having a positive influence on environmental WTP while Danielson et al. (1995), Krupnick et al., (2002), Bergmann et al., (2006) have found a negative effect on WTP. Finally, Popp (2001), Berrens et al., (2004), and Veisten et al., (2004) have found that the level of education as having no significant effect on WTP.

This study therefore made few hypotheses in the multiple variable econometric model Equation (*xii*) although all other variables of interest were investigated as shown in Table 5. Income, educational level and number of children in the households' were hypothesised to positively influence WTP. These observations have also been made by studies such as Ojeda et al., (2007) and Longo et al., (2007).

Other variables that were assumed to improve income levels; employment status and credit sources were also hypothesized to influence the WTP positively. The number of rooms in the household, households land size and consumer ranking of air polluting were taken as inherent endowment factors and thus hypothesized to influence the WTP positively. The distance from the tea factory was hypothesized to influence the WTP negatively. This was based on the assumption that the further the household was from the pollution point source the least likely it would be affected by that pollution (Tulyenge, 2002). Other variables such as awareness, internal validity of responses and social capital were also investigated to assess how they influence WTP for the environmental benefits associated with Gura SHP.

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Table 5: Hypothesis tested in the analysis for WTP model.

Variable: Definition	**Apriori sign**
Awr : Dummy for Awareness variables; 1 if aware of the Gura SHP, 0 otherwise	(+ve/-ve)
Awr : Dummy for health detriment awareness: 1 if associates any detrimental health effect with TF, 0 otherwise.	indeterminate
Y : Total monthly Household income.	(+ve)
Age : Age of the household head in years.	indeterminate
Ed : Total number of years schooled by household head.	(+ve)
hhh : Dummy for household head; 1 if father, 0 otherwise	indeterminate
Ar : Dummy for consumer ranking of air polluting; 1 if ranks environment high, 0 otherwise.	(+ve)
Ds : Distance between the pollution source and the HH	(-ve)
Und : Dummy for consumer understanding and sincerity in answering the questions; 1 if found to understand and sincere, 0 otherwise	indeterminate
$Emplsts$: Dummy for employment status; 1 if formally employed, 0 otherwise	(+ve)
fin : Dummy for financial commitments; 1 if consumer could commit some money to cheaper electricity connection, 0 otherwise.	indeterminate
fin : Dummy for financial sources; 1 If sought credit from financial institutions, 0 otherwise.	(+ve)
$hhxt$: Number of rooms in the household	(+ve)
$hhxt$: Households land size in acres	(+ve)

Source: Author's Survey

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The results are arranged as follows: Section 4.1 gives a summary of the frequencies and some mean statistics of the households' social, economic and demographics characteristics. Sections 4.2 to 4.5 give the households' characteristics of the energy sources. The sections that follow seek to address the study objectives and are arranged as follows; Sections 4.6 to 4.7 give findings of the current and projected rural electricity demand and a series of multivariate analyses of the factors that influence rural electricity demand. Sections 4.8 to 4.9 give the local communities valuation of environmental benefits associated with Gura SHP and the factors that determine that value. The study used statistical package for social sciences (***SPSS 15.0***) mainly for analysing social, economic and demographic characteristics and Statistical Package (***Stata 9.0)*** mainly for F and t-tests statistics and regressions results. Tables in this chapter are generated from author's data sources.

4.1 Household social-economic and demographics characteristics.

The households' descriptive characteristics can be generally presented as shown in Table 6. The results shows that 59% of those interviewed were males and 41% were female. The average number of people living in a household was 5.83 with a standard deviation of 3.29 implying that there was a big disparity in the number of people living in the households. These results fall within the range of those found by the Kenya integrated household budget survey, KIHB, of 2005 and Rural Electrification Master Plan, REMP, of 2008 which give the mean household size for Nyeri as 4.1 and 5.3 respectively (Government of Kenya, 2005; 2008). The small difference however could be attributed to the population increase over time and densities at different locations. The results show that 91% of the interviewed households were headed by male and 9% by female. Results also show the average household's land size holding to be 2.6 acres with a standard deviation of 2.2 implying that there a big disparity in the land size holding. This figure is different to the Government of Kenya (2005) KIHB results that give the average land size as 1.5 acres. The reason for this difference could be attributed to land tenure-ship in terms of family and individual ownership. Of the interviewed households around 74% had children below the age 18 years while 26% had none.

Table 6: Household's social-economic characteristics descriptive statistics.

Variable	Mean	Std. Dev.
Percentage of male-headed households	0.91	0.32
Percentage of male respondents	0.59	0.49
Number of people living in the household	5.83	3.29
Households land size	2.57	2.21
Percentage of households with children below the age of 18years	0.74	0.44
Average number of years in School	10.94	2.91
Percentage of formally employed household heads	0.11	0.31
Total household's income	14552	9321
Average age of the household head	48.67	10.74

Results indicate that mean number of years the household head attended school as approximately 11 years with a very small standard deviation implying that most of the household heads had some formal education of up to secondary level. These results are consistent with the Government of Kenya (2005) KIHB which gives 99.5% as having attended school while only 0.5

as not attended. The employment status of the respondents shows that only around 11% had formal employment and 89% as not. These results are supported by the Government of Kenya (2008) REMP that gives non-formal employment (agriculture) of the area as being 79.8% of all the employments. The results shows that the combined average total income of the household was Kshs 14, 552 with a standard deviation of approximately Kshs 9320 implying that there is a big disparity in the income levels of the households in the study area. This income data is consistent with the Government of Kenya (2008) REMP that found that 80% of the households in Nyeri district as earning between Kshs 5,000 to 20,000.

The age limit of the household heads was categorized in classes of 10 from the age of 25 to 55 and the mid value per class taken for analysis. The mean age of the respondent was calculated as 48.6 years with a standard deviation of 10.7 implying that there is no big disparity in the ages of the household heads. This figure is consistence with the Government of Kenya (2005) KIHB which gives more than 60% of the population in Nyeri district as being between the ages 15-64.

In conclusion these findings indicate that households in the study area are highly educated and have little disposable incomes. This is because the main sources of income is generated from non-formal employment (mostly farming) which is highly handicapped by the small land size holdings and the high number of dependants who consume that income. The incomes however, could be improved through land intensification.

4.2 Household energy uses

The households' energy uses and the associated costs are represented in Table 7. The first row of the table shows the common energy types used by households in the region. The second row shows the percentage number of households' using a particular type of energy in the region. The third row shows the mean monthly bills for every energy type. The rest of the table maps each energy type with its uses in percentage form.

The results indicate that firewood is the most commonly used energy source with about 93% of households using it for various purposes which include but not limited to domestic cooking, heating water and house heating. The mean monthly cost of firewood was Kshs 776. The firewood consumption results are consistent with the Government of Kenya (2002; 2008) Ministry of Energy demand, supply and policy strategy paper for households and REMP which gives firewood consumption to be 89% and 93% respectively. The Government of Kenya (2008) REMP gives the mean monthly payment for firewood in Central and Eastern Kenya at Kshs 395. The big difference could be attributed to the location's supply and demand dynamics that have partly been stretched by huge tea factory demands (EATTA, 2008).

Table 7: Households' energy uses.

	Electricity	Fire-wood	Wood Waste	Char-coal	Kero-sene	Crop Residue	LPG	Solar	Dry Cell	Vehicle Battery	Gen	Can	Bio gas
Percentage (%) households energy use	17.9	92.5	37.3	53.8	86.3	25.5	17.5	12.7	80.2	40.1	9.9	9.9	0.9
households mean monthly bills(Kshs)	596.9	776.4	316.3	892.8	365.6	0.0	1.472	0.0	170.1	81.0	0.0	24.8	0.0
Domestic cooking(%)	34.2	100.0	86.1	82.5	4.9	100.0	83.8	0.0	0.0	0.0	0.0	0.0	100
Heating water (%)	52.6	95.9	79.7	76.3	6.6	98.1	32.4	0.0	0.0	0.0	0.0	0.0	0.0
House heating (%)	15.8	83.2	49.4	76.3	0.0	51.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lighting (%)	97.4	3.1	0.0	0.0	97.8	5.6	21.6	77.8	0.0	14.1	0.0	14.3	0.0
Ironing (%)	73.7	0.0	0.0	67.5	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Home business (%)	15.8	0.0	0.0	1.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Entertainment (%)	81.6	0.0	0.0	0.0	0.0	0.0	0.0	85.2	0.0	0.0	0.0	0.0	0.0
TV (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.2	0.0	0.0	0.0
Radio/cassette (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.6	94.1	0.0	0.0	0.0
Flashlight (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Clock (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.6	0.0	0.0	0.0	0.0
Refrigeration (%)	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Standby (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100	0.0
Others (%)	10.5	1.0	2.5	0.0	0.0	0.0	2.7	7.4	1.2	2.4	0.0	0.0	0.0

The mean household monthly costs for kerosene and dry cell battery stood at Kshs 366 and 170 respectively. The Government of Kenya (2008) REMP report gives the mean monthly payments for kerosene and dry cell battery at Kshs 436 and 155 respectively which is consistence with this study results given the error margins and location specificity. Other bio-fuels are also used in various quantities and these include charcoal 54%, wood waste 37% and crop residue 26%. The mean monthly costs for these energy types are given as Kshs 892, 316, and 0 for charcoal, woodwaste and crop residue respectively. The Government of Kenya (2002) Ministry of Energy demand, supply and policy strategy paper for households gives the national average charcoal use to be 47%, farm residue 29% and wood waste at 5.1 %. The Government of Kenya (2008) REMP gives the mean monthly costs for charcoal in Central region to be Kshs 384 but lacks data for other bio-fuel related energy types. The differences in the uses and the charcoal costs could be attributed to the location difference. These bio-fuels are used mainly for domestic cooking, heating water, house heating and ironing.

Electricity use was limited to only 18% of the interviewed households and its uses mainly range from lighting 98%, entertainment 82%, ironing 74%, heating water 53%, domestic cooking 34%, house heating 16%, home business 16%, refrigeration 11% and other uses (mobile charging) at 11%. The mean monthly bill for electricity for the month of June 2008 was given at approximately kshs 600. The Government of Kenya (2008) REMP report on electricity connection in the region is within that range and was given at 13% of the population while the mean monthly bill for the month of April 2007 was Kshs 714. The results of electricity use and costs will be discussed further in the following sections. Vehicle battery is used by 40% of the interviewed households mainly for entertainment and lighting. The mean monthly bills for charging the vehicle battery are given as Kshs 80. Solar energy is used by 13% of the household for lighting and entertainment. The LPG was used by 18% of the respondents for domestic cooking, heating water and lighting. The monthly bill for the LPG is given at Kshs 1472. Candles are used in very little households (10%) mainly as standby energy. These results are consistent with the Government of Kenya (2008) REMP that gives the solar panel connection in the region to be 35%. LPG use as 12% and candles at 15%. The report also gives the mean monthly bills for charging the vehicle battery and candle costs for Nyeri at Kshs 62 and 13 respectively. The slight difference, however, could be attributed to the location difference.

In conclusion the results have shown that the use of clean energy sources (Solar and Electricity) is small compared to that of unclean energy sources. The households energy costs results in reference to those connected to the national grid and those not connected have also shown that the former spend a substantially small amount of money for lighting and entertainment than the latter. This is because the costs incurred by households not on the national grid for lighting and entertainment (Kerosene, drycell battery, solar and vehicle battery) are more that the costs incurred from electricity use by their counterparts. These energy substitutes could be targeted for taxation, tariffs or bans to encourage shifts in the use of preferred energy types.

4.3 Frequencies of connections of the households on the national grid

In order to understand the responsiveness of consumers to the Government of Kenya initiative of the rural electrification programme, a frequency table for the year the households were connected to the national grid and their intended additional appliance use was ran and presented in Table 8.

Table 8: Frequencies of households connected to the national grid

	Mode	Percentage (%)
Year connected	2007	11
	2005-2008	56
Plans for more appliances?	Yes	50
	no	50
Additional appliances (intended)	lighting	38
	farm mechanism	23

Table 8 shows that 56% of households connected to the national grid were connected between the year 2005 and 2008. These findings show a slightly positive response to the government of Kenya's initiative of expansion of rural electrification programme to most active centres in rural areas (Government of Kenya, 2005). Half of those connected had future intentions of adding more appliances which included mainly lighting and farm mechanism. Consequently, the projected increase in demand out of the intended addition of appliances was tested as a function of income in the demand analysis regression model.

4.4 Frequencies of households' not connected to the national grid

Table 9 shows the frequencies of characteristics of those not connected to the national grid. The Table shows that 87% of those not connected to the national grid consider the KShs 35,000 connection fee (for the 70% within the rural electrification range) to be very high but would consider getting connection at flexible rates. Only 2% of the interviewed households could afford the electricity connection of Kshs 35,000 fee. However, 38% of the interviewed households

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Table 9: Frequency statistics for households not on the national grid

	Given Reason	% Number of HH
Reason for not being connected	Connection cost high	87
	Expects government to pay	1
	Family rivalry	1
	Cannot afford currently	7
	No perceived benefits	1
	Others	3
	Connection fee	% Number of HH
Connection possibilities against the indicated connection fee	Kshs 000	9
	Kshs 0001-5000	12
	Kshs 5001-10000	41
	Kshs 10001-15000	24
	Kshs 15001-20000	10
	Kshs 20001-25000	2
	Kshs. over 25000	2
Household location from the marginal rural electrification point	Distance	% Number of HH
	Within 600m radius	70
	Beyond 600m radius	30
	Use	% Number of HH
Intended electricity use	Lighting	100
	Domestic ccooking	48
	Heating water	62
	Ironing	78
	Entertainment	89
	Home business	63

4.5 Independent samples test for households characteristics and fuel energy costs

To determine the social-economic and fuel costs variables that are statistically significant between households connected to the national grid and those not connected, an independent sample t-test was ran and the results are presented in Table 10.

Table 10: Indepedent sample t-test for households characteristics and fuel energy costs

Variable	Mean Difference	Std. Err	t	Sig. (2-tailed)
Number of years in school	-1.34	0.53	-2.55**	0.012
Presence of Children below the age of 18	-0.06	0.08	-0.69	0.491
Employment Status	-0.17	0.06	-3.05***	0.003
Total income	-10,577	1545.4	-6.85***	0.000
Age of the Household Head	-3.94	1.95	-2.02**	0.045
Number of rooms per household	-2.42	0.58	-4.18***	0.000
Land size	-0.02	0.41	-0.06	0.954
Total Costs of fuel	-659.98	298.48	-2.21**	0.028
Proportion of Fuel Cost to Total income	+2.526	0.74	-1.31	0.191
Costs of Firewood	+21.72	208.97	0.1	0.917
Costs of Wood waste	+60.19	36.83	1.63	0.104
Costs of Charcoal	-147.40	111.32	-1.32	0.187
Costs of Kerosene	+244.15	49.96	4.89***	0.000
Costs of LPG	-340.89	137.72	-2.48**	0.014
Costs of Dry cell batteries	+103.60	21.65	4.79***	0.000
Costs of Vehicle batteries	+27.08	7.54	3.59***	0.000
Costs of Candles	-8.84	1.44	-6.12***	0.000

Degrees of freedom df 210

Mean difference (mean of households not on national grid less households on the national grid)

*****Significant at 1%,**Significant at 5%, *Significant at 10%**

Six social-economic variables; education level, employment status, total income, age of the respondent, number of rooms per households and fuel costs are found to have significance difference between the two categories. The results show those households connected to the national grid were 1.34 years more educated than those not connected to the national grid. These results were statistically significant at 10% level. The results also show the mean employment status of the households connected to the national grid was higher than those not connected to the national grid. These results were significant at one percentage level. The mean total income for the households connected to the national grid was Kshs 10,578 more than the counterparts not on the national grid and this was statistically significant at one percentage. There was a four-year statistically significant age difference of the household heads between the two groups with those connected to the national grid as being more aged than those not connected. The households connected to the national grid also have approximately 2-3 more rooms in their households than those not connected to the national grid at one percentage significance level. The results show that the households connected to the national grid spent approximately Kshs 660 more on fuel costs than those not connected. This result is statistically significant at five percent level. These findings show that households' connected to the national grid are more affluent and have more disposable incomes than their counterparts not connected to the national grid.

The results show that five energy sources costs; kerosene, LPG, dry cell battery, vehicle battery, and candles as having statistically significant difference between the two groups. The mean costs for LPG and candle costs for the households connected to the national grid are higher than those not on the national grid at Kshs 340.89 and 8.84 at five percent and 10% significance levels respectively. Considering that the main use for LPG is cooking, it can be inferred that households on the national grid supplement firewood for domestic cooking more often than those not on the national grid. Candle is used as lighting standby energy for the households on the national grid during power outages and this explains the significant difference between the two groups. However, the mean costs of kerosene, dry cell batteries and vehicle battery costs for the households not connected to the national grid are higher than those not on the national grid at Kshs 244, 104 and 27 at one percentage significance level. Since the main uses of the three energy sources is lighting the results show that the households not on the national grid spend a significant higher price on the lighting energy sources than their counterparts that are connected to the national grid.

4.6 Current and projected rural electricity demand

Table 7 in Section 4.2 gave the mean electricity bill in the month of June 2008 as Kshs 596. When this amount is translated to the units of energy consumed according to the KPLC July, 2008-rates, it totals 73kWh per household per month and a peak load[2] demand of 1.25 kW. This is because the indentified household's main rural electricity uses (given in Table 7) are lighting 97.4%, Entertainment 81.6% and Ironing 73.7%. Table 11 shows the current and projected rural electricity demand based on different discounted connection fees in the study area.

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[2] Peak load demand- the maximum electricity wattage demanded at any hour of the day

Table 11: The current and projected electricity demand along the Gura SHP area

Connection fee	% Number of customers	Average Number of HH around $20KM^2$ from Tea Factory	Average electricity energy monthly consumption (MWh) @73kWh/hh	Average Peak load Demand (MW) @1.0kW/hh
over 25000	18	1434	104.68	1.79
20001-25000	22	1736	126.72	2.17
15001-20000	30	2415	176.30	3.02
10001-15000	50	3962	289.25	4.95
5001-10000	83	6642	484.83	8.30
0001-5000	93	7434	542.68	9.29

The results show the current electricity peak demand based on the 18% of the population already connected to the national grid to be 1.8 MW or an average monthly electricity energy consumption of 105 MWh (See Row 2 of Table 11). This figure is higher than the national monthly average rural electricity energy consumption demand of 65 kWh and could be attributed to the study area's slightly higher average levels of monthly income of Kshs 14,552 compared to the national average monthly income of Kshs 12,000 (Government of Kenya, 2005). The Government of Kenya (2008) REMP report also gives households mean monthly electricity energy consumption demand for Nyeri district to be 70kWh. The results also show the peak load demand and projected monthly electricity energy consumption based on reduced connection fees (See Rows 3 to 7). The results show that the highest peak load demand and mean monthly electricity energy consumption demand to be 9.3 MW and 543 MWh respectively (See Row 7 of Table 11).

4.7 Factors affecting rural electricity demand along the Gura SHP

As a first step, summary statistics for all variables were calculated to determine whether the mean responses for a given independent variable were statistically different from those presented in the descriptive statistics in Sections 4.1and 4.5. To validate the statistics all variables were also subjected to Shapiro-Wilk (W) test for normal data to determine whether they followed a normal distribution. The definitions, means, standard deviations and test for normality are included in Table 12. The Table indicates the measures of central tendency and dispersion for each explanatory variable. The mean standard deviations and Shapiro-Wilk test statistics for normality distributions shows that all explanatory variables as having normal curves. The Shapiro-Wilk tests for normality shows that the probability of getting a value greater than zero as being highly rejected. This implies that this study fails to reject the hypothesis that the explanatory variables are normally distributed. All explanatory variables were therefore included in the final regression analysis. The means of households with presence of children below 18 years, household head, and employment status variables are consistent with the described household characteristics in Section 4.1. The results also show that the households mean monthly total income to be Kshs 14,574 and the mean age of the household head to be 48.7years.

Table 12: Definations and descriptive statistics for the explanatory variables

Variable	Mean (Std.Dev)	W-test for Normality	
		W	p>|z|
Natural logarithm of the monthly price for firewood	4.21***(3.36)	0.807	0.000
Natural logarithm of the monthly price for wood waste	1.00***(2.12)	0.889	0.000
Natural logarithm of the monthly price for charcoal	3.14***(3.32)	0.833	0.000
Natural logarithm of the monthly price for kerosene	4.98***(2.00)	0.662	0.000
Natural logarithm of the monthly price for LPG	1.07***(2.53)	0.864	0.000
Natural logarithm of the monthly price for drycell battery	4.04***(1.98)	0.744	0.000
Natural logarithm of the monthly price for vehicle battery	1.18***(1.93)	0.872	0.000
Natural logarithm of the monthly price for candle	0.32***(0.96)	0.843	0.000
Highest number of years schooled by the HH	10.94***(2.91)	0.902	0.000
Number of people living in the household	5.73***(3.54)	0.593	0.000
Dummy for Presence of children below 18years. Scaled as 1 if Present and 0 otherwise	0.70***(0.44)	0.988	0.065
Dummy for household head. Scaled as 1 if father and 0 otherwise	0.89***(0.32)	0.94	0.000
Dummy for employment status. Scaled as 1 if formally employed and 0 otherwise	0.11***(0.31)	0.931	0.000
Total monthly households income	14573***(9337)	0.938	0.000
Age taken as continuous variable	48.67***(10.74)	0.973	0.000

***, **, *** represent levels of significance for normality at 10%, 5% and 1%, respectively.**

Since Table 7 results showed that household's choice of the energy types was found to complement each other for a particular use. the model was subjected to test for multicollinearity using a correlation matrix on all the explanatory variables. Appendix 1 shows the correlation matrix results of all the explanatory variables. The correlation matrix results shows that all the partial correlation coefficients of all the explanatory variables to be between -0.4249 to +0.569. The lowest coefficient is between candle costs and kerosene costs at -0.4249. This implies that candle and kerosene energy sources are the greatest substitutes of each other. The highest correlation coefficient is between drycell battery costs and kerosene costs at +0.569. This implies that drycell and kerosene energy sources are the greatest complements of each other. All the partial correlation coefficients apart from that of kerosene to dry cell batteries costs fall below the ± 0.5 implying that they are least correlated. The kerosene and dry cell costs correlation coefficient is slightly higher that 0.5 but less than 0.6. Partial correlation coefficients of 0.8 and more indicate high correlation between two independent variables and this cause's multicollinearity problem (Kennedy, 1985). The correlation matrix in Appendix 1 therefore shows that the model will not have multicollinearity problem. The double-logarithm model for demand analysis was run using a two-stage Heckman selection model and the results are given in Table 13.

Table 13 shows that about 48% of the new electricity connections are correctly predicted and the Chi-square (338.64) of the hypothesis that all regression coefficients are jointly equal to zero is highly rejected.

Table 13: Emperical results for electricity demand: Heckman two-step selection model

Explanatory Variables	Probability of Electricity Connection		Electricity Demand	
	Coefficient (Std. Err)	t-value	Coefficient (Std. Err)	t-value
Dummy for Head of household	0.592(0.648)	0.91	0.1927 (0.2689)	0.72
Number of years attended school	-0.013 (0.054)	-0.25	-0.038** (0.0194)	-1.97
Number of people living in HH	-0.045 (0.057)	-0.8	-0.092*** (0.033)	-2.81
Presence of children (age < 18yrs)	0.231(0.391)	0.59	0.161 (0.173)	0.93
Dummy for Employment Status	-0.071 (0.413)	-0.17	-0.193 (0.133)	-1.45
Total household's income	1.120*** (0.314)	3.57	-0.055 (0.298)	-0.18
Age of the household head	0.019(0.016)	1.2	0.0122* (0.006)	1.91
Dummy for electricity tariff			-1.0619*** (0.092)	-11.61
Natural Log of Price of firewood	-0.067 (0.044)	-1.53	-0.009 (0.021)	-0.41
Natural Log of Price of Wood waste	-0.146 (0.111)	-1.31	-0.069 (0.048)	-1.43
Natural Log of Price of Charcoal	0.0065 (0.046)	0.14	0.012 (0.018)	0.66
Natural Log of Price of Kerosene	-0.354*** (0.062)	-5.76	0.071 (0.085)	0.84
Natural Log of Price of LPG	-0.008 (0.054)	-0.15	0.010 (0.017)	0.6
Intercept	-11.0896*** (3.043)	-3.64	5.164 (3.268)	1.58
Inverse Means Ratio			-0.317 (0.403)	-0.79
Number of obs =		211		
Censored obs =		175		
Wald chi2(25) =		338.64		
LR chi2(12) =		92.63		
Prob > chi2 =		0.000		
Pseudo R^2 =		0.4804		

***, **, *** represent levels of significance at 10%, 5% and 1%, respectively.**

The probit regression results in Table 13 show household total income and the price of kerosene as the only variables that would lead to increased probability of new connections. The results show that total households' income as having a positive value and being significant at one percent. This implies that increased household's income would lead to high probability of new connections. These results are supported by Table 10: Section 4.5 results of the independent sample t-test result which showed significance mean income difference between the households on the national grid and those not on the national grid categories. These results are also consistent with the Government of Kenya (1980; 2002) energy demand and supply status studies that found the overall the price of electricity connection was high relative to households' incomes. The results also show the price of kerosene as being inversely related to the probability of electricity connection at one percent significant level. When the price of kerosene is increased by one percent there will be a high probability of new connections. This could be explained by the fact that kerosene is the closest substitute to electricity for lighting as shown in Table 7 in Section 4.2.

The electricity demand regression results show own-price of electricity and three social economic variables as influencing electricity demand. The results also show that the inverse mills ratio is not significant implying that there would not have been a selection bias between the variables that shift the probability of household connection and those that affect the level of household electricity consumption were the study to use a single stage electricity demand analysis. The own-price elasticity results indicate that electricity is considered as a luxury good and an increase in electricity tariffs would lead to significant reductions in electricity demand (Varian, 1992). This consumption trend could be attributed to the readily available cheap energy substitutes in rural areas as observed by Lyman (1994). This study therefore fails to reject the hypothesis that electricity own price influences demand negatively. The other tested hypothesis of cross elasticities of the other energy sources are found as being not statistically significant and are rejected in this study.

The results show that literacy levels influence electricity demand. Households with higher education level were found to be demanding less electricity. This phenomenon could be attributed to the fact that those with higher education might be aware of energy benign uses. The number of people living in the household affects electricity demand negatively. Since high number of children is taken as a proxy for poverty (Tsakloglou and Panopoulou, 1998) these results indicate that increased poverty will lead to reduced electricity demand. There is a direct relationship between the age of the household head and electricity demand implying that households headed by aged people are more likely to demand more electricity. This result could be explained by the fact that as people tend to age they retire more in their rural from urban homes and this increases the likelihood that they would consume more electricity (Government of Kenya. 2002).

4.8 Local community's valuation of the environmental benefits associated with the Gura SHP

4.8.1 WTP for the environmental benefits of the Gura SHP

Before calculation of the WTP, an exclusion exercise of "protest votes[3]" from zero WTP was carried out. Table 14 shows the reasons given by households that were not WTP anything for the project implementation.

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[3] Protest votes are the zero votes that are considered invalid because the respondents are assumed to act in protest against the implementing authority while giving their votes.

Table 14: Frequency statistics of the reasons given for not WTP

Reason	Frequency	Percentage
HH does not perceive any benefits	1	3.4
HH currently constrained financially	11	37.9
HH thinks other stakeholders should pay	2	6.9
HH does not trust the implementing body	15	51.7

Table 14 shows that 51% of the respondents in this category of zero WTP voters said that they do not trust the implementing authority while 38% said that they are currently constrained financially. Seven percent of the respondents in this category thought that other stakeholders should pay while only three percent said that they do not perceive any benefits. Apart from the 38% who gave the reason of "being constrained financially in the meantime", other responses were treated as protest votes. Analysis of the zero answers to the WTP question have resulted in the exclusion from the sample of those individuals who stated a WTP of zero for reasons other than financial restrictions (Adams et al., 2007). In such cases, it is believed that the individuals acted in protest against the implementing authority. In this way, the protest votes were excluded from the sample and all zeros WTP values changed to one. The results of the exclusion exercise are shown in row three of Table 15.

Table 15: Societies implied mean WTP for the implementation of the Gura SHP out of the perceived environmental benefits.

	N	Amount (Kshs)				W-test
		Min	Max	Sum	Mean	P>|z|
All responses WTP	212	0	24000	878560	4144	0.849
WTP>0	182	1000	24000	878560	4827	0.778
WTP excluding Protest votes	193	0	24000	878571	4552	0.777

e sample means WTP was Kshs 4144 while that of 182 respondents with positive response as Kshs 4827. The sample mean of WTP excluding "protest votes" was Kshs 4552. The apiro-Wilk W-test statistic for the three samples (W=0.849, 0.778 and 0.777) indicate that the mples come from a normally distributed population of observations (Greene, 1993).

This study therefore used the mean WTP with the excluded "Protest votes" for analysis. The number of respondents in this category was 193 (91%). Each respondent was willing to contribute an amount totalling Kshs 4552 during the two years towards the implementation of the project. This amount equals to a monthly sum of approximately Kshs 190. The total populations' mean values were aggregated to sum Kshs 16.6M implied annual society's WTP for the environmental benefits associated with the Gura SHP. Assuming Gura SHP will have a production capacity of 2.8 MW and using the emission abatement conversion[4] figures of Table 3, this amount would translate to annual abatement of 1173 tons of CO_2. To get the societal money equivalent of a ton of CO_2 (valuation of a ton of CO_2) this study divided the societal total annual WTP by the expected annual tons of abated CO_2 to get a valuation of Kshs 1399/tCO_2 or US$ 20/tCO_2 (using an exchange rate of Kshs 70 to US$ 1 as of July 2008). Most of the results in the damage cost literature carried out in developed countries are in the range of US$ 5 to 125/tCO_2 (Pearce et al., 1996). The calculated figure can be considered high in a developing world context and could be attributed to communities' high ranking of the environment and the method employed in its calculation. Studies that employ the WTP methodology and use a demand curve approach, find estimates for the values of CO_2 emissions much higher than those based on the damage cost method, suggesting that the benefits to society are substantial (Longo et al., 2008).

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[4] Emission Conversion factors is given by 0.8ton CO_2/MWh multiplied by 0.6 load factor (IPCC, 1996).

4.8.2 Factors that influence the WTP for the environmental benefits

As a first step, summary statistics for all explanatory variables were calculated. The means, standard deviations and test for normality are included in Table 16. The table indicates the measures of central tendency and dispersion for each explanatory variable. The means standard deviations and Shapiro-Wilk test statistics for normality distributions shows that most explanatory variables as having normal curves apart from the dummies for social capital, Gura SHP awareness and environmental benefits awareness. The Shapiro wilk tests for normality shows that the probability of getting a value greater than zero for the three variables as being high. This implies that this study fails to reject the hypothesis that social capital, awareness of Gura SHP and environmental benefits variables are not normally distributed. In this respect, the three variables were dropped from the final regression analysis. The mean distributions of dummy variables for ranking of the environment, presence of children below 18 years, understanding of the questions, source of financial base, household head, and employment status are the consistence with those of the described general household characteristics in Section 4.1. The results also shows the mean age of the respondents with positive WTP to be 38.3 years, the mean monthly total income as Kshs 15, 410 and the mean distance to the tea factories as 1.58 km. These results are consistent with those presented in the descriptive statistics in Section 4.1.

Table 16: Definitions descriptive and normality test statistics for the explanatory variables for the WTP model.

Variable	Mean (Std. Dev)	W-test for Normality	
		W	(p>|z|)
Dummy for Gura SHP Awareness; Scaled as 1 if aware of Gura SHP and 0 otherwise.	0.39(0.49)	0.995	0.721
Dummy for Health detriments Awareness; Scaled as 1 if aware of Health detriments and 0 otherwise.	0.79**(0.41)	0.983	0.013
Dummy for Environmental benefits Awareness; Scaled as 1 if aware of Envi benefits and 0 otherwise.	0.58(0.50)	0.999	1.000
Total household income	15409***(9418)	0.938	0.977
Age of household head	38.3***(1.08)	0.964	0.000
Dummy for Presence of children below 18years. Scaled as 1 if Present and 0 otherwise	0.70***(0.44)	0.988	0.065
Number of people living in the household	5.73***(3.54)	0.593	0.000
Number of years in school	2.92***(0.77)	0.901	0.000
Dummy for Household head; Scaled as 1 male and 0 otherwise.	1.12***(0.39)	0.940	0.000
Dummy for Consumer ranking of air pollution; Scaled as 1 if ranks Envi high and 0 otherwise.	0.24***(0.43)	0.977	0.002
Distance between the pollution source and HH	1.58***(0.90)	0.957	0.000
Dummy for Consumer understanding and sincerity in answering the questions; Scaled as 1 if sincere and 0 otherwise.	0.77*(0.43)	0.988	0.065
Dummy for employment status; Scaled as 1 formally employed and 0 otherwise.	0.11***(0.31)	0.931	0.000
Current Financial Status variables;(amount consumer could immediately commit to electricity connection);	12212***(5836)	0.907	0.000
Dummy for credit; Scaled as 1 if sought credit and 0 otherwise.	0.10*** (0.31)	0.996	0.000
Dummy for Social capital (group Membership); Scaled as 1 if a member of a group and 0 otherwise.	0.42 (0.49)		0.897
Number of rooms in the household	6.09*** (3.41)	0.867	0.000
Household's land size	2.74***(2.39)	0.604	0.000

***, **, *** represent levels of significance for normality at 10%, 5% and 1%, respectively.**

order to better understand the determinants of the household WTP responses and to learn hether these determinants are consistent with economic demand theory, an OLS regression nalysis was performed with the WTP amount as the dependent variable. *Stata package 9.0* was sed for the regression analysis. Table 17 shows the generated regression results.

able 17 shows the Breusch-Pagan and Cook-Weisberg test for heteroskedasticity which had the ull hypothesis as the disturbance terms having constant term. The tests results shows that the robability of obtaining a value greater than the Chi-square is 0.001 implying that the equation is highly significant at 99% confidence interval. This study thus fails to reject the null hypothesis that the constant variance of the disturbance term is constant. This model therefore fulfils the OLS assumption of constant variance of the disturbance term.

The results show the linear regression of the positive WTP responses against various variables. The regression results show the adjusted R^2 to be 0.40 implying that the variables in the table jointly explain 40% of the total factors that affect the WTP (Gujarati, 2002). Three variables: household`s total monthly income, employment status and financial commitment were found to influence the WTP in a statistically significant manner.

able 17: Muiltivariate regressions analysis for the WTP

planatory Variables	**Dependent Variable**			**WTP**
	Coefficient	**Std. Err.**	**P>t**	**t**
ummy for Health detrimental Awareness	-0.079	0.222	0.723	-0.36
otal household income	1.258***	0.341	0.000	3.68
ge of the household head	0.079	0.357	0.22	0.824
umber of years in school	0.018	0.076	0.815	0.23
ummy for household head	-0.209	0.152	0.173	-1.38
ummy for Consumer ranking of air ollution	-0.097	0.113	0.395	-0.85
istance between the pollution source and H	-0.019	0.233	0.935	-0.08
ummy for Consumer understanding and incerity	-0.113	0.129	0.382	-0.88
Dummy for Employment status	0.486**	0.197	0.016	2.47
urrent Financial status	0.641***	.115	0.000	5.56
ummy for Credit Access	0.166	0.180	0.359	0.92
Dummy for Presence of children below the ge of 18yrs	0.566	0.476	0.236	1.19
Number of people living in the household	0.003	0.06	0.956	0.06
umber of rooms in the household	-0.071	0.106	0.507	-0.67
Land size	0.101	0.079	0.203	1.29
ntercept	3.617***	1.194	0.003	3.03
Number of obs =	**193**			
Adj R-squared=	**0.4021**			
Prob > F =	**0.000**			

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance ***Variables: fitted values of wi***

chi2(1) = 10.71 ***Prob > chi2 = 0.0011***

Dependent variable: WTP*Significant at 1%,**Significant at 5%, *Significant at 10%**

expected the total monthly income had a positive coefficient. The income was significant at e percent implying that an increase in monthly income would lead to the households reasing the WTP substantially. This result is also supported by economic theory which states at as income increases people's consumption tends to shift from normal goods to luxury goods e the environment (Varian, 1992). This finding is also supported by other studies like ulyenge (2002), Ali (2005) and Longo et al., (2008) which found that income is major factor at determines the WTP. The study therefore fails to reject the hypothesis that income fluences WTP positively. The other tested hypothesis of education and presence of children elow 18 years have the expected sign but have limited statistical significance implying that this study rejects the hypothesis that they positively influence WTP in the study area.

The results show other investigated variables that were found to influence WTP in a statistically significant manner. Of the investigated variables, formal employment and current financial status were found to influence WTP positively. Formal employment was found to affect WTP positively at one percent significant level. This implies that an increase in formal employment would lead to a substantial increase in the WTP value. The amount households not on the national grid would be willing to pay for subsidised electricity connection was taken as a proxy for the current financial status and this seemed to affect the WTP positively at one percentage significance level. The positive influence of employment status and current financial status on WTP could be attributed to the fact that the two variables act as proxies for increased and high household's disposable incomes respectively. Overall these results demonstrate construct validity of this study (Mitchell and Carson, 1989).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

This study sought to determine the current and projected rural electricity demand and the factors that affect that demand. The study then determined the community's valuation of the indirect environmental benefits of the Gura SHP project and the factors that determine that valuation. The study found that the current electricity peak load demand (based on only 18% of the population connected to the national grid) for the areas surrounding the four tea factories to be approximately 1.79MW. The current monthly energy consumption demand was found to be 105MWh. The projected electricity peak load demand was calculated to range from 1.8 to 9.3MW. The projected monthly energy consumption demand was calculated to range from 125 to 543MWh. These demand figures show that there is enormous potential for rural electrification (clean energy) and policy should therefore target encouraging more investments in clean energy generation to meet that demand.

The current electricity connection fee, households' income and the cost of kerosene were found as the probable factors that could affect new electricity connections. Policy should therefore target initiation and enhancement of income improving projects to increase new electricity connections.

The study also found that electricity pricing, poverty levels proxy (number of people living in the household) and education levels as some of the factors that negatively affect electricity consumption demand. The age of the household head was found to affect electricity consumption demand positively. These factors could be targeted by policy to enhance electricity consumption demand. Suggested policy recommendations would be to stabilize electricity prices through proper control of supply and demand so as not to hurt economic development during supply deficit periods. The demand control could also target price control of the close electric energy substitutes to shift on electricity use. On education, policy should target improving education standards as a way of encouraging low electricity uses and increase new connections.

The associated societal total annual environmental benefits of the areas surrounding four tea factories was found to be KShs 16.6M or US$ 20/tCO2. This figure is higher than most parts of the world implying that people in the area highly value the environment. The ranking of the environment to other social issues also revealed that the population ranks it high. This is a very good indicator to policy maker who should fearlessly target environmental benign activities in the area. Policy should just target environmental awareness and remindial activities (programmes) to the population surrounding the Gura SHP for environmental protection. Results found that income and employment status affected WTP positively. The policy implication of these results is that economic empowerment activities that aim at increasing incomes should be enhanced in the study area for the communities to protect and appreciate the environment better.

5.1 Recommendations for further research

Further research on the following aspect may be valuable wholesome package of the environmentally friendly energy production and use that would address the supply and demand deficit:

1. **Analysis of effective lending for electricity supply**

The study has established that there is a big potential (demand) of electricity. The study has also established that key in increasing the electricity demand would be bolstering people's incomes.

Improving incomes could be attained through institution of affordable lending schemes. The model to be followed in attainment of the same however, has not been established and a study on determining the most efficient models for lending to the community for electricity connection could help in acceleration of rural electricity connection.

2. Effect on different energy users and uses on the environment and economy

The study has established that the readily available cheap energy substitutes in rural areas as being a major factor that highly determines electricity demand and has recommended price control of the close electric energy substitutes. An ex-ante study on the economic and environmental effects of the targeted energy substitutes would identify and prioritize (mapping out) the order of most economic and environmental efficient energy types. This study would also quantify user energy demand on all other energy types and the prices thereon. Such a study would also go along way in National and Global policy issues such as green accounting.

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APPEDIX 1: Correlation Matrix of the Explanatory Variables in the 2-Step Heckman Selection Model

	Ln Education level	No of Pple living in HH	Presence of Children below age 18years	Employment Status	Ln Total HH income	Ln Age	Ln Price firewood	Ln Price Woodwaste	Ln Price Charcoal	Ln Price Keresene	Ln Price LPG	Ln Price Drycell Battery	Ln Price Vehicle Battery	Ln Pri Candl
Ln Education level	1.00													
No of Pple living in HH	-0.02	1.00												
Presence of Children blow age 18years	-0.27	-0.07	1.00											
Employment Status	0.18	-0.08	0.07	1.00										
Ln Total HH income	0.41	0.004	-0.09	0.33	1.00									
Ln Age	-0.22	0.13	0.39	-0.01	0.00	1.00								
Ln Price of firewood	0.03	0.08	-0.07	0.04	0.05	-0.06	1.00							
Ln Price of Woodwaste	0.06	-0.05	-0.17	-0.06	-0.11	-0.09	0.11	1.00						
Ln Price of Charcoal	0.22	-0.03	-0.02	0.11	0.23	-0.03	0.06	0.11	1.00					
Ln Price of Keresene	-0.04	0.08	-0.16	-0.18	-0.21	-0.17	0.03	0.13	0.06	1.00				
Ln Price of LPG	0.24	-0.04	-0.06	0.12	0.36	-0.02	-0.13	-0.17	0.17	-0.24	1.00			
Ln Price of Drycell Battery	-0.11	0.07	-0.01	-0.09	-0.25	-0.02	-0.02	0.06	-0.03	0.57	-0.28	1.00		
Ln Price of Vehicle Battery	0.10	0.08	-0.08	-0.04	-0.11	-0.04	0.09	0.21	0.06	0.17	-0.17	-0.01	1.00	
Ln Price of Candle	0.16	0.05	0.07	-0.01	0.16	0.09	-0.01	-0.03	0.05	-0.42	0.19	-0.31	0.01	1.00

Appendix 2: QUESTIONAIRE

University of Nairobi/UNEP/EATTA

Ex-Ante Analysis of Rural Electrification demand; costs and Environmental benefits: The case of Gura SHP, Kenya. 2008

Household Survey 2008

HH Name ______________________

Respondent(s) ______________________

Household No.

Date:(dd/mm/yy)....../07/2008

HHID ____________

MEM ____________

SURDATE ____________

(Instruction: Record the member number of the Respondent from the Demography table on page 10 after the survey is completed.)

Identifying Variables:

Supervisor: ____________

Enumerator: ____________

Province: _Central__

District: ___Nyeri____

Division: ____________

Location: ____________

Sub-Location: ____________

Village: ____________

SNUM ____________

ENUM ____________

PROV ____________

DIST ____________

DIV ____________

LOC ____________

SUBLOC ____________

VIL ____________

SECTION 1:
RURAL ELECTRIFICATION DEMAND ANALYSIS

ENERGY CONSUMPTION

please indicate which of the following fuels your household has used for any activity in the past. Code appropriately in the boxes provided.

[1] Yes [2] No

egy1. grid electricity.If yes go to ele1-10 then to ele 28-30. If no go to ele 11-30	**egy1**
egy2. firewood. If yes go to FW	**egy2**
egy3. wodwaste. If yes go to WW	**egy3**
egy4. charcoal.If yes go to CHA	**egy4**
egy5. kerosine.If yes go to KER	**egy5**
egy6. farm residue. If yes go to CPR	**egy6**
egy7. LPG(gas).If yes go to LPG	**egy7**
egy8. solar energy.If yes go to SOl	**egy8**
egy9. drycell battery.If yes go to DRY	**egy9**
egy10. Vehicle battery.If yes go to VEH	**egy10**
egy11. eletricity(own generation).If yes go to Gen	**egy11**
egy12. candles.If yes go to CAN	**egy12**
egy13. biogas.If yes go to BIO	**egy13**

ELE(ELECTRICITY)

ele1. what purpose do you use electricity?

[1] Yes [2] No

ele1.1lighting	**ele1.1**
ele1.2 domestic cooking	**ele1.2**
ele1.3 heating water	**ele1.3**
ele1.4 Ironing	**ele1.4**
ele1.5refrigeration	**ele1.5**
ele1.6 entertainment	**ele1.6**
cpr1.7 househeating	**ele1.7**
cpr1.8 home business	**ele1.8**
cpr1.9 other(specify)	**ele1.9**

ele2 what is your average monthly bill for electricity in Kshs?	**ele2**
ele3what is the average kilowatt hour units consumed per month?	**ele3**
ele4 Which year were you connected to the grid	**ele4**
ele5. do you use electricity for home business?	**ele5**
[1] Yes [2] No.	
ele6 if yes for what purpose? Else skip to the next energy type	
ele6.1 lighting	**ele6.1**
ele6.2refrigeration and cold storage	**ele6.2**
ele6.3food processing	**ele6.3**
ele6.4irrigatio	**ele6.4**
ele6.5hairdressing	**ele6.5**
ele6.6tailoring	**ele6.6**
ele6.7farm mechanism	**ele6.7**
ele6.8milling	**ele6.8**
ele6.9others(specify)	**ele6.9**
ele 7 is the business connection the same as domestic?	**ele7**
ele8. if yes what is the average kilowatt hour do you consume per month?	**ele8**
ele9. do you have plans to add more electric appliances?	**ele9**
ele10. if yes which ones?	
ele10.1 lighting	**ele10.1**
ele10.2refrigeration and cold storage	**ele10.2**
ele10.3food processing	**ele10.3**
ele10.4irrigation	**ele10.4**
ele10.5hairdressing	**ele10.5**
ele10.6tailoring	**ele10.6**
ele10.7farm mechanism	**ele10.7**
ele10.8milling	**ele10.8**
ele10.9others(specify)	**ele10.9**

C

ele11 why are you not connected to the national grid(for those not connected to the national grid)? [1]connection costs high [2]expects government to pay [3] family rivarly [4]cannot afford curently due to other commitment [5]household does not percieve any benefits [6]other(specify)..	**ele11**
ele 12 can you afford to pay for electricity provided at a cheaper price? [1] Yes [2] No	**ele 12**
ele13 if yes how much(in Kshs) would you be willing to contribute? Else skip to the next energy type	**ele13**
ele14if connected to the grid what electricity appliances do you intent to buy?	
ele14.1 lighting	**ele14.1**
ele14.2 domestic cooking	**ele14.2**
ele14.3heating water	**ele14.3**
ele14.4Ironing	**ele14.4**
ele14.5 entertainment	**ele14.5**
ele14.6refrigeration	**ele14.6**
ele14.7 cold storage	**ele14.7**
ele14.8food processing	**ele14.8**
ele14.9irrigation	**ele14.9**
ele14.10hairdressing	**ele14.10**
ele14.11tailoring	**ele14.11**
ele14.12farm mechanism	**ele14.12**
ele14.13milling	**ele14.13**
ele14.14others(specify)	**ele14.14**
ele15is the hh within 600m radii from the nearest transformer? [1] Yes [2] No	**ele15**

CREDIT, SOCIAL CAPITAL AND HOUSEHOLD CHARACTERISTICS

ele16 are you a member of any social group? **ele16** ☐

[1] Yes [2] No (if yes go to ele17 and 18 else go to ele19)

ele17 is the group associated with financial assistance to members? **ele17** ☐

[1] Yes [2] No

ele18are all the group members on the national grid(for those not within the 600m transformer radii)? **ele18** ☐

[1] Yes [2] No(if no go to ele 19)

ele 19 is there plan for joint electricity connection(for those not within the 600m transformer radii) **ele19** ☐

[1] Yes [2] No(if yes go to ele20 if no go to ele21)

ele20what stage is the venture? **ele20** ☐

[1]Initial[2] in progress[3] due completion

ele21what is preventing the joint connection initiative from taking place? **ele21** ☐

[1] lack of cohesion [2] electricity connection prohibitively high[3]divergent goals [4] other(specify)..

ele22Did any household member try to get any credit for the rural electrification connection? **ele22** ☐

[1] Yes [2] No(if yes go to ele23 if no go to ele27)

ele23 Did you receive the credit that you tried to obtain? **ele23** ☐

[1] Yes [2] No(if yes go to ele24 and 25. if no goto ele26

ele24How much credit did you receive **ele24** ☐

ele25For the two main sources of credit, what was the source and the amount that you received from each? **ele25** ☐

[1] SACCO[2]bank[3] MFI/NGO [4]friend/relative[5] other(specify).....

ele26If you tried to get cash credit but did not get what was the reason for not getting? **ele26** ☐

[1] No collateral[2]had outstanding balance[3] no response [4] other(specify)......................................

ele27what was the reason for not applying credit? **ele27** ☐

[1] No collateral[2]had outstanding balance[3]percieved high interest rates[4] other(specify)....................................

ele28What are the terms of ownership of your land? **ele28** ☐

[1] permanent [2] Rental[3]Temporaly ownership[4] other(specify...........

ele29how many rooms are in your house? **ele29** ☐

ele30What is your HH land size? **ele30**

D

FW(FIREWOOD)		
fw1. what purpose do you use firewood?		
fw1.1 domestic cooking	fw1.1	
fw1.2 heating water	fw1.2	
fw1.3 house heating	fw1.3	
fw1.4 Lighting	fw1.4	
fw1.5 home business	fw1.5	
fw1.6 other(specify)	fw1.6	
fw2 how do you obtain your firewood? [1] collect/given only [2] purchase only[3] mainly purchase/collect some [4] mainly collect/purchase some[5] other(specify	fw2	
fw3 where do you collect your firewood from(for those that apply-collection)? [1] Boundary/fences [2] Crop land[3] woodlot [4] Roadside[5]Neighbor [6] Trustland [7] Gazetted forest[8]others	fw3	
fw4 how much time was used in collecting firewood by the following members?(hours per month)		
fw4.1 adult male(s)	fw4.1	
fw4.2adult female(s)	fw4.2	
fw4.3children	fw4.3	
fw5 what is the one way distance is covered in collection?	fw5	
fw6 how much (in kshs)do you but monthly firewood requirements? (include costs of transportation)	fw6	
WW(WOODWASTE)		
ww1. what purpose do you use WW?		
ww1.1 domestic cooking	ww1.1	
ww1.2 heating water	ww1.2	
ww1.3 househeating	ww1.3	
ww1.4 lighting	ww1.4	
ww1.5 home business	ww1.5	
ww1.6 other(specify)	ww1.6	
ww2 what type of ww do you use [1] Timber offcuts [2] saw dust/shavings[3] other(specify	ww2	
ww3 how much time was used in collecting ww by the following members?(hours per month)	**ww3**	
ww3.1 adult male(s)	**ww3.1**	
ww3.2adult female(s)	**ww3.2**	
ww3.3children	**ww3.3**	
ww4what is the one way distance is covered in collection?	**ww4**	
ww5how much do you buy ww-monthly requirements? (applicable to those that purchase) include costs of transportation	**ww5**	
CHA(Charcoal)		
CHA1. what purpose do you use charcoal for?		
Cha1.1 domestic cooking	**Cha1.1**	
Cha1.2 heating water	**Cha1.2**	
Cha1.3 househeating	**Cha1.3**	
Cha1.4 Ironing	**Cha1.4**	
Cha1.5 home business	**Cha1.5**	
Cha1.6 other(specify)	**Cha1.6**	
Cha2 how much did it costs in Kshs(include costs of transportation if applicable) per month?	**Cha2**	
Cha3 what was the one way distance travelled (Km) to Purchase charcoal?	**cha 3**	
KER(KEROSINE)		
ker1. what purpose do you use kerosine?		
ker1.1 domestic cooking	**ker1.1**	
ker1.2 heating water	**ker1.2**	
ker1.3 lighting	**ker1.3**	
ker1.4 home business	**ker1.4**	
ker1.5 others(specify)	**ker1.5**	
ker 2.how much money(convert from litre usage multiplied by costs) do you use in your hh per month?	**ker2**	
ker3what was the one-way distance(in km)is used to make this pirchase?	**ker3**	
ker4what type of kerosine appliance do you use?		
ker4.1lantern	**ker4.1**	
LPG(Liquified Petroleum Gas)		
lpg1. what purpose do you use lpg for?		

E

ker4.2cookerstove	ker4.2
ker4.3pressurelamp	ker4.3
ker4.4tin lamp	ker4.4
ker4.5 other(specify	ker4.5

CPR(Farm residue)

cpr1. what purpose do you use farm residue?

[1] Yes [2] No

cpr1.1 domestic cooking	cpr1.1
cpr1.2 heating water	cpr1.2
cpr1.3Ironing	cpr1.3
cpr1.4 househeating	cpr1.4
cpr1.5 lighting	cpr1.5
cpr1.6 home business	cpr1.6
cpr1.7 other(specify)	cpr1.7

cpr2 what type of farm residue do you use?

cpr2.1 maize cobs	cpr2.1
cpr2.2 maizestalks	cpr2.2
cpr2.3animal dung	cpr2.3
cpr2.4cofee pruning	cpr2.4
cpr2.5tea pruning	cpr2.5
cpr2.6other(specify)	cpr2.6

Cpr3 how much time was used in collecting farm residue by the following members?(hours per month)

Ww3.1 adult male(s)	Cpr3.1
Ww3.2adult female(s)	Cpr3.2
Ww3.3children	Cpr3.3
Cpr4 what was the one way distance travveled(in Km) traveled to collect farm residue?	Cpr4

(VEH)VEHICLE (LEAD) BATTERIES

veh1. what purpose do you use vehicle batteries?

lpg1 1lighting	lpg1.1
lpg1.2 domestic cooking	lpg1.2
lpg1.3 heating water	lpg1.3
lpg1 4 for home business	lpg1.4
lpg1 5other(specify)	lpg1.5
lpg2how much do you spend for LPG per month?	**lpg2**
lpg3 what was the one way distance travelled(in Km) to purchase LPG?	**lpg3**
(SOL)SOLAR ENERGY	
sol1. what purpose do you use solar energy?	
sol1 1lighting	**sol1.1**
sol1.2 entertainment	**sol1.2**
sol1 3 heating water	**sol1.3**
sol1 4 for home business	**sol1.4**
sol1.5other(specify)	**sol1.5**
sol2how may solar panels do you have?	**sol2**
sol3what is the power rating(watts)of your solar PV system	**sol3**
sol4 what was the cost of solar PV system in ksh?	**sol4**
sol5do you have solar water heating panels?	**sol5**
[1] Yes [2] No.	
sol6how many solar water heating panels do you have?	**sol6**
sol7what capacity(in litres)can be heated by the system?	**sol7**
(DRY)DRYCELL BATERIES	
dry1. what purpose do you use drycell batteries?	
dry1 1flashlight	**dry1.1**
dry1.2 radio/cassette	**dry1.2**
dry1 3 clock	**dry1.3**
dry1.4 others(specify)	**dry1.4**
dry2 how much do you spend on drycells per month?	**dry2**
Gen2 how much did you purchase the generator?	**Gen2**
Gen3how much power is generated by the generator(in kilowatt hour)	**Gen3**

F

veh1.1Television	veh1.1
veh1.2 radio/cassette	veh1.2
veh1.3 lighting	veh1.3
veh1.4 others(specify)	veh1.4
veh2 how much do you spend on the purchase of the battery?	veh2
veh3how often do you charge the battery per month?	veh3
veh3.1how much does the charge cost in Kshs?	veh3.1
veh4what is the primary charging source?	veh4
[1] home charger [2]solar panel.[3] commercial [4] other(specify	
veh5what is the one way distance travelled(KM) to have the battery recharged?	veh5
(Gen)ELECTRICITY -Generator	
Gen1. What purpose do you use generator energy?	
Gen1.1lighting	Gen1.1
Gen1.2 domestic cooking	Gen1.2
Gen1.3 heating water	Gen1.3
Gen1.4 Ironing	Gen1.4
Gen1.5refrigeration	Gen1.5
Gen1.6irrigation	Gen1.6
Gen1.7water pumping	Gen1.7
Gen 1.8stand by	Gen1.8
Gen1.9 entertainment	Gen1.9
Gen1.10 home business	Gen1.10
Gen1.11 other(specify)	Gen1.11

Gen4 what type of fuel do you use?	**Gen4**	
[1]Petrol [2] Diesel [3] kerosine		
Gen5how many days permonth do you run your generators?	**Gen5**	
Gen6 how many hours per day do you run your generator?	**Gen6**	
Gen7please estimate onthly expediture on fuel in kshs	**Gen7**	
(CAN)CANDLES		
can1. what purpose do you use candles?		
can1.1lighting	**can1.1**	
can1.2 standby	**can1.2**	
can1.3others(specify)	**can1.3**	
can2How many sticks do you use per month?	**can2**	
can3how much do yo spend for the purchase per month?	**can3**	
(BIO)BIOGAS		
bio1. what purpose do you use biogas?		
bio1.1lighting	**bio1.1**	
bio1.2 domestic cooking	**bio1.2**	
bio1.3 heating water	**bio1.3**	
bio1.4others(specify)	**bio1.4**	
bio2what was the totalcost of this bio plant?	**bio2**	
Plant in Kshs……………………		
Installation cost in Kshs……………………………		
bio3what is the costs of maintainance of the system?	**bio3**	

SECTION 2: ENVIRONMENTAL BENEFITS

Awareness and knowledge about Gura SHP

env1. Are you aware about the proposed Gura SHP?

[1] Yes [2] No. env1

env2 Do you associate any detrimental health effects with the tea factories?

[1] Yes [2] No. env2

envi3 What health detriments do you associate with?

[1] Respiratory [2] Eyes.[3] Earring [4] other(specify env3

WTP ELICITATION

Explain the following background information

Background Information
Small Hydropower Projects (SHP) produce power in small quantities and could be used by tea factories in reducing operating costs. increasing power supply reliability for rural electrification and reducing greenhouse gas emissions during tea processing. One of the perceived environmental benefits of the reduced emissions is the control of common respiratory diseases. The common respiratory diseases in the areas surrounding the tea factories are mainly caused by the inhalation of emissions from tea factories and indoor pollution out of use of kerosene lamps (for users). These diseases have been known to cause a number of sick days per annum for a normal human being in households unlike other similar areas that are not near Tea factories. During those sick days households are assumed to loose daily revenue plus incur health expenses for the medical care sought. The production of SHP will also lead to improved conservation of the water catchment which will have long term benefit of improved precipitation and increased water flow in rivers. In general SHP will lead to the realization of the following accrued indirect environmental benefits:

1. Improved Health
2. Increased Non-farm productivity
3. Increased agriculture productivity
4. Improved precipitation and water flow (climate change mitigation)

env4 Is the information presented new to you? env4

[1] Yes [2] No.

WTP elicitation

Assume that the project will be collectively financed by a fund which all the stakeholders (tea factories and farmers and surrounding communities) who support the implementation of this project would have to pay. The project would be realized by an independent organization and it would be financed exclusively by means of the fund. The fund works by pass- and fail principle: Either there is enough money for implementation of the project, or the money does not suffice for the envisaged benefits. In this case the project will not be realized and each proponent of the project gets his money back. Under those circumstances...............

env5... would you be willing to contribute to have the Project implemented? **env5** ☐

[1] Yes [2] No.(if yes go to env6. If no go to envi7)

env6 how much would you be willing to pay for 2 years as your contribution into such a fund to have that project implemented out of these environmental and economic benefits **env6** ☐

env7 Why are you not willing to contribute anything at all for the project implementation? **env7** ☐

[1] I don't perceive any benefits [2] I am currently constrained financially [3] Other stakeholders' should pay for it [4] I do not trust the implementing independent bodies[5] other(specify

env8 Should the environment be considered as a service that has an economic value? **env8** ☐

[1] Yes [2] No.

env9 How do you rank environment as a social problem in relation to the following(rank all from 1-top priority to 5-lowest priority) **env9** ☐

_educaton_crime_environment_unemployment_corruption

ENUMERATOR'S SECTION

enu1 How well did the respondent understand the questions? **enu1** ☐

[1] Well[2] Not too well[3] Not at all

enu2 How confident were you about the respondent's sincerity? **enu2** ☐

[1] Very confident[2] Not so[3] Not at all

enu3Approximate the distance to the tea factory **enu3** ☐

3 DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD MEMBERS

Demog07/08.sav (Key variables: hhid, mem)

Reference Period: The Past 18 months -Jan 2007to June 2008

Who is the head of the household 1 Father 2. Mother 3.other (specify)	**dem1**	
What is your gender Gender (1) Male (2) Female	**dem2**	
What is the highest level of education attained: 1 None 2. Primary 3. Secondary 4 Tertiary college 5. University	**dem3**	
Number of people in the household	**dem4**	
Presence of children below 18 years at home living with you [1] Yes [2] No.	**dem5**	
What is your Employment status: 1 Formally employed 2. Self employed 3 Unemployed 4. Student 5. Other................	**dem6**	
Which range best describes your monthly income for all wage earners of your household? (Circle category) 1 Below 2500; 2 .2500 to 5000; 3.5000 to 10,000; 4 =10,000 to 20,000; 5 =20,000 or more.	**dem7**	
Which range best describes your monthly NON-FARM income of your household? (Circle category) 1. Below 1000; 2 1000 to 5000; 3 5000 to 10,000; 4.=10,000 to 20,000; 5 =20,000 or more.	**dem8**	
Which range best described respondents age category. 1. Below 25; 2 .26-35; 3.36-45; 4. 46-55; 5. above 55;	**dem9**	

Remarks by the enumerator..
....
....
....
....

Thank you