AN ASSESSMENT OF SOCIO-ECONOMIC BACKGROUND OF CHARCOAL PRODUCTION, TRADE AND HOUSEHOLD USE IN BLANTYRE LOW INCOME SETTLEMENTS

Master of Science in Environmental Protection and Management (MSc EPM) Thesis

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(BSc Chemistry)

A thesis submitted in partial fulfilment of the requirements for a Master of Science in Environmental Protection and Management (MSc EPM)

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DECLARATION

I declare that this research entitled *An Assessment of Socio-economic Background of Charcoal Production, trade, and Household use in Blantyre urban fringe settlement* is my own work. It is submitted in partial fulfillment of the requirements for the Master of Science Degree in Environmental Protection and Management at the Polytechnic, University of Malawi. It has not been submitted for any other degree to any University.

SIGNATURE :

DATE :

CERTIFICATE OF APPROVAL

The undersigned certify that this thesis represents the student's own work and effort and has been submitted with our approval.

Dean – Postgraduate Studies and Research:_____

Signature:_____

Date:_____

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Head of Department:_____

Signature:_____

Date:_____

DEDICATION

This thesis is dedicated to my family more especially to my son Grecian, my parents: Mr and Mrs Kalenga and my brothers and sisters (Wycliff, Hazwell, Zenita and Thandiwe). Their unwavering support, patience and prayers were not in vain. May the good Lord bless them all.

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ABSTRACT

The dependence on charcoal as the major source of energy for cooking remains a hard-hitting challenge in our cities. Most of the households in Blantyre low income settlements rely on charcoal and this is being witnessed in the increases in the number of traders on charcoal, charcoal shops, as well as charcoal users in the city. This is a clear evidence that efforts to discourage charcoal business are ineffective and as a result there is much pressure on the forestry resources. The fast disappearance of trees has a number of environmental effects, one of which is the climate change, in the long run this is also affecting crop yields and deepening poverty. This report presents the findings of a study which was undertaken to examine the social- economic background of charcoal business in Blantyre urban fringe settlements. The study covered two townships, namely Ndirande and Chirimba. The selection of these townships was informed by the prevalence of hot charcoal business in those areas. In addition, these townships are among the low income settlements where most of the urban dwellers are found due to poverty and their main source of energy is charcoal; and increasing electricity tariffs seriously affect livelihoods of low-income and middle-income households majority of them being in the study areas.

The researcher used both structured and unstructured questionnaires to collect data from the charcoal producers, transporters, traders and the consumers. In addition to these, Focus Group Discussions, Key Informant Interviews and Observations were employed to obtain data from the target population. Investigating the factors that influence the charcoal use, 110 charcoal users were purposively selected. Using Multiple Regressions Analysis, 5 household socio-economic factors were identified that promote the use of charcoal in the households. These are (in order of contribution) literacy, size, gender, age, and income. The study revealed that, there is relationship between the charcoal use and the five predictor variables although it is not very significant. This weak relationship was attributed to perception among the respondents that electricity is more expensive than charcoal. Although some Non-Governmental Organizations (NGOs) and other stakeholders have been advocating for fuel-efficient charcoal stoves with an aim of reducing charcoal consumption rates, the adoption rate among the respondents is very low.

All the charcoal producers in the study area, use the traditional earth kilns and they do not have any knowledge on improved charcoal production technologies. This is because charcoal extraction in Malawi is done in secrecy although there is a provision in the forestry Act of 1997 that, charcoal business can be done upon being issued with a license from the department of forestry.

The study recommends that, they should be a political will to improve the socio-economic conditions of the residents in the low income settlements of the country to facilitate fuel transition from charcoal to cleaner fuels and other sources of energy. They should also be promotion of sustainable charcoal production and use of improved charcoal stoves.

Key words: Socio-economic factors, Environment, Deforestation, Charcoal, Low Income Settlements.

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LIST OF ABBREVIATIONS AND ACRONYMS

CHAPOSA	Charcoal Potential in Southern Africa
CO_2	Carbon Dioxide
CO	Carbon Monoxide
CH_4	Methane
EMA	Environmental Management Act
ESCOM	Electricity Supply Commission of Malawi
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
GHG	Green House Gas
GOM	Government of Malawi
ICPS	Improved Charcoal Production System also called Adam-Retort
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
LIA	low-Income Areas
MBAULA	Movement for Bio-Energy Advocacy Utilization and Action in Malawi
MDF	Malawi Defense Force
NEAP	National Environmental Action Plan
NEP	National Environmental Policy
NGO	Non-Governmental Organisation
NSO	National Statistical Office
NTFP	Non Timber Forest Product
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
T/A	Traditional Authority
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
USAID	United States Agency for International Development

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CHAPTER 1

INTRODUCTION

1.0 Background of the Study

It is a well-known fact that most households in developing countries including Malawi depend on the use of firewood and its derivative (charcoal) as a source of energy. The overdependence on charcoal as a source of energy is very common in Urban Low income Settlements. According to Matovu (2000), urban low-income settlements refer to the settlements where most of the urban poor (but not all residents) usually reside. The dwellings constructed by the poor in low-income settlements usually resemble conditions of slums. However, many of the low income settlements are characterized by a marked pattern of economic differentiation. Thus although many residents can be described as being poor or very poor, the area also may have a class of more well-to-do local entrepreneurs landlords, etc. Reports indicate that, fuel wood and charcoal supply about 95% of the domestic and commercial cooking energy needs in the developing countries (FAO, 2000). According to Roop (2013) the need for wood fuels arises from the low electrification rate in these developing countries. For example, in Malawi only 30% of urban households are on the electric grid. Of those 30% that have electricity, only 38% use electricity for cooking. Moreover, 43% of the urban population in Malawi depends on charcoal whilst 42% depend on firewood for energy (Ministry of Energy, Mines and Natural Resources, 2009).

Reports indicate that, about 60% of the charcoal used in Malawi comes from Forest Reserves and National Parks and almost 40% comes from customary land. Nearly 2% of charcoal used in Malawi comes from Mozambique (Ministry of Natural Resources, Energy and Environment, 2010). According to Malimbwi and Zahabu (2008), some of the factors influencing the choice of using charcoal instead of firewood in urban areas include:

- Charcoal has a higher calorific value per unit weight than firewood (about 31.8 MJ per kg of completely carbonized charcoal with about 5 percent moisture content as compared to about 16 MJ per kg of firewood with about 15 percent moisture content on dry basis,
- Due to its high calorific value per unit weight, it is more economical to transport charcoal

over longer distances as compared to firewood,

- Storage of charcoal takes less room as compared to firewood,
- Charcoal is not liable to deterioration by insects and fungi which attack firewood,
- Charcoal is almost smokeless and sulphur free, as such it is ideal fuel for towns and cities.

In addition to these, Ali and Victor (2013) enumerate three distinct uses of charcoal that makes it unique as household fuel. These are: charcoal is cleaner, easier, and less smelling than other biomass fuels; it is light weight, thus the conversion of wood into charcoal reduces its weight, and makes it easier and cheaper for transportation and it can also be used in smaller quantities, with cheap burning devices for domestic applications.

The most common method of charcoal production requires an axe, a shovel, a panga and a fork. The trees are cut and may or may not be left to dry before being cut into manageable pieces. The Firewood pieces are stacked in a neat mound up to 1.5 m high, before being sealed with earth. Fire is induced through an opening – usually at the base of the stack – and then allowed to spread before sealing the hole. When the burn is completed, the stack is unsealed and left to cool. The time depends on a number of factors – but especially on the kiln's dimensions and the size and species of wood used. Basically, the harder the wood, the better the charcoal (Knöpfle, 2004).

1.1 The research problem

Overdependence on charcoal as a source of energy is continuing to be a worrying phenomenon in Blantyre low income settlements just as it is the case in other cities of Malawi. This overdependence on biomass has a number of environmental effects, one of which is the climate change which is influencing floods and droughts that Malawi is currently experiencing. In the long run this is also affecting crop yields and deepening poverty. Malawi, just like many other developing countries, has had a number of studies on charcoal production, trade and consumption, with an aim to protect our forest resources (Kambewa et al., 2007). Recently the Government of Malawi started using Malawi Defence Force (MDF) solders to protect some of the Government forestry reserves. Dzalanyama forestry in Lilongwe and Kaning'ina forestry in Mzuzu are two of the government forestries which are currently being guarded by the MDF

solders to discourage the charcoal production. Despite these efforts from various studies and other stake holders like the natural resource experts, government and its development partners, charcoal business is still continuing. This increase in charcoal business is being witnessed in the increases in the number of traders on charcoal, charcoal shops, as well as charcoal users in our cities. This is a clear evidence that efforts to discourage charcoal business are ineffective, so charcoal business is likely to continue in Malawi. In a study done by Kambewa et al., (2007), it was observed that for the 6.08 million standard bags of charcoal produced annually in Malawi, an estimated 1.4 million m^3 of wood is required, or about 15 000 ha of forest per annum is being cleared due to charcoal extraction.

There is little knowledge on the social-economic factors that are influencing the increase in charcoal production, trade and use. The fear is that if the current charcoal production processes and consumption will continue to be unsustainable, our future generations will not be able to meet their energy needs and this will also lead to the loss of biodiversity.

It was therefore, the goal of this study to identify the socio-economic aspects related to the production, trade and household use of charcoal in the study area. The study was also intended to find out the proportion of the charcoal consumers who are currently using energy saving charcoal stoves and establish the extent to which charcoal producers in Malawi understand and adopt sustainable practices of charcoal burning. This would chart a plausible course by which to move the charcoal sector of Malawi towards sustainability.

1.2 Main Objective of the Study

The main objective of this study was to identify the socio-economic background of charcoal production trade and household use in Blantyre low income settlements.

1.3 Specific Objectives

Specifically, the study aimed at achieving the following objectives:

I. To study socio-economic factors that are influencing charcoal production, trade and household use in the study area.
II. To assess current charcoal demand in the study area

III. To identify the proportion of the charcoal consumers who are currently using improved charcoal stoves.

IV. To establish the extent to which charcoal producers in Malawi understand and adopt sustainable practices of charcoal production.

V. To identify barriers to sustainable charcoal production.

1.4 Research Questions

In order to achieve the objectives above, the following research questions were addressed.

I. What are the socio-economic aspects that are influencing charcoal production, trade and use in the study area?

II. What is the current charcoal demand in the study area?

III. What is the proportion of the charcoal consumers who are currently using improved charcoal stoves?

IV. To what extent do charcoal producers in Malawi understand and adopt sustainable practices of charcoal production.

V. What are the barriers to sustainable charcoal production?

1.5 Significance of the Study

This study has enormous significance both at global level as well as at national level. In view of the continuous global call to conserve the environment against the ever growing demand and supply of wood fuel with its ascending environmental threats, research of this sort is very crucial in achieving results that would inform the on-going discourse (Roop, 2013). The current efforts in combating global climate change are traceable to environmental shocks/imbalances (Roop, 2013). The study could contribute to the identification and formulation of global strategies, plans and programmes of action for the conservation and sustainable exploitation of biological diversity despite the increase in population and demand for energy.

Various studies have shown that, in Malawi national forest is rapidly depleting. According to the findings of a study by Barry et al., (2010), the deforestation rate in Malawi is about 2.8% per year. Some of the responsible factors for the situation include unsustainable traditional methods of charcoal burning, perennial bush fires, poor farming practices and logging. The

research findings and recommendations could serve as important information in managing the situation.

Additionally, this study could serve as one of the reference materials for future researches. This would not only promote academic successes through a contribution to the body of knowledge to academics and policy makers, but also would help the rural communities to sustain their livelihood. The general hope is that, government agencies including the District Assemblies in the study area could also enact effective environmental and charcoal production by-laws based on the research findings and recommendations.

1.6 Organization of the Thesis

The study was conducted in Ndirande and Chirimba Townships in Blantyre City, which is located to the south east of the capital city, Lilongwe. The study examined the socio-economic background of charcoal production, transportation, trade and household use in these two townships. The study examined the following variables in order to achieve its objectives; literacy level of household head, number of persons in the household, gender of the household head, age of the household head, and monthly income of household head.

The thesis is organised into five chapters. Chapter one contains the introduction to the study. It covers the background information, problem statement, research objectives and significance of research. Chapter two contains literature review on charcoal production, transportation, trade and household use. Concepts on environmental impacts of charcoal production and theoretical issues regarding charcoal production are also reviewed. Chapter three discusses the research design and the methodology of data collection and analysis on charcoal production, trade and consumption. Chapter four presents findings from data analysis and their discussions. Finally, Chapter five presents the conclusion and recommendations of the study.

1.7 Limitations of the Study

- The time allocated for the study was not adequate given the nature of the research study.

● Finance was also a limiting factor since it was a self-funded research.

1.8 Operational Definition of Terms

Charcoal: refers to a solid residue derived from the carbonisation, distillation, pyrolysis and torrefaction of wood (trunks and branches of trees) and wood by-products, using continuous or batch systems (pit, brick and metal kilns).

Woodfuel: includes all types of biofuel derived directly and indirectly from trees and shrubs grown on forest and non-forest land.

Carbonisation: Carbonisation is defined as the heating of wood in the presence of limited supply of air, whereby water vapor and other volatile products are driven off as gas or smoke (distillation process), and charcoal remains as the end product.

Forest: forest is defined as an ecosystem which is dominated by trees. It is a living system and resource which can be inherited from nature or created.

Forestry: the art and science of managing forests, tree plantations, and related natural resources.

Forest resources: refer to the stock of forest resources both timber and non-timber which private as well as public agencies manage with the aim of satisfying private or corporate needs.

Forest reserve: A forest reserve is defined as an area set aside and preserved by the government as a wilderness, national park, or the like.

Forest Plantations: Forest Plantations are intensively managed stands of trees that have been artificially planted with native or exotic species, laid out in rows.

Woodlot: a woodlot is an area restricted to the growing of trees.

Low-income areas: Low-income areas refer to the settlements where most of the urban poor (but not all residents) usually reside.

Slum: a slum is defined as a heavily populated urban area characterised by substandard housing and squalor.

Household: comprises a person or a group of persons generally bound by ties of kinship who live together under a single roof or within a single compound and who share a community of life in that they are answerable to the same head and share a common source of food.

Head of household: This is a person among the household members who is acknowledged by other members of household as such and is often the one who makes most decisions concerning the welfare of the members of the household.

Fuel: is any material that is used predominantly for heat, light or power (i.e. energy) by burning e.g. charcoal, kerosene and LPG.

Environment: is basically the circumstance or conditions that surround us. It comprises of physical, ecological, social, and economic environments.

Livelihood: Livelihood is defined as adequate stocks and flows of food and cash to meet basic needs.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Having established the general overview of the study in the previous chapter, this chapter seeks to provide broader information on nature and process of charcoal production, trade and household use and conditions of forestry resources in Malawi. The chapter further examines various types of charcoal stoves currently in use in Malawi and other countries, environmental impacts of charcoal usage, social economic aspects of charcoal business as well as the legal aspects and policies relevant to the charcoal industry.

2.1 A global overview on charcoal production, trade and household use

Below is a global overview on charcoal production, transportation, trade and household use.

2.1.1 Charcoal

Charcoal is defined as the solid residue derived from carbonization distillation, pyrolysis and torrefaction of fuel wood (FAO, 2004). On the other hand, Stephen (2011) defined charcoal as the general term for a range of carbonized materials with varying combustion and dark properties (Figure 1). Thus charcoal is a wood fuel made from burning wood in a low-oxygen environment. The dense black substance that results is made up mostly of carbon and produces more heat and energy per kilogram than wood (Tobin, 2011). Infact the biomass carbonization to charcoal results in a more refined, energy-intense fuel than raw biomass (Kenya Forest Service [KFS], 2013).

Figure 1: Picture of Charcoal (Source: KFS, 2013)

Reports indicate that, charcoal still remains the dominant source of cooking and heating energy for eighty percent of households in Sub Saharan Africa (SSA) (Arnold et al., 2006; Zulu & Richardson, 2013). Even in countries where electrification rates are at their highest, as in Nigeria or Ghana, 60-70% of the population still uses charcoal for cooking and heating. This clearly shows that, charcoal bussines is still very hot business in most of the African countries. The unsustainable charcoal production and usage which is common in these Sub Saharan African countries, has been agrowing concern due to its threat of deforestation, land degradation and climate change impacts. The sustainability of this high dependence on charcoal in these SSA countries is rely questionable. African countries are looking at the energy opportunities offered by other resources, including solar and wind energy. A historical overview on Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia indicates that, the demand for wood fuel is rising due to the relatively high cost of electricity and petroleum-based fuels (e.g. paraffin) as well as the rapid human population growth, particularly in urban areas (Falcão, 2005).

2.1. 2 Nature and Process of Charcoal Production

The charcoal production process comprises of tree felling, brushwood burning, kiln covering, wood carbonisation and access road construction, accompanied by atmospheric pollution (Gumbo et al., 2013). During the production process, the volatile and liquid matter is driven off leaving behind an energy-rich form of carbon that is light weight making it easy to transport and store. It is usually produced by raising the temperature of wood beyond the point at which many of its organic components become chemically unstable and begin to break down. According to Seidel (2008), carbonization occurs at temperatures between 450 to 600°C in absence of air.

Under these conditions organic vapours and gases are lost and part of the organic substances polymerizes, all of which increase the carbon content of the product. After the process is finished, charcoal is the final remains. The material left behind is a black, porous charcoal that retains the original form of the wood but has just one fifth the weight, one half the volumes, and about one third of the original energy content (Stephen, 2011). This production process may take up to a few weeks. About half of the energy in the fuel wood is typically lost in the process (but the charcoal produced has higher energy content per unit mass). When the process has ended, the kilns are opened or dug up and the charcoal is removed (NL Agency, 2010). To prevent most of the wood from igniting during production (pyrolysis), charcoal must be made in an environment of restricted air flow.

One of the factors affecting quality as well as the yield is temperature (Seidel, 2008). At relatively low temperatures around 300°C a high yield of charcoal is obtained. This charcoal has a high content of volatile material, which is undesirable because it produces noxious fumes during use. Temperatures around 600°C give lower yields but the charcoal has a low content of volatiles making it a preferred fuel. Charcoal can be made from both hardwood and softwood. However, hardwood is usually preferred because the charcoal has higher energy content and is easier to handle (Seidel, 2008).

2.2 Socio-economic factors that influence charcoal production

Based on the study conducted by Stephen (2011), charcoal industry, in spite of its environmental and social harm is a very important economic activity for both rural and urban economies. It has the potentials of reducing unemployment as well as contributing to improving living conditions. In a study conducted in the eastern part of Tanzania, it was discovered that unemployment rate among the rural communities is one of the social-economic factors that influences the rural communities in charcoal production (Monela et al., 1999). Most of the people who have been stricken by poverty and thus have low income and limited access to alternative energy sources tend to be forced to find refuge in charcoal extraction for employment and income. Thus poverty seems to be the prominent factor compelling people to engage in charcoal production. Reports indicate that, charcoal industries in some of the top producing countries, namely Tanzania and Uganda, employ tens to hundreds of thousands of citizens, many of whom receive up to 70% of their annual income from this market (Jones, 2015).

The study which was done in Zambia by Gumbo et al., (2013) agreed with the findings of Stephen which confirmed that poverty, lack of employment and limited livelihood options are major factors behind charcoal production. Acheampong (2005, p. 9) defines Livelihood as adequate stocks and flows of food and cash to meet basic needs. Various legislative gaps have been exploited by charcoal producers and, coupled with the ease of entry into the charcoal business, as well as limited monitoring by the Department of Forestry, illegal activities around charcoal have not been actively discouraged. Charcoal business is viewed as a source of additional income to households in most of African countries where charcoal is produced. At the national level, charcoal production contributes significantly to the respective GDPs of Zambia (3.7%), Malawi (3%) and Tanzania (2.3%) (Kambewa et al., 2007; Kalinda et al., 2008; Siedel 2008).

The other driver of charcoal production is the increase in human population numbers and growth rates. Thus population growth can be a rudimentary but effective indicator of trends in aggregate energy consumption (Falcão 2008; Siedel, 2008). More specifically, charcoal demand is driven primarily by rising numbers of urban poor, dependent on fuelwood for their cooking and heating needs (Matthews & Hammond, 1999). According to Chidumayo (2010), in Zambia, the contribution of charcoal production to deforestation has been increasing steadily since independence in 1964, and the growing urban population has been partly blamed for this. Given Zambia's 2.5% annual population growth rate and an annual urbanization rate of 3.2%, consumption and demand for charcoal will continue to rise in the country's cities (Chidumayo, 2010). In Mozambique, Tanzania and Malawi, respective urbanization rates of 4.0%, 4.7% and 5.3% have been observed and charcoal demand in these countries may trigger higher rates of production in their neighbours. As in other parts of eastern and southern Africa, charcoal production in Mozambique is stimulated by the purchasing power of urban dwellers (Falcão, 2008; Siedel, 2008). Thus unequal wealth distribution coupled with rapid population growth has kept demand for traditional fuelwood high in most of these developing countries.

2.3 Socio-economic factors that influences charcoal transportation, and trading

There are so many social – economic factors which influence people to engage in both charcoal transportation and trade. One of these social – economic factors is poverty. Reports indicate that, in almost all parts of Zambia (Hibajene & Kalumiana 2003; Falcao 2008; Chidumayo 2010),

Malawi (Kambewa et al., 2007), Mozambique (Falcao, 2008) and Tanzania (Malimbwi et al., 2005) charcoal is being sold due to poverty and it is a source of livelihoods for many people. Charcoal production contributes significantly to household incomes (Sibale & Banda, 2004; Mutamba 2007; Jumbe et al., 2008). The findings of these studies clearly show that, trade in charcoal is the major contributor to livelihoods to most of the people in these countries. Additional studies such as Jumbe et al., (2008), Mutamba (2007) and Mickels-Kokwe (2005) reinforce these findings. The charcoal trade also offers income generation through small-scale retail businesses run mostly by women, who sell charcoal in urban areas and along road servitudes. In Mozambique, a study has shown that approximately USD 200 million per annum of charcoal is sold in urban areas, primarily for cooking (Kwaschik, 2008). An estimated 92 800 people in Malawi depend on charcoal, including 46 500 producers, 12 500 bicycle transporters, 300 'other' transporters and 33 500 traders (Kambewa et al., 2007).

The charcoal trade also serves as a source of cash income and employment for both urban and rural dwellers. It is viewed as a source of additional income to households in much of Africa where charcoal is produced. In Zambia, as in most charcoal-producing countries, charcoal is produced in rural regions and transported to urban areas such as Lusaka through an intricate chain of traders and transporters (Gumbo et al., 2013). In both Zambia and Malawi, demand for transportation and marketing of charcoal is high compared to cropping, and creates the most jobs in rural areas. Besides the multitudes of bicycles ferrying charcoal on Malawian and Zambian roads, large (and often old) trucks are now regularly involved in charcoal transportation (Hibajene et al., 1993).

2.4 Socio-Economic Factors Affecting Household Charcoal Use

According to Gumbo et al., (2013), the consumption of resources, such as fuel wood, is heavily influenced by human population numbers and growth rates. Thus population growth is one of the effective indicators of trends in aggregate energy consumption. More specifically, charcoal demand is driven primarily by rising numbers of urban poor, dependent on fuel wood for their cooking and heating needs (Matthews & Hammond (1999) as cited in Gumbo et al., (2013)). Reports indicate that, for the past few years most of the sub-Saharan countries including Malawi have experienced high rate of urbanization (Gumbo et al., 2013). For instance in Mozambique,

Tanzania and Malawi, respective urbanization rates of 4.0%, 4.7% and 5.3% have been observed (Gumbo et al., 2013). Rapid economic growth in many developing countries has failed to bring about such a shift for millions of people; unequal wealth distribution coupled with rapid population growth has kept demand for traditional fuel wood high (Matthews & Hammond, 1999).

The poor economic status of most of those living in unplanned settlements also contributes a lot to the demand for charcoal. According to Hibajene and Kaweme (1993), charcoal, is relatively cheap compared to electricity and petroleum-based fuels, and therefore a preferred energy source of low-income peri-urban households. Other contributing factors include: price, transportation and availability of energy substitutes. Kambewa et al., (2007) observed that, the urban poor are particularly dependent on charcoal for cooking than the low density areas, because they have few affordable alternatives. Olubusola (2007) as cited in Ali et al., (2013) claim that the choice between firewood and charcoal among urban families seems to be dictated, to a large extent, by poverty with charcoal having the highest figure. Thus most families prefer to use charcoal because it is cheaper compared to other sources of energy. Besides income, Guptilla and Kohlin (2003) identify convenience, price and reliability of supplies as the main attribute influencing transition to charcoal use. In general, they observe that charcoal consumption decisions depend on how household characteristics interact with external factors such as prices, forest cover, population and urbanization.

2.4.1 Correlation between the Social economic status of Households and Type of Energy Source

Reports indicate that, household characteristics have either a positive or negative correlation with both the likelihood of consuming and demand of household cooking energy. Below is the literature on some of the correlations between the social economic status of households and type of energy source.

2.4.1.1 Family size

Family size is expected to have a positive correlation with use rate of less clean fuel (Nyembe, 2011). Ouedraogo (2006) in his study of household energy preferences for cooking in urban Ouagadougou in Burkina Faso showed the existence of significant relationships between the use rates of firewood, charcoal and liquid petroleum gas (LPG) and household size. He found that households with large family size were the poorest and were the main users of firewood. Conversely, the richest households had smallest family size and were the main user of charcoal. In general this depicted the fact that poor families have large family size and are likely to rather use firewood than charcoal whereas rich families are likely to use mainly charcoal at the expense of firewood. The same findings were arrived at by Mekonnen and Kohlin (2009) in their endeavor to find the determinants of household fuel choice in major cities of Ethiopia where households with large family size were found to be more likely to consume charcoal and wood and less likely to use kerosene. However they found that households with small family size consumed more kerosene whereas electricity consumption did not depend on family size. Interestingly, in determining factors affecting household fuel choice in Guatemala, Hetberg (2005) found that household size was associated with fuel stacking – larger households used more of both fuels – clean and less clean (LPG and firewood respectively).

2.4.1.2 Education level

Education level of the head of the household is postulated to have a negative relationship with rate of usage and demand of less clean fuels. According to National Statistics Office and UNICEF [NSO & UNICEF], (2008), the head of household is a person among the household members who is acknowledged by other members of household as such and is often the one who makes most decisions concerning the welfare of the members of the household. The higher the level of education of the household head the higher is the probability of consuming/using clean fuels. Mekonnen and Kohlin (2009) in their attempt to find the determinants of household fuel choice in major cities of Ethiopia conjectured that higher education (secondary and post-secondary) engendered households to more likely use electricity and kerosene than wood and charcoal as cooking energy. This finding was also confirmed by Ouedraogo (2005) in his study of household preferences for cooking in urban Ouagadougou in Burkina Faso. He found that households with a head that had higher education level had lower firewood adoption probability

than the household with a head with lower education. Heltberg (2005) in his study of factors determining household fuel choice in Quatemala also found the same that education level of the household head had a very significant negative impact on wood consumption while at the same time encouraging demand for LPG (clean fuel).

2.4.1.3 Gender of the household head

Gender of the household head is postulated to influence consumption of a particular fuel type. In major cities of Ethiopia, Mekonnen and Kohlin (2009) found that female-headed Households were more likely to use wood than charcoal while charcoal consumption was higher in male-headed households. They attributed this to the fact that males are generally more mobile than females and thus have better access to larger quantity of charcoal.

2.4.1.4 Age of the household head

Age of the household head is also said to have influence on the likelihood of consuming a particular fuel type. The households with older heads are more likely to consume wood fuel than non wood fuels. Mekonnen and Kohlin (2009) found that households with older heads in major Ethiopian cities were more likely to use wood and kerosene than electricity and charcoal while demand of wood increased with age. This finding was attributed to the role of habits on the part of older people reflected in their resistance to change if they grew up with wood as their main fuel as well as limited access to other energy types such as electricity.

2.4.1.5 Standard of living variables

Mainly in the literature, household standards of living are mainly reflected in the housing conditions which are proxied by the following variables: material used for floor, roofs, walls, if the house is electrified or not, and modern plumbing – water and/or sewerage system (Abeyasekera, 2002). Household standards of living are hypothesized to have a significant negative relationship with consumption of fuelwood. As standards of living for a particular household improve consumption of fuelwood declines and vice versa. Ouedraogo (2005) in his study of household energy preferences for cooking in urban Ouagadougou in Burkina Faso found that as standards of living improved, the use of firewood declined whereas the use of charcoal

and LPG rose. In urban Ethiopia, Abebaw (2003) in his study of household determinants of fuelwood choice found that possession of a refrigerator increased the probability of consuming charcoal contrary to his *a priori* anticipation that the probability of charcoal consumption would be reduced since refrigerator reduces the frequency of cooking.

2.5 Importance of Forest Resources in Malawi

Forest resources has a number of importance, for instance forests supply 90 percent of the country's energy needs and provide timber for construction and other industrial use. Forests also help maintain air, soil and water quality; influence biochemical processes; regulate run-off and groundwater, reduce downstream sedimentation and the incidence of flash flooding in addition to controlling soil erosion; provide watershed protection and enhance water resources (Ministry of Environment and Climate Change Management, 2012).

Not only that, forests and woodlands also provide medicinal plants and food. Forest and trees also contribute to rural incomes through collection and sale of various forest products including Non Timber Forest Products (NTFPs). Forests contribute to the economy of the country through timber exports and the provision of jobs in forestry. They are also important in the provision of ecosystem services such as nutrient cycling and soil formation. Forests act as carbon sinks and when they are reduced, carbon sinks are reduced, thereby putting Malawi on the map in terms of GHG net emission (Ministry of Environment and Climate Change Management, 2012).

2.6 Environmental Impacts of Charcoal Production

Charcoal production has a number of negative environmental impacts which is affecting the live hoods of people. One of the environmental problems which is very common is the deforestation which is a common problem among the sub-Saharan African countries including Malawi. Angelsen and Kaimowitz, (1999), as cited in Stephen (2011), observed that removal of woody biomass for fuel poses some far-reaching consequences on the structure and functioning of ecosystems worldwide. Fuel wood extraction has been cited for increasing soil erosion, reducing soil moisture content and decreasing soil fertility as nutrient leaching is increased. This is because increasing demand for charcoal means cutting more trees to get wood for charcoal making. Vegetative cover and subsoil nutrients are also fast declining through the

charcoal activities. These are then associated with more extensive effects including reservoir siltation, flooding, and water shortages due to shifting ground water regimes and biological impacts such as reduced faunal abundance and biodiversity. Additionally, in extreme cases such changes are expected to culminate in changes in weather patterns and, in drier regions, desertification, thus making the increased utilization of fuel wood by urban populations is one of the most critical environmental issues sub-Saharan Africa must address (Stephen, 2011).

The subtler impacts of tree-cutting for fuel wood are much more relevant when discussing the ecological impact of cutting. The most important perhaps is change in species compositions as cutting influences the survival and reproduction of preferred fuel species relative to less preferred species. A study done in Nigeria, Burkina Faso, Mali, Niger and Senegal found 18 substantially different species compositions in farmed parkland and a nearby ecologically equivalent forest reserves (Kindt et al., 2008). Tree species which do not coppice may disappear altogether. A study in Senegal noted that many tree species, particularly large trees have very few seedlings and therefore very low probabilities of regenerating naturally. Another study in Ghana found that an important fuel wood species such as mahogany used by 80 percent of households in two villages in the savannah belt during the past decade was no longer available (Stephen, 2011).

Nkonoki (1983) observes that widespread loss of trees has serious social and economic consequences. This is because extensive deforestation processes such as increased rate of soil erosion, poor infiltration and retention of rainwater and eventual worsening microclimate conditions lead to socio-economic hardships.

Another environmental concern of charcoal burning arises in the form of pollution produced at the site of production (Table 1). This pollution is a threat not only to the environment as a whole, through greenhouse gas emissions, but it also poses a health risk to those in close proximity to the kiln during firing. These environmental concerns must be properly addressed if the production of charcoal is going to move toward sustainability. The link between emissions of greenhouse gasses and global climate change necessitate that, emissions from kilns used to produce charcoal must be addressed. Table 1 below shows data from a study which was looking at greenhouse gas emissions associated with charcoal production in Brazil and Kenya. In the

first two cases (KEM 1 – 2), the kilns were constructed and operated by members of University of Nairobi's grounds staff using traditional methods. KEM 3-5 were constructed and operated by migrant charcoal makers. A selection of different trees reflective of wood fuel used normally in Kenya was used including *Cronton megalopis* (KEM 1), *eucalyptus* (KEM 2), and *black wattle* (KEM 3-5).

Table 1: Emission Factors, g of pollutant per kg of charcoal produced

Kiln Type	**% Charcoal Yield1**	**CO_2**	**CO**	**CH_4**	**$TNMHC_2$**	**N_2O**	**NO_x**	**TSP_3**
KEM 1	22.6	1992	207	35.2	90.3	0.12	0.087	41.2
KEM 2	21.6	3027	333	46.2	94.9	0.30	0.130	34.1
KEM 3	28.0	1787	240	47.9	93.8	0.16	0.035	25.0
KEM 4	31.1	1147	195	61.7	124	0.084	0.045	38.7
KEM 5	34.2	1058	143	32.2	60.1	0.068	0.021	12.8

KEM = Kenyan Earth Mound

The results in Table 1 shows that, while % yield of charcoal can be seen to increase with different wood sources, emission factors remain quite high. In each case there was more CO_2 produced than charcoal. Such studies show the dire situation as it stands presently.

2.7 Conditions of Forestry Resources in Malawi

According to the Ministry of Natural Resources and Environmental Affairs, (2004), the country has forest resources covering about 30 percent of the land area. It is estimated that about 28% (2,632,000ha) of the total land area of Malawi can be broadly classified as forest land covered with vegetation. Out of these forest resources, 16,000 ha constitute plantations and woodlots. Gazetted forest reserves amount to 85 in number, totaling to about 1,109,626 ha where as154, 137 ha are proposed forest reserves and protected hills slopes. In addition, 800,000ha are natural

woodlands on customary land (Ministry of Natural Resources and Environmental Affairs, 2004).

Forest resources on customary land are under pressure because it is annually being depleted because of opening of new gardens, estates, fuel wood, pole collection, overgrazing, building infrastructure such as roads, settlements and bush fires. This has led to deforestation and land degradation which have far reaching effects on living standards on the people. This situation has been aggravated by high annual population growth rate of over 2.4% (Ministry of Natural Resources and Environmental Affairs, 2004).

According to FAO (2007) report, Malawi's annual deforestation rate is estimated to be between 33,000 ha and 71,000 ha; an average could be of 52,000 ha per year. A slightly higher figure of 53,000 ha per year was given by FAO in 1995 for the deforestation rate between 1980 and 1990, and other sources have quoted 50,000 ha per year. A study which was conducted by Kambewa et al., (2007), reviled that, for 6.08 million standard bags of charcoal that is produced annually in Malawi, an estimated 1.4 million m^3 of wood is required, or about 15 000 ha of forest per annum. Charcoal production and the use of wood fuels in general are certainly contributors to such high numbers of trees felled, but it is the illegal harvesting of the trees without any reforestation or forest management practices that is causing the loss of those forests. If properly managed, wood can be a sustainable energy source for Africa and Malawi in particular. However, a large percentage of the wood being harvested for charcoal production in sub-Saharan Africa is being done illegally (Kambewa et al., 2007).

Other causes of deforestation and forest degradation in Malawi include cutting of trees for harvesting of edible caterpillars and use of herbal medicines. Malawi State of Environment and Outlook Report reviled that, cutting trees for collection of caterpillars is a common problem in Ntchisi and Chimaliro Forest reserves **(**Ministry of Natural Resources, Energy and Environment, 2010). Developmental activities have also contributed to deforestation. For example part of kalwe forest reserve has been cleared to pave way for the contraction of a new Nkhatabay district hospital. Road construction has been especially destructive as it involves removal of trees to pave way for the road as well as clearing and digging some areas for quarry. For example, parts of Matandwe Forest Reserve have been heavily degraded due the construction of Nsanje road. Indirect causes of deforestation are factors that influence actions that lead to deforestation and

forest degradation such as population growth, poverty, HIV/AIDS and land tenure **(**Ministry of Natural Resources, Energy and Environment, 2010). As population increases there is increase in production and consumption which requires increasing land under agriculture and settlement and increased consumption of forest products. Population growth also puts pressure for farmlands. The emergency of HIV/ AIDS is also aggravating the problem of unsustainable utilization of forests. Infected and affected people are using forests as safety nets and sources of income for vulnerable families such as child headed households **(**Ministry of Natural Resources, Energy and Environment, 2010).

2.7.1 Forest Reserves and Plantations in Blantyre District

Blantyre district has a quite number of forest reserves and plantations covering a total area of 15, 058.2 ha (UN HABITAT, 2011). Most of the said forest reserves and plantaions are planted with blue gum and are in advanced state of deforestation. For instance, Namatunu Forest Reserve in T/A Lundu which used to be the largest forest in the district is presently in a clear felled status, occupying 53 percent of the total land (UN HABITAT, 2011). There is much pressure on forest resources in Blantyre district. Most of the district is open land due to clearing land for agricultural, settlement and development and over 90% of household in Blantyre use fuel wood and charcoal as a source of energy. Compared to other district, deforestation rate in Blantyre is very alarming. Being the major commercial and Industrial city of the country, people are always migrating into the district looking for employment or business. Pressure indicators are fuel wood, charcoal, timber and poles and land for settlement and farming (UN HABITAT, 2011).

2.8 Available charcoal production technologies

Charcoal production technology centers on the kiln. In eastern and southern Africa, the earth kiln is predominant and two types are generally used – the pit kiln and the surface earth-mound kiln (Pereira et al., 2001; Siedel, 2008 as cited in Gumbo et al., 2013). Efficiencies vary between kilns, which, though similar in design, can differ in terms of size and performance. Additionally, patterns of stacking wood in the kiln, species composition, stem size, wood moisture content, climatic conditions and level of experience of the charcoal producer will also affect efficiency. For most traditional kilns, only 35% of available wood carbon is fixed in

charcoal, the rest being released into the atmosphere as smoke and non-condensed gases such as CO_2, CO, CH_4 and others (Gumbo et al., 2013).

The technologies available are described below from the simple traditional kilns for domestic production to advanced technologies with increasing potential for industrial production. The layout is organized in such a way that provides the description of the technologies, construction of kiln and process of carbonization, advantages and challenges, cost implication, durability, replicability, management with respect to groups and sustainable production and mobility in regard to raw materials. Despite the variations in kiln types, the steps for producing charcoal are essentially the same. The main differences are the kiln insulation material used and the arrangement (SEI, 2001 as cited in Herd, 2007). Below are some of the available charcoal production technologies.

2.8.1 The traditional earth-mould Kilns

This is a common kiln used for charcoal production. It can be constructed from locally available material. In brief, wood is collected and stacked in the polygonal shape of kiln. The wood is then covered with a layer of grass and the construction is sealed with soil. A small opening allows the control and monitoring of the process. When the kiln has been lit, it requires continuous attention for 3 to 15 days depending on the size. After the kiln has cooled down charcoal can be harvested. One of the advantages of the traditional earth Kilns is that it is easy to construct with minimal cost on material in use. It can also be constructed whenever the material is found reducing the hassle of transportation. In addition to that, traditional earth Kilns is a method that has developed for a long time and where the mastery of process control has been perfected. However, carbonization takes rather long and the process requires continuous attention. In most cases, control of the carbonization process is not always easy and often results to low grade charcoal, contaminated with soil crumbs and sometimes results in low recovery (Seidel, 2008).

According to Bailis (2003), in these kilns as shown in Figure 2 and 3 below, between five and ten tons of wood are needed to make 1 ton of charcoal (at a mass-based conversion efficiency of 10-20%). Thus, using such kiln between 60-80% of the wood's energy is lost in the production

process of charcoal. Therefore charcoal production using traditional kilns is associated with high consumption of wood.

Figure 2*:* Earth mount method of charcoal production (Source: Lurimuah, 2011)

The traditional earth kiln concept is shown in the Figure 3 below.

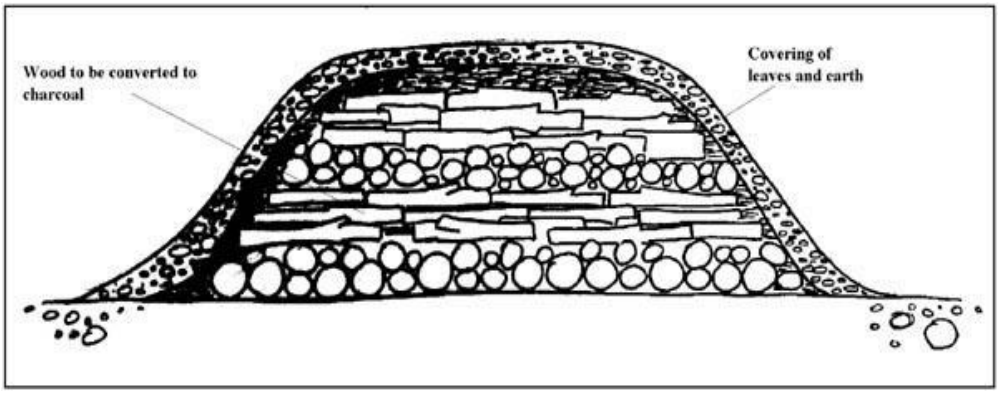

Figure 3: Traditional earth Kiln concept (Source: KFS, 2013)

2.8.2. Earth Pit Kilns

Earth pit kilns are the traditional way of making charcoal in many parts of the world and may represent the simplest technology for charcoal production. In brief, wood is stacked in a pit, sealed with a layer of grass and soil and carbonisation is started by igniting the wood at one end. Pit kilns can also be built in small size and thus they are suitable for families and even individuals. In pit kilns also large pieces of wood can be used. However, ventilation may be difficult to control and frequently carbonisation is incomplete, producing only low quality charcoal. Further, efficiency is lower than in earth mound kilns. To improve efficiency, pit kilns can be equipped with a chimney which allows the use of biomass other than wood such as

coconut shells. Nevertheless, even the improved pit kiln is less efficient than a well-managed earth mound kiln. In addition, pit kilns are labour intensive since a pit must be dug into the ground (Seidel, 2008).

2.8.3 Sustainable charcoal production technologies

The term sustainable resource management has different interpretations by different people and at different places. The Brundtland Commission sees it as a system of forest management that meets the needs of the present generation without compromising the ability of future generation to meet their needs (Todaro & Smith, 2009 as cited in Stephen, 2011, p. 9). According to Ayodele et al., (2009), sustainable exploitation of wood fuels involves the production of charcoal without endangering the natural environment. He stressed that sustainable management of forest is the maintenance of forest area and its species composition over a certain period of time. One of the benefits of sustainable charcoal production to the charcoal producers and traders is that they use less wood to make more charcoal due to efficiency. Consequently this may result in reduction on deforestation and they can be enough rain, fresh air, and improved firewood collection (Stephen, 2011). Sustainable fuel wood production and its efficient utilization can be achieved through adoption of improved energy technologies, with sustained efforts to eliminate waste of limited wood resources. Figure 4 critically analyzed this scenario.

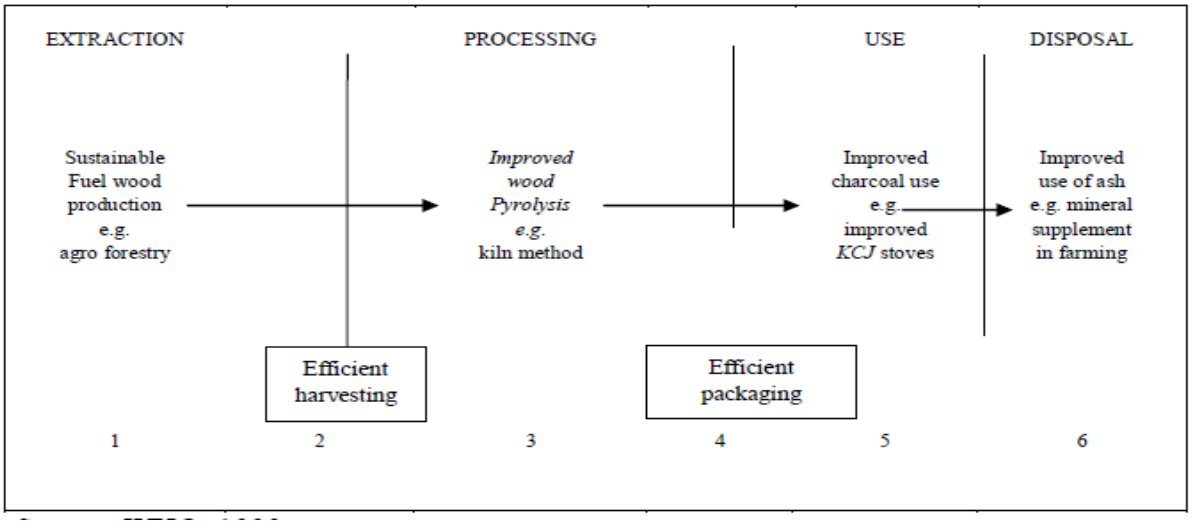

Figure 4: Sustainable consumption schemes for charcoal production and utilization (Source: Stephen, 2011)

There are several environmental and socio-economic benefits associated with each stage of Figure 4. The underlining interest is to achieve sustainable charcoal production and utilization. From Figure 4, when wood is obtained from the forest, using efficient ways by minimising destruction to other tree species, minimum waste will be generated. The wood is then converted into charcoal using improved/modern and efficient kilns after which proper handling needs to be ensured during packaging, storage and transportation to minimize waste. Charcoal easily crumbles depending on the quality. Finally, the charcoal produced needs to be consumed using improved cook stoves such as the Kenya Ceramic Charcoal (KCJ) in Kenya, which is recommended by WHO for consuming relatively less charcoal during cooking. Below are some of the sustainable charcoal production technologies being practiced in most of the sub Saharan African countries (Stephen, 2011).

2.8.3.1 The improved traditional earth kiln

The improved earth kiln, introduces a wire mesh or metal sheet to reduce contamination of the charcoal and chimneys to enhance control of the carbonization process. The process is similar to that of the traditional earth Kiln where the wood stack is tightly packed, covered with a thick layer of leafy green material followed by a heavy layer of soil. The main advantage is that it produces less defiled charcoal and control of carbonization process is improved by the presence of chimneys. However these benefits are achieved at an additional cost as both the mesh wire and chimneys cost money (Seidel, 2008).

2.8.3.2 Casamance-Kiln

According to Seidel (2008), the Casamance kiln was developed in Senegal and is an earth mound kiln equipped with a chimney. This chimney, which can be made of oil drums, allows a better control of air flow. This is an improvement of the earth kiln (Figure 5). The construction process follows an elaborate pattern of laying wood pieces putting the larger ones at the center, standing the wood upright and allowing for air flow within the lower levels of the stack. Once the stacking is complete; the wood is covered with a wire mesh and a thick layer of soil. The wood is covered fully with leaves and soil. Air inlets and a chimney are placed at the bottom of the kiln. This technology improves on control of the carbonization process and achieves better

recoveries. In Casamance kilns, the hot flues do not escape completely but are partly redirected into the kiln and this enhances pyrolysis. Due to this reverse draft carbonisation is faster and more uniform giving a higher quality of charcoal and efficiency up to 30 %. The kiln can also be constructed whenever the material is found and a little cost is incurred with the construction of the chimneys. Disadvantages of this kiln type are that it requires some capital investment for the chimney and it is more difficult to construct and it may not be appropriate for large scale charcoal production (Seidel, 2008).

a) (**b**)

Figure 5: The Casamance Kiln (a) Before covered with soil, (b) After covered with soil (Source: K F S, 2013)

2.8.3.3 Steel Kilns

There are different types of steel kilns which have been developed and are considered as some of the modern charcoal production (Figure 6). They are capable to carbonize even poor quality wood and can easily be transported when necessary. However as the annual output of a typical demountable steel kiln is about 100 – 150 tones, they are not suitable for high-volume production (Seidel, 2008). Furthermore, the investment costs may be as high as 1.000 US$, which limits the use of steel kilns considerably. Nevertheless the efficiency of steel kilns is high (27 – 35 %) and carbonisation is very quick (16 to 24 hours after ignition). Some of the examples of steel kilns currently in use in most of the African countries include: KEFRI type, Kinyanjui type, Portable metal Kilns (KEFRI) and Ring Kilns (Seidel, 2008).

a: KEFRI type kiln b: Kinyanjui type kiln

c: Portable Metal Kiln kilns

d: Ring Kilns

Figure 6: Steel Kilns (Source: KFS, 2013)

2.8.3.4 Brick kilns

Unlike the kilns discussed so far, brick kilns are usually stationary. The study by Seidel in 2008 revealed that, brick kilns have an efficiency of up to 30 % and are suitable for semi-industrial production of charcoal. One type is the truncated pyramid kiln, which is used in Chad mainly in the informal sectors. However, it has a lower efficiency than other brick kilns. The most notable type is the Argentine half orange Kiln, which was adopted by the Malawi Charcoal Project. It is made entirely out of brick and mud as mortar. Loading and unloading is performed through two opposite doors, which are sealed before the kiln is ignited. The carbonisation cycle is much quicker and allows harvesting of charcoal after 13 – 14 days. Using a kiln of about 6 m diameter up to 15t of high quality charcoal can be produced per month. However, as brick kilns are stationary once built, they can only be used in areas with easy supply of wood. Furthermore, the wood has to be cut with some precision and water supply is required for preparation of mortar. Kilns can also be produced using concrete instead of bricks; however, as their construction is very cost-intensive they have not succeeded in Africa. Some of the examples of brick kilns include: Half orange brick kiln, Doum shaped brick Kilns and Rectangular brick kiln (Figure 7), (Seidel, 2008).

a: Half Orange Brick Kiln b: Doum shaped brick Kilns

c: Rectangular brick kiln

Figure 7: Brick Kilns (Source: KFS, 2013)

2.8.3.5 Adam-Retort

Improved Charcoal Production System (ICPS), also called Adam-Retort after its inventor, and may be presented as an example of retort technology (Figure 8). A study by Seidel (2008) revealed that, Adam-Retort kiln returns the wood gases back to the carbonisation chamber, burns the volatile a higher proportion of the tar components almost completely and uses the heat for the carbonisation process. Efficiency can be as high as 40 % and noxious emission are reduced by 70 %. In addition the production cycle is completed within 24 to 30 hours. The retort is suitable for semi-industrial production. However, it's a stationary kiln, investment costs are about US$300 to 400 and special skills are required for construction (Seidel, 2008).

Figure 8: Adam - Retort Kiln (Source: KFS, 2013)

From the literature it is observed that the use of improved kilns can be considered as a crucial step in achieving sustainable charcoal and therefore it is highly desirable. However, most of the charcoal producers use inefficient traditional kilns. One of the reasons for this is that brick and concrete kilns are stationary, whereas charcoal is frequently produced in a manner which requires mobile kilns or kilns constructed on site for the duration of production. Investment costs for many improved kilns are also too high especially for metal kilns which are transportable, and special skills are required to construct and to operate improved kilns. Table 2 below compares some of the characteristics of the charcoal production technologies.

Table 2: Summary of Charcoal production technologies

Type of technology	**Applicability (Large or small scale)**	**Advantages**	**Disadvantages/ Challenges**	**Efficiency**
Traditional Earth kiln	Used for small scale production	Known and easily mounted	Not easy to control, Charcoal easily contaminated, polluted,	15 – 20 %
Improved / Casamance	Small scale production	Controlled air flow and process	Stack arrangement need precision	26 – 30 %
Drum kilns KEFRI design	For domestic use	Easy to construct	Charcoal easily contaminated	20 -30 %
Maxwell design	Small scale	Makes use of the little twigs	Clean charcoal produced	20 -30 %
Mekko kiln (Biochar)	Both small/ large	Mobile/high recovery/recycled gases	Still prototype/ costly	50 – 75 %
Portable metal kiln	Both small/large	Portability/good recovery	costly	26 -30 %
Ring kilns	Small/	High recovery	Costly	30 -50 %

	Industrial			
Brick kilns Half orange kilns	Small scale	Uses small materials	costly	50 – 60 %
B. Dome shaped	Large scale	Can be for large scale production	Costly transportation of materials	28 – 30 %
Rectangular shaped	Small scale	Good recovery, and for enterprise development	Transportation of materials	28 - 30 %
Retort	Large scale use	Mobile, other by products	Costly and need large materials	70 - 80 %

(Source: KFS, USAID, UNDP, GEF Umbrella Cost Sharing Agreement. Report (2008)

2.9 Some available charcoal and wood stove Technologies

2.9.1 Traditional charcoal and wood stoves

Majority of households in Africa use traditional stoves (Figure 9), which are cheap and can be afforded even by poorer households. In a study done by Seidel (2008), it was discovered that, most of the traditional stoves from Ghana, Kenya, Madagascar and Uganda are made of metal without insulation, which allows most of the heat to escape. Use of traditional stoves wastes a lot of charcoal consequently this results in high consumption of charcoal per household. Literature shows that, efficiency of commonly used traditional metal charcoal stoves range between 12-15%, slightly more efficient than the three stone fire using wood whose efficiency ranges between 8 – 12% (Figure 10). Apart from wasting a lot of charcoal, some traditional stoves emit large quantities of noxious fumes which are not health to human bodies (MEM, 1998 as cited in Malimbwi et al., 2004).

Figure 9: Traditional charcoal Stove (source: Seidel, 2008)

Figure 10: Three Stone using wood (Source: Sepp, 2008)

2.9.2 Improved charcoal and wood stoves

The common distinguishing features on improved charcoal stoves are a ceramic liner as insulation, an enclosed fire to retain the heat and ventilation gates to control the air flow. Improved charcoal stoves burn charcoal with an efficiency of 30 to 50 % above the traditional stoves and emit much less or even no noxious fumes. Charcoal consumption per capita is reduced between 27 and 42% (Seidel, 2008). Some of the improved charcoal stoves are shown in the table 3 below. According to USAID (2007) report on fuel efficient stove programs, stove efficiency is contingent on variables within four broad categories: a) fuel types and characteristics, b) combustion efficiency, c) heat transfer efficiency, and b) behavior of the user (USAID, 2007). Table 3 bellow shows some of the improved stoves for fuel wood and charcoal combustion (Sepp, 2008).

Table 3: Some of the improved stoves for fuel wood and charcoal combustion

Characteristics	**Improved stove (First generation)**	**Improved Stove (Second generation)**	**High efficiency Stove**
Combustion Technology			
Efficiency	20 – 25%	25 – 35%	> 35%

2.10 Summary

This chapter has reviewed several literatures on nature and process of charcoal production, social economic factors that influence charcoal production, transportation and trade. The chapter has also examined on the importance of forestry resources in Malawi, environmental impacts of charcoal production as well as condition of forestry resources in Malawi and Blantyre city in Particular. It has further examined on some of the available charcoal production technologies and efficient charcoal and firewood stoves.

It has been revealed that charcoal is the solid residue which is derived from carbonization distillation, pyrolysis and torrefaction of fuel wood. In spite of its environmental and social harm charcoal is a very important economic activity for both rural and urban economies. It has the potentials of reducing unemployment as well as contributing to improving living conditions of charcoal producers, transporter as well as the charcoal traders. It has further been revealed that human population numbers and growth rates plus the poor economic status of most of those living in low income settlements are some of the contributing factors on the overdependence on charcoal as main source of energy.

Although forest resources has a number of importances like maintenance of air, soil and water quality the literature has revealed that charcoal production has a number of negative environmental impacts which is affecting the live hoods of people. Some of these impacts include: deforestation as well as pollution produced at the site of production. These negative environmental impacts can be minimized if the charcoal producers can adopt the improved efficient charcoal production kilns and if the charcoal consumer can be using efficient charcoal wood and stoves. The next chapter presents the research methodology that was adopted for the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

This chapter outlines the research methods /approach that were adopted for sourcing data or information in order to accomplish the study objectives and questions. The chapter contains the profile of the study area, research design, definition of the target population, sample size, sampling techniques and data collection and analysis techniques/instruments.

3.1 Study Area

The study was conducted in Ndirande and Chirimba Townships in Blantyre City, which is located to southeast of the capital city, Lilongwe (NSO, 2008). Blantyre District is bordered by Mwanza District in the North, Zomba in the North East, Chiradzulu in the South East, Thyolo in the South and Chikwawa in the west. It is located in the Shire Highlands and is the geographical center of the Southern Region of the Country (See Figure 11 below).

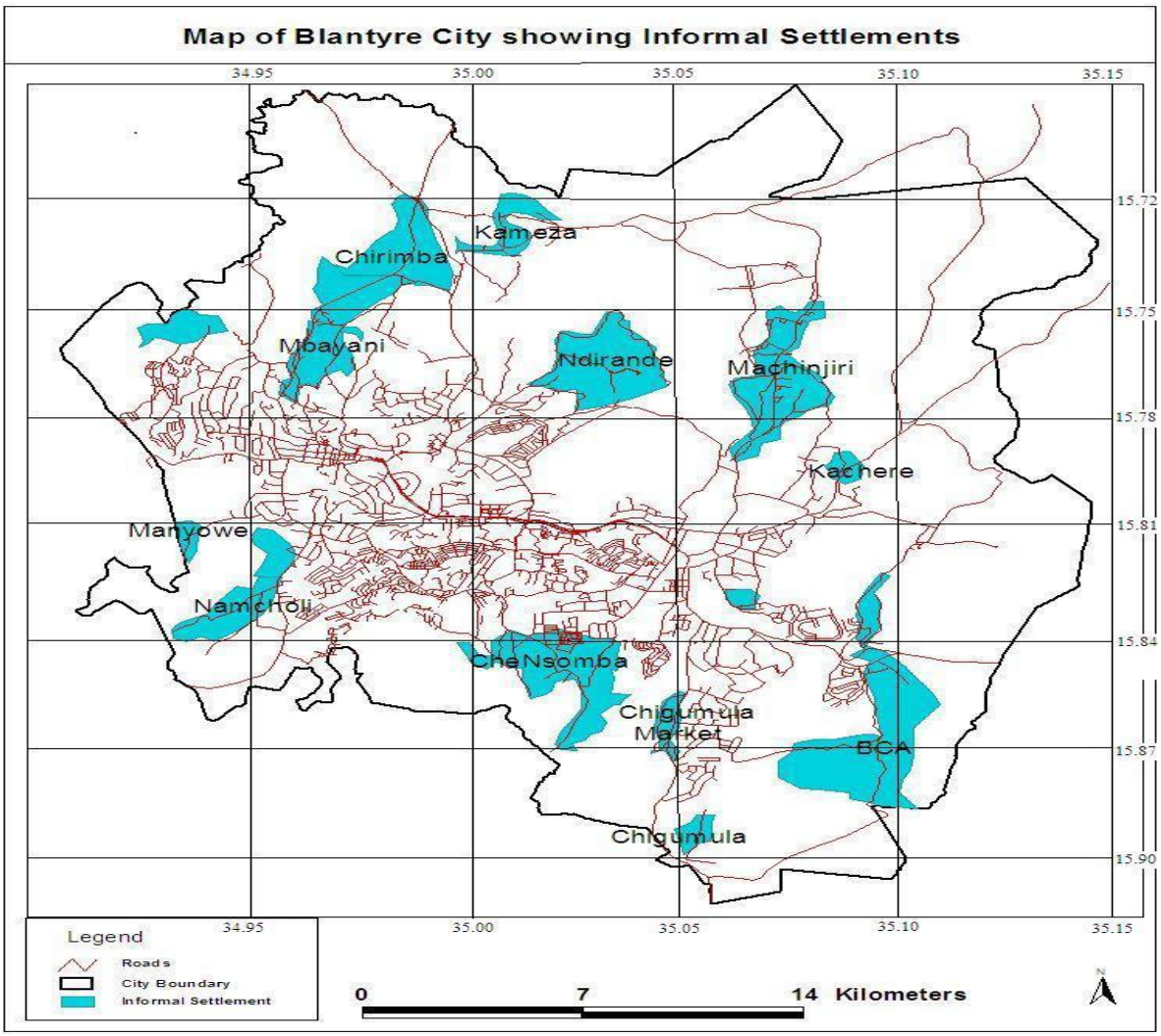

Figure 11: Map of Blantyre City showing informal settlements (Source: BCC).

Malawi is one of the most densely populated countries in Africa, with a population density of 158.3 people per square kilometer; although Blantyre City is not Malawi's largest city in terms of population, it has the highest population density in the country, with 3,269 people per sq. km. Over 65% of the city's population lives in 21 low-income areas (LIA) which occupy about 23% of the land in Blantyre (Table 4), some of which are unplanned (Muwamba, 2010). Poverty stands at 24% while unemployment stands at 8% (NSO, 2008). A National Statistical report of 2008 indicates that Blantyre City has a population of about 884,497 (NSO, 2008).

Table 4: Blantyre city List of Low Income Areas (LIAs)

Kameza	Manase
Machinjiri	Chatha
Mapanga	Naotcha
Chilomoni (Mulunguzi)	Soche
Mbayani/Chemusa	Chiwembe Village
Ndirande (Safarao, Makata, Zambia)	Misesa
Kachere	BCA (Mavuto Branch)
Mzedi	Bangwe/ Namiyango
Manyowe	Chigumula

(Source: Maoulidi, 2012)

3.2 Energy sources for Blantyre city

Only 12% of informal settlement residents in Blantyre city have access to electricity, which is supplied by the Electricity Supply Commission of Malawi (ESCOM). This clearly shows that, majority of the residents depend on wood fuel (UN HABITAT, 2011). The high use of wood fuel (charcoal and firewood) as a source of energy has huge negative consequences on the environment and alternative sources of energy must be explored in order to prevent the continued used of wood fuel. A small number of people rely on solar power as their main source of energy (UN HABITAT, 2011).

3.3 Research Design

Research design is the conceptual structure within which research would be conducted and encompasses methodology and procedures employed to conduct the research (Newman & Benz, 1998). The research design refers to the overall strategy chosen to integrate the different components of the study in a coherent and logical manner (Drew et al., 2008). The study

undertook a descriptive design whereby, collection of data was done through observation, photography, interviewing or administration of questionnaires to the sample population, relevant document review, analysis and interpretation. A descriptive research describes the characteristics of phenomena, opinions, preferences, subjects, and perceptions of people of interest to an investigation (Borg & Gall, 1993). A descriptive research is concerned with what exist and is related to some preceding event that has influenced or affected the present condition or event such as gender, age, occupation and education level that pointed to factors influencing charcoal production, transportation, trade and use at household level (Best & Kahn, 1993). According to Bell (1993), a descriptive study focuses on obtaining data from representative sample of the population from which the researcher is able to generalize findings of the large population as a whole. The researchers chose this design because it fits the type of study carried out. Mugenda and Mugenda (1999) assert that a descriptive study is used to determine the reasons and causes for the current situation under study. The research described the socio-economic factors contributing to charcoal production, transportation, trade and use.

3.4 Research Strategy

According to Burchinal (2008), a research strategy is the plan on how a researcher is going to answer the research question(s) and research objectives. It also reflects the fact that the researcher has thought carefully about why she/he is employing a particular strategy. The researcher should have valid reasons for all research strategy decisions. The justification should always be based on the research question (s) and objectives. Strategy is concerned with the overall approach adopted for the project. Tactics is about the finer details of data collection and analysis. Decisions about tactics require you to be clear about the different data collection methods (e g questionnaires, interviews, focus groups, and published data) and subsequent analysis.

The study employed a household survey as a research strategy. Surveys of charcoal producers were conducted at Sezani (Ntcheu) and Neno (along the M1 road), whereas surveys of charcoal transporters, vendors and consumers were conducted in Ndirande and Chirimba townships. According to Burchinal (2008), survey research strategy is the method of gathering data from respondents thought to be representative of some population using an instrument composed of

closed structure and/or open-ended items (questions). Since the research project was social in nature, a household survey was a suitable research strategy as it is the dominant form of data collection in the social research (Burchinal, 2008). It provides for efficient collection of data over broad populations, which can be administered in person, by telephone, and over the Internet. Some forms of survey research by telephone or the Internet may be completely automated. However, it is the strategy to a method which artificially forces respondents to formulate opinions, masking the complexity of conflicting views and unconscious biases within each respondent, and critics note that in many arenas (e.g., race relations) survey items poorly predict actual behaviour. In addition to that there is an economy in data collection due to the focus provided by standardized questions. Only questions of interest to the researcher are asked, recorded, codified, and analyzed. Time and money is not spent on tangential questions (Burchinal, 2008).

A case study research strategy was also adopted for collecting of data on charcoal production, transportation as well as trade within the study area. Yin (2003) defined a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. This renders case study as a suitable strategy for investigating complex social phenomena where the investigator has no or little control. They normally address research questions that deal with "hows" and "whys". This helped the researcher to study the charcoal production and business in its real-life situation.

The data which was collected included socio-economic characteristics, charcoal production processes and types of kilns used, problems resulting from charcoal production, charcoal trade, combustion appliances, charcoal quantities and current charcoal demand in the study area.

3.5 Nature and Sources of Data

The nature of data that was collected by the researcher was both qualitative and quantitative data. The data collected informed the study and was in line with the objectives of the research. According to Borg and Gall (1993), qualitative research describe and develop an understanding

for social situation, event or interaction while quantitative research are by nature structural, predetermined, and specific and yield numbers, charts and tables.

The researcher collected data from both primary and secondary sources. Primary data sources included direct field observations of charcoal production methods, photography of charcoal production methods, the means used in charcoal transportation, charcoal trading, interviewing key resource persons, household heads, and informal interviews and focused group discussions with locals**.** Secondary data were obtained from publications, annual and quarterly reports and books both in hard and soft copies.

3.6 Methods of Data Collection

The study employed various methods of data collection including:

3.6.1 Direct Interviewing

The researcher used this as a method of data collection by use of questionnaire as the research tool. Questionnaires with both open ended and close ended questions were administered by means of personal interviews to 110 charcoal consumers, 15 charcoal producers (8 producers from Sezani (Ntcheu) and 7 producers from Neno), 10 charcoal transporters and 10 charcoal traders.

3.6.2 Observation

Physical aspects relevant to the study were observed and recorded with the aid of observation guides. The technologies adopted for charcoal production, means of transportation, as well as the types of charcoal stoves currently being used in the study area were observed using this method. This tool captured data that needed quick recording like the kiln type and also acted as a back-up for information not captured in the questionnaires.

3.6.3 Key Informant Interviews

This method involved collection of data by interviewing the key resource persons including officials from the district council, officials from forestry department, and a resource person from Non-Governmental Organization which advocates on improved charcoal stoves and other cleaner sources of energy called Movement for Bio-Energy Advocacy Utilization and Action in Malawi (MBAULA).

3.6.4 Focused Group Discussions

A group interview was done to find out if charcoal producers in the study have adopted the improved charcoal production technologies and to find out the major contributing factors to charcoal production, transportation and trade. Group members were selected through nonrandom sampling methods. The research used open-ended questions to obtain wide range information from the groups.

3.6.5 Photography

Physical features were photographed so as to capture information on charcoal production technologies, means of transportation, trading areas, and type of charcoal stove currently in use in the study area. Digital camera was used as a tool for taking photographs.

3.7 Instruments for Data Collection

3.7.1 Questionnaires

The research used questionnaire as the main data collection instrument. Questionnaires were less expensive since it allowed saving of time, human and financial resources and convenient (Kumar, 1999). The questionnaires were developed by adopting constructs from various previous related studies. The questionnaire was administered by means of personal interviews in order to encourage the respondents to actively participate and share their opinions. Closed ended questions presented the respondent with the opportunity to choose one answer from a series of options. Open ended questions allowed the respondents to have freedom in giving response.

3.8 Unit of Analysis

The unit of analysis for the study were, charcoal producers, transporters, traders and consumers. In order to attain a credible study, some state agencies including the Forestry Department and Blantyre City Council were also part of the empirical units for data acquisition. In this study Charcoal producers are local producers that cut wood from forests and produce charcoal. Some charcoal producers are also transporters and traders. Charcoal transporters are local or urban individuals who transport the charcoal from production site to local markets using heads, bicycles, and oxcarts as well as vehicles modes of transport. At the market, they sell the charcoal at wholesale price to retailers who in most cases are women or directly to consumers in bulk along roadsides. Charcoal traders in this study are men and women who buy from transporters and repackage the charcoal into small packages for local consumption Charcoal consumers are those who buy charcoal from producers, vendors and retailers. They are mostly town and city dwellers. They drive the demand and supply of charcoal and should be targeted as far as sustainable supply is concerned, since they provide the market incentives.

3.9 Sampling Techniques and Procedures

Sampling refers to drawing of a sample (a subset) from a population (the full set) (Israel, 2009). On the other hand Population refers to all members of the target study, while a target population is the larger group which ones hopes to generalize or apply his/her research findings (Fraenkel & Wallen, 1993). The goal in sampling is to produce a representative sample, thus, a sample that is similar to the population on all characteristics, except that it includes fewer people because it is a sample rather than the complete population. The following sampling techniques and procedures were used in the study area;

3.9.1 Purposive Sampling

A purposive sampling is a non-representative (nonrandom) subset of some larger population, and is constructed to serve a very specific need or purpose (Mugenda & Mugenda, 1999). According to Rivers et al., (2003), nonrandom sampling is where the sampling frame is not well-defined and there is no known probability of selection. Purposive sampling represents a group of different non-probability sampling techniques and the researcher will attempt to zero in on the target population group, interviewing whoever is available (Tesot, 2012). Also known as judgmental, selective or subjective sampling, purposive sampling relies on the judgment of the researcher

when it comes to selecting the units (e.g., people, cases/organizations, events, pieces of data) that are to be studied (Fraenkel & Wallen, 1993). Usually, the sample being investigated is quite small, especially when compared with probability sampling techniques (Mugenda & Mugenda, 1999).

The main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which will best enable you to answer your research questions. This method was employed in the selecting the 110 charcoal consumers in the study area and the key resource persons which included 3 Blantyre District council Officials, 4 Blantyre Forestry officials and 1 Official from a Non-Governmental Organisation which is advocating on improved charcoal stoves called MBAULA. The researcher purposively selected two low income settlements of Blantyre city (namely: Chirimba and Ndirande townships) for social- economic background factors on charcoal usage. These townships were purposively selected because there are among the low income settlements where most of the urban dwellers (but not all residents) are found due to poverty and their main source of energy is charcoal (over 90% of households depend on charcoal). According to Kambewa et al., (2007), charcoal is a vital energy source for the urban poor. Low-income households have a higher per capita charcoal consumption, and with charcoal and/or fuelwood accounting for three-quarters of their total household energy expenditure. The purposive sampling method was also used due to the nature of housing in the study area, Both Chirimba and Ndirande townships are among the high density areas in Blantyre city where most houses (but not all) are not well planned. Thus the respondents from these two townships were selected and interviewed using convenience sampling which is one of the types of non random sampling methods.

3.9.2 Snowball sampling

Snowball sampling begins with identification of someone who meets the criteria for inclusion in your study (Berg, 2001). Then asked to recommend others who they may know who also meet the criteria. Although this method would hardly lead to representative samples, there are times when it may be the best method available. Snowball sampling is especially useful when you are trying to reach populations that are inaccessible or hard to find. This method was useful for the charcoal producers as they could not be easily located as they are doing their business illegally as

a result there doing it in secrecy. The same snowball sampling method was also used on charcoal transporters and traders. Using snowball sampling data on production sites was sourced from Sezani (Ntcheu), and Neno. These production sites were chosen because they are among the sites which supply charcoal in the selected Low income settlements of Blantyre city.

3.9.3 Sampling Frame

According to Turner (2003), a sampling frame is the set of source materials from which the sample is selected or just a list of all the subjects that are in the population. The definition also encompasses the purpose of sampling frames, which is to provide a means for choosing the particular members of the target population that are to be interviewed in the survey. The sampling frame for charcoal consumers was nonrandomly made up of respondents from both Chirimba and Ndirande townships in Blantyre city using the land use map for Blantyre city. Thus the number of households was approximately determined by physical counting the households using Google earth satellite images. The data revealed that there an approximation of 7,451 households in Ndirande and 4,000 households in Chirimba townships. In total there were approximately 11,451 households. A total of 110 charcoal consumers was selected and interviewed (Table 6). Since charcoal business in the study area is done in secrecy, the sample frame for charcoal producers, transporters and traders was determined based on their availability (convenience). A total of 15 charcoal producers, 10 transporters and 10 charcoal traders were selected and interviewed. On the other hand 4 Officials from forestry department, 3 Officials from Blantyre District Council and 1 Official from a Non-Governmental Organization which advocates on improved charcoal stoves were also selected and interviewed (Table 5).

Table 5: Institutions Contacted

Institutions	Questionnaires Administered	Positions
Blantyre District council	3	District Environmental Officer, Director of Wildlife and parks, District Health Officer

Department of Forestry	4	District Forestry Officer, Regulation and quality control Officer, Assistant District Officer and Deputy Regulation and quality control Officer
NGO's on improved charcoal stoves (MBAULA)	1	Project coordinator
TOTAL	8	

3.9.4 Sample Size Determination

Based on the availability of the respondents and nature of housing in the study area, a sample size of 72 charcoal consumers was nonrandomly selected from about 7451 households in Ndirande Township. From about 4000 households in Chirimba Township a total of 38 charcoal consumers was sampled and interviewed. According to the NSO report of 2008, a household consists of one or more persons, related or unrelated, who live together and make common provision for food. They regularly take all their food from the same pot, and/or share the same grain store (*nkhokwe*) or pool their incomes for the purpose of purchasing food. Persons in a household may live in one or more dwelling units. With nonrandom sampling, population elements are selected on the basis of their availability (e.g., because they volunteered) or because of the researcher's personal judgment that they are representative (Chaturvedi, n.d.). Convenience sampling was not used just because such samples were easy to recruit and less expensive, but because it was also easy for the researcher to use whatever individuals were available rather than selecting from the entire population which was difficult to determine. In addition, since the research was social in nature, the responses also were almost replicating, so a total of 110 charcoal consumers were interviewed. So due to difficulties in determining the actual number of households and nature of housing in the study area, it was necessary for the

researcher to use convenience sampling method. The same nonrandom sampling method was used when selecting charcoal producers, transporters, and traders.

Table 6: Sample size for the charcoal consumers interviewed

Category	Location	Frequency	Percentage (%)
Charcoal consumers	Ndirande	72	65.5
	Chirimba	38	34.5
Charcoal Producers		10	100
Charcoal transporters		10	100
Charcoal traders	Ndirande	7	70
	Chirimba	3	30

3.10 Methods of Data Analysis

The primary data collected from the field was coded and analyzed using statistical package for social sciences (SPSS) version 16.0 and Excel spreadsheet software. This was done while ensuring that original meanings of the statements made by respondents were maintained. Both descriptive and inferential statistics were used in data analysis and the results presented in form graphs, tables and charts. The open-ended questions were manually analyzed by grouping responses into similar themes and tallying them and frequencies determined using excel spreadsheet. The closed-ended questions responses were appropriately labeled and entered into the statistical package for social sciences software (SPSS) Version 16. The frequencies generated by SPSS were then transferred to Excel and figures generated. Multiple Logistic Regression analysis was also used to identify the factors that influence the production and use of charcoal as source of energy among the households in the low income settlements.

3.11 Summary

This chapter has discussed on the study area, research design and methodology that were employed for data collection and analysis. The study undertook a descriptive design whereby, collection of data was done through observation, photography, interviewing or administration of questionnaires to the sample population, relevant document review, analysis and interpretation. The study employed a household survey as a research strategy. Surveys of charcoal producers were conducted at Sezani (Ntcheu) and Neno (along the M1 road), whereas surveys of charcoal transporters, vendors and consumers were conducted in Ndirande and Chirimba townships. A case study research strategy was also adopted for collecting of data on charcoal production, transportation as well as trade within the study area. The unit of analysis for the study were, charcoal producers, transporters, traders and consumers. Some state agencies like the Forestry Department and Blantyre City Council were also part of the empirical units for data acquisition. A mixture of both open and closed-ended questions was used as data collection tools and Statistical Package for Social Sciences (SPSS) as well as Microsoft Excel were used for data analysis.

The data which was collected included socio-economic characteristics, charcoal production processes and types of kilns used, problems resulting from charcoal production, charcoal trade, combustion appliances, charcoal quantities and current charcoal demand in the study area. The nature of data that was collected by the researcher was both qualitative and quantitative data. Both convenience sampling and Snowball sampling were used in determining the sample size.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the findings of the study. The first section presents findings of the socio-economic factors for charcoal business. These findings of the study explain the social and economic characteristics of the charcoal producers, transporters, traders as well as the charcoal consumers in the study area. The second part of the section looks at the current charcoal demand in the study area and the types of charcoal kilns which are currently in use. The results presented in table 7 are derived from the household survey of the charcoal consumers.

4.1 The social –economic Factors influencing the use of charcoal by households

Table 7 below shows some of the social - economic characteristics of the charcoal consumers in the study areas.

Table 7: The social –economic Factors influencing the use of charcoal by households

Variables		**Ndirande**		**Chirimba**		**Total**	
		Freq		**Freq**		**Freq**	
		n = 72	**%**	**n = 38**	**%**	**n = 110**	**%**
Gender	Male	32	44.4	26	68.4	58	52.7
	Female	40	55.6	12	31.6	52	47.3
Age (Years)	● 20 – 29	2	2.8	3	7.9	5	4.5
	● 30 – 39	45	62.5	24	63.2	69	62.7
	● 40 - 49	5	6.9	5	13.2	10	9.1
	● 50 - 59	18	25	5	13.2	23	20.9
	● 60 +	2	2.8	1	2.6	3	2.7

Number of persons per household	● 1 – 5	40	55.6	26	68.4	66	60
	● 6 – 10	29	40.3	12	31.6	41	37.3
	>10	3	4.2	0	0	3	2.7
Literacy Level of the Head of Households	● University	9	12.5	6	15.8	15	13.6
	● College	13	18.1	2	5.3	15	13.6
	●Secondary	23	31.9	10	26.3	33	30
	● Primary	21	29.2	19	50	40	36.4
	● None	6	8.3	1	2.6	7	6.4
Monthly Income of the Heads of Households	● K16,000 – 26,000	11	15.3	10	26.3	21	19.1
	● K27,000 – 37,000	2	2.8	1	2.6	3	2.7
	● K38,000 - 48,000	1	1.4	0	0	1	0.9
	● K49,000 – 59,000	13	18.1	8	21.1	21	19.1
	● >K60,000	6	8.3	0	0	6	5.5
	●No response	39	54.2	19	50	58	52.7

4.1.1 Gender of the charcoal consumers

Although charcoal issues are kitchen items that are in the domain of women, male gender dominated the respondents with 52.7% (table 7). This male dominance was observed from both Ndirande (44.4 %) and Chirimba townships (68.4 %). According to Ali and Victor (2013), gender of the head of the household is a very significant factor in the household. Female headed households are distinct from male-headed households, especially in terms of decision-taking at a household level. Here, women can take better decision about the quality and quantity needed for the household for the various types of food to be cooked than the men. Therefore it is more likely that a family where there is a woman is more likely to use charcoal in a cost effective way than a family where there is no woman.

4.1.2 Age range of the charcoal consumers

The age range of respondents was 20 – 60+ years (Table 7). However, the age of majority of the respondents was between 30 and 39 years, from both Ndirande (62.5%) and Chirimba Townships (63.2%). Although the correlation (R) between the dependent variable (charcoal usage) and the linear combination of the 5 predictor variables of which age is one of them, the results shows that majority of respondents were young. The implication of this is the ease within which the younger household heads adopts the use of charcoal in the households and it also relates to the types of food to be cooked, frequency of cooking and household size. Younger heads of households seem to eat different meals and frequently than the older ones, hence more charcoal is needed. However, they are not likely to have larger household sizes than the older ones. Therefore from the table 7 above it is clearly shown that, charcoal usage is partly influenced by the age group of the consumers. This in agreement with the findings in table 7 above which shows that majority of the charcoal consumers in these two study areas were the young ones (30 – 39 years).

4.1.3 Family Size for charcoal consumers

The number of persons in the household can also influence the types and quality of food to be cooked, as well as the quantity of charcoal to be used (Ali & Victor, 2013). The household with large number of persons is more likely to use large quantities of charcoal than those with few numbers of persons. The reason is that where there more people in a household the quantity of food to be prepared will also be large, consequently this will require more charcoal to be used. Table 7 above shows that majority of the charcoal consumers in the study area have 1 – 5 persons per household (60 %) seconded with households with 6 – 10 persons (37.3 %). This is in agreement with the 2008 national statistics results (NSO, 2008, P. 13), which shows that most of the families in the southern region including the study area have 1 to 5 persons per household. As already stated a household consists of one or more persons, related or unrelated, who live together and make common provision for food and they regularly take all their food from the same pot. In this study area, most households besides the household head and the spouse, there are children as well as dependents. In most cases these household members are fed at home, therefore there should be a corresponding increase in the quantity of charcoal needed for cooking. Table 7 above shows number of persons per household in the study area.

4.1.4 Literacy Level of the Head of Households

From the table 7 above, it was observed that the highest level of education recorded for the respondents was primary (36.4%), this was followed by secondary (30 %). Thus majority of the respondents were not well educated. This trend was common to both Ndirande and Chirimba Townships. Literacy is defined as ability to read and write in any language (NSO, 2008). According to Ali et al., (2013), the literacy level determines the level at which the head of the household is informed and this variable is closely related to social status, income, household size, eating habit, and type of food consumed. All these can trigger fuel choices of a household either switching to charcoal or alternative sources of energy, as well as the quality of charcoal that is needed in the household. Although there is a possibility of other contributing factors to charcoal usage, the correlation shown in table 7 is partly influenced by the literacy level of the head of the household. Most of the charcoal consumers in these study areas (although not everybody) are not well educated as a result the type of jobs they secure are low paying and they have larger families. Consequently this influences them to be using charcoal as their source of energy. Even those who have electricity in their house they don't use it for cooking for fear of electricity bills.

4.1.5 Monthly Incomes of the Head of the Households

The monthly income of the head of the household of which sometimes is related to literacy level determines the economic status of the household (Ali & Victor, 2013). The higher the income of the head of the household, the greater the flexibility of shift will be to the desired household fuel. For instance, high relative prices of other household fuels induce fuel switching usually, towards charcoal. Specifically high income households continue to use charcoal after they have otherwise switched to other household fuels. Heltberg (2005) gives two reasons for this. First, it competes with wood as a cooking fuel in urban areas where wood has become distant from urban centers; and as such it acts as a transition fuel. Second, it competes with other alternative fuels in some end uses, i.e. specialized cooking. Table 7 above shows the monthly income of the heads of households in Ndirande and Chirimba townships. The majority of the respondents were not comfortable to disclose their monthly income (52.7 %), therefore it was difficult to determine on how income influences the choice of energy at household level. Only 47.3 percent of the respondents disclosed their monthly income. Therefore from the

regression analysis in table 8 and 9 bellow it is clearly shown that, besides the other reasons that promote the popularity and use of charcoal in the study area like: frequent black, demands of different methods of cooking according to taste, availability and affordability, monthly income of the head of the household also contribute to the increase in charcoal usage in the study area. Most of the respondents were saying that, they are forced to use charcoal as their main source of energy due to poverty.

4.2 Data Analysis

The Multiple Linear Regression Analysis was used for the data analysis to find the correlation between the use of charcoal (dependent variable) and the 5 main predictor variables, called factors. These predictor variables were: Literacy level of household head, Number of persons in the household, Gender of the household head, Age of the household head, and Monthly income of household head. The results of these are shown in the Tables 8 and 9 below.

From Table 8, the study identified that the use of charcoal (dependent variable) a household uses is explained by 5 main predictor variables, called factors. These factors are the household socio-economic characteristics that affect charcoal use in the households in Ndirande and Chirimba townships. The effects of each of the socioeconomic factors on the use of charcoal in households can be obtained from inspection of each of their percentage contributions (R^2). In decreasing order, they are listed below;

1. Literacy (Literacy level of household head)
2. Size (Number of persons in the household)
3. Gender (Gender of the household head)
4. Age (Age of the household head)
5. Income (Monthly income of household head)

Also, from computation, as shown in Table 9, the correlation (R) between the dependent variable and the linear combination of the 5 predictor variables is 0.496. This indicates that the relationship between the charcoal use and the five predictor variables is not very strong though positive. This was expected because the study discovered that apart from these 5 social-economic factors there are other reasons which are promoting the use of charcoal in the study area like: frequent black outs, demands of different methods of cooking according to taste and availability.

Besides most of the households in these Townships (50.9%) are not connected to the national grid (Table 10**)**, this implies that these households have no choice other than to use charcoal and firewood as their primarily energy source. Some of the respondents complained that even if they can have the capacity to have their houses connected to electricity, it takes time for Electricity Supply Corporation Of Malawi (ESCOM) to connect their households to the national grid. This also lives them with no choice other than to use charcoal and firewood as their main source of energy. The results also revealed that although some of respondents have electricity in their houses (49 %), they still rely on charcoal as their source of energy (n =54). This is in agreement with the findings of Kambewa et al., (2007) which showed that charcoal is used by both rich and poor. However, in a study done by Ali and Victor in Nigeria (2013), it was discovered that there was a very significant and positive relationship between charcoal usage and the social- economic predictor variables. This disparity can be as a result of these other factors that promote the popularity of charcoal usage, like the unreliability of the electricity. The coefficient of multiple determinations (R^2) was 0.246. This means that 24.6% of the variation in the quantity of charcoal can be explained by the variations in the five (5) predictor variables.

Table 8: Regression Analysis of the Main Predictor Variables

Predictors	**R^2**	**Coefficient of** Det**ermination**
Literacy of Household Head	0.202	20.2
Number of persons in the household	0.023	2.3
Gender	0.006	0.6
Age of the Household Head	0.005	0.5
Monthly Income of Household Head	0.003	0.3
Total		23.9

Table 9: Model Summary of Regression Analysis

R	R^2
0.498	0.246

Table 10: Number of households connected to electricity in the study areas

Location	Number of households connected to electricity	Percentage (%)	Number of households not connected to electricity	Percentage (%)	Total
Ndirande	37	51.4	35	48.6	72
Chirimba	17	44.7	21	55.3	38
Total	54	49.1	56	50.9	110

4.3 Source of Charcoal in the study area

Figure 12 below shows some of the areas where charcoal comes from. Some of the areas which supplies charcoal to Chirimba and Ndirande Townships include: Chileka (Blantyre), Mwanza, Neno and some comes from Sezani (Ntcheu district).

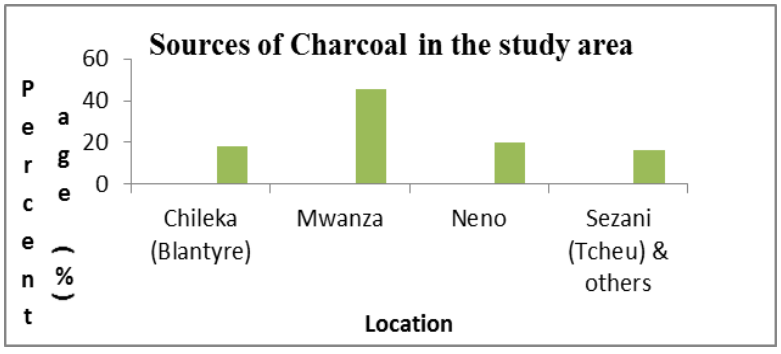

Figure 12: Areas where charcoal comes from

Increase in popularity and use of charcoal in the study area has a direct link to a corresponding increase is charcoal transportation, and trading which also results in an increase in charcoal production from the production sites because the availability of the market. When the respondents were asked on where charcoal comes from, it was discovered that 45.5 % of the charcoal in both Chirimba and Ndirande Townships comes from Mwanza (n=50), 20 % comes from Neno (n=22), 18.2 % comes from Chileka (n=20) where as 16.3 % comes from Sezani and other locations (n=18) as the areas immediately around the city has already been depleted (figure 12). These findings are in agreement with the findings of the study which was done by Kambewa et al in 2007. In their findings it was discovered that, Blantyre is the top consumer of charcoal produced from Neno and Mwanza districts (largest charcoal producers). Other sources such as The Republic of Mozambique, Blantyre rural, Balaka, Chikwawa, Mulanje and Zomba districts also continually supply charcoal to Blantyre district (Kambewa et al., 2007).

The mode of charcoal transport ranges from manual carrying by man and beasts of burden to loading on bicycles and vehicles. Charcoal transported from Neno and Mwanza districts mainly goes to Chemusa, Ndirande and Mondoni markets. Despite charcoal being an important economic activity, it has led to adverse forest deforestation within Blantyre district and districts that supply charcoal to Blantyre. Unsustainable exploitation, use of low efficiency traditional earth kilns during production and unsustainable consumption heighten the severity of this crisis.

4.4 The social –economic Factors influencing charcoal Production, Transportation and Trade

The study revealed that, charcoal producers from the study area are local producers that cut wood from forests and produce charcoal. They include both men and women, although the majority are men (73.3 %). When the producers were interviewed on the reason why there is male dominance in charcoal production process, it was revealed that it was due to the nature of the job (charcoal production process) is not gender-responsive, and therefore requires excessive manual labour. The majority of producers produce charcoal illegally from customary land forests and forest reserves and there are responsible for forest degradation in the study area. Some charcoal producers are also transporters and vendors. Most of the charcoal producers interviewed (66.7%) indicated that they have 1 to 5 persons per household (n=10) and majority of them (80%) had primary level of education (table 11). The average household monthly income was estimated to

be MK25, 000. Majority of the charcoal producers (about 80 %) reported that charcoal production is their main source of income (n = 12), although some (20 %) mix charcoal production business with other business activities like farming and some small businesses (n = 3) (Figure 13). The similar trend was also observed for charcoal transporters as well as traders.

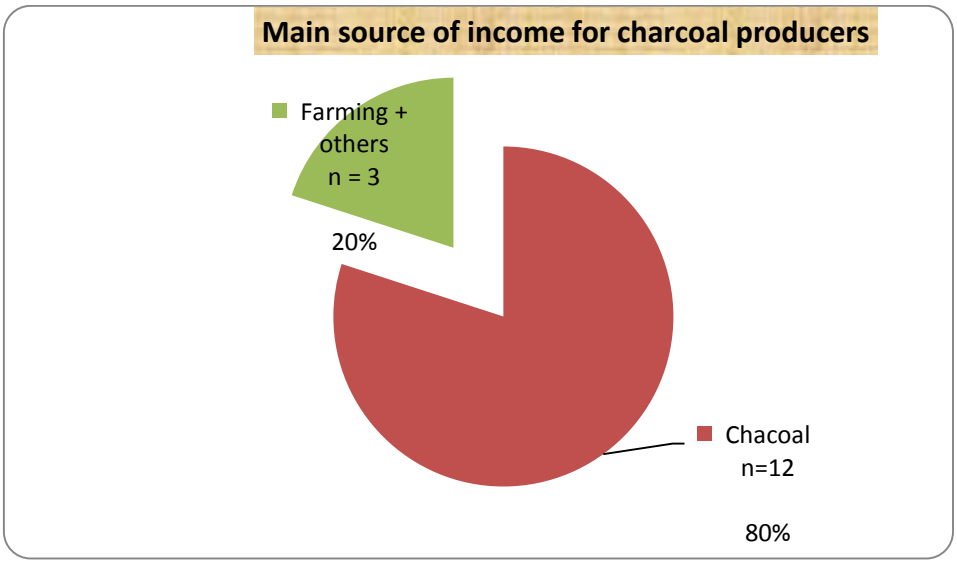

Figure 13: Main source of income for the charcoal producers in the study area

Unlike the charcoal producers where there was a small female representation, all the transporters interviewed were males (n=10). Majority of the charcoal transporter interviewed were youth in the age range of 30 – 39 (50%). This was also expected as the transportation job requires more effort just like the way it is with charcoal production process. Although some of the transporters had secondary education (20%), majority of them had primary education level (70%). The average household monthly income of the charcoal transporters was estimated to be between MK20, 000 and Mk30, 000 (table 11).

For charcoal traders, about 60 % of those interviewed were males (n=6) whereas 40 % were female (n=4). About 70 % of the traders had attained primary education and 30 % secondary education. The average household monthly income of the charcoal traders was similar to those of producers and transporters, majority were in the range of Mk 21,000 to Mk 30,000 (40%) (Table 11 below).

All interviewed respondents (charcoal producers, transporters and traders) said charcoal business was an important economic activity, providing employment to a number of people in the study areas. The study revealed that industry enables charcoal producers, transporters traders, to acquire basic items necessary for their sustenance. Assets, such as bicycles, motor bikes, roofing materials are all acquired with charcoal money. Some charcoal producers also use charcoal money to buy livestock for keeping. Some of the earnings are used for buying consumer goods like food stuffs, clothing, children's educational needs; water and sanitary facilities. Therefore, it is clearly that the financial returns charcoal producers, transporters and traders they receive from their activities is main reason why they engage in charcoal production. However, as indicated earlier in the study, charcoal production constitutes serious environmental challenges in the area. The study further revealed that most of the charcoal producers, transporters and traders are not well educated with primary education as their highest qualification attained. According to Ali et al., (2013), the literacy level determines the level at which the head of the household is closely related to social status, income, as well as household size. All these factors explain the reason why there is high dependence on charcoal business in the study area. In addition to that, literacy level can also have an impact on the level of understanding on the negative impacts of charcoal business on environment. Consequently this can also affect the adoption rate of new charcoal production technologies among the producers. Therefore just like the way it is in charcoal consumption these social – economic factors namely: literacy, family size, gender, age as well as monthly income of a household contribute to overdependence on charcoal business in the study area.

Table 11: The social –economic Factors influencing charcoal Production, Transportation and Trading

Variables		**Producers**		**Transporters**		**Traders**	
		Freq		**Freq**		**Freq**	
		n=15	**%**	**n = 10**	**%**	**n =10**	**%**
Gender	**Male**	**11**	**73.3**	**10**	**100**	**6**	**60**
	Female	**4**	**26.7**	**0**	**0**	**4**	**40**

Age (Years)	**• 20 – 29**	**2**	**13.3**	**3**	**30**	**1**	**30**
	• 30 – 39	**1**	**6.7**	**5**	**50**	**5**	**50**
	• 40 - 49	**10**	**66.7**	**2**	**20**	**2**	**20**
	• 50 +	**2**	**13.3**	**0**	**0**	**1**	**10**
Number of persons per household	**• 1 – 5**	**10**	**66.7**	**8**	**80**	**6**	**60**
	• 6 – 10	**4**	**26.7**	**2**	**20**	**2**	**30**
	>10	**1**	**6.7**	**0**	**0**	**1**	**10**
Literacy Level of the Head of Households	**• University**	**0**	**0**	**0**	**0**	**0**	**0**
	• College	**0**	**0**	**0**	**0**	**0**	**0**
	•Secondary	**1**	**6.7**	**2**	**20**	**3**	**30**
	• Primary	**12**	**80**	**7**	**70**	**7**	**70**
	• None	**2**	**13.3**	**1**	**10**	**0**	**0**
Monthly Income of the Heads of Households	**• K11,000 – 20,000**	**4**	**26.7**	**4**	**40**	**2**	**20**
	• K21,000 – 30,000	**8**	**53.3**	**1**	**10**	**4**	**40**
	• K31,000 - 40,000	**3**	**20.0**	**4**	**40**	**3**	**30**
	• >K40,000	**0**	**0**	**1**	**10**	**1**	**10**

4.5 Are there some preferred species of trees/wood to others?

Most of the charcoal producers interviewed revealed that the most preferred species of trees/wood for charcoal production include: *Brachystegia floribunda* (Tsamba), *Sterculia quinqueloba* (Msetanyani) *Diplorhynchus condylocarpon* (Mthombozi), *Combretum zeyhri* (Chinama); *Pterocarpus rotundifolius* (Mbalitsa). But the study revealed that due to scarcity of these preferred species, charcoal producers are now forced to be using any available species in the forests. Thus due to deforestation most of the species of trees have disappeared forcing the charcoal producers to have no any choice but to be using whatever is available.

4.6 The Current Charcoal Demand in the study Area

The results of this study indicate that majority of the households in both Ndirande (86.1%) and Chirimba (89.4%) Townships depend on charcoal as their main source of energy for cooking (table 12). Very few respondents reported that they use electricity as their main source of energy for cooking, 11.1% in Ndirande and 5.3% in Chirimba. On firewood it was discovered that, only 2.8% of respondents in Ndirande and 5.3% in Chirimba depend on it as their main source of energy for cooking. This is clearly indication that there is more demand for charcoal in the study area. Consequently this is putting much pressure on the forest resources within the district as well as the surrounding areas like Mwanza and Neno which supply charcoal in Blantyre. This is in agreement with similar studies done by Kambewa et al., (2007) which estimated that majority of urban families in Malawi (90%) relies on biomass energy, dominated in the main urban centers by charcoal. This is also in line with National Action Programme for Malawi for the United Nations Convention to Combat Desertification (UNCCD) report of 1996 which indicated that, wood fuel energy consumption was estimated at 93%, petroleum at 3.5%, electricity at 2.3%, coal at 1% and other biomass fuels at 0.2% (Ministry of Natural Resources and Environmental Affairs, 2001).

Table 12: Main Source of Energy for Cooking in the study area

	LOCATION OF THE REPONDENT				**Total**
MAIN SOURCE OF ENERGY FOR COOKING	**Ndirande**	**Percent (%)**	**Chirimba**	**Percent %)**	
Electricity	8	11.1	2	5.3	10
Charcoal	62	86.1	34	89.4	96
Firewood	2	2.8	2	5.3	4
Total	72	100	38	100	110

4.7 The proportion of the charcoal consumers who are currently using improved Charcoal Stoves in the study area

As a response to the charcoal challenges some of the NGOs have been advocating for fuel-efficient charcoal stoves with an aim of reducing charcoal consumption rates. The results of this study indicate that adoption is however low. The majority of the households interviewed (about 65.5 %) indicated that they still use local (traditional less efficient) charcoal stoves and only 5% use more efficient charcoal stoves (Figure 14). This clearly shows that there is small proportion of the charcoal consumers who are currently using improved charcoal stoves. Just like other developing countries the thermal efficiency of commonly used metal charcoal stoves in Malawi is between 12 – 15% compared to over 35% of improved ceramic charcoal (Sepp, 2008).

Traditional charcoal stove **First generation improved stove**

Figure 14: The Commonly used charcoal stoves in the study area

Many studies independently concluded that a higher initial investment cost for improved stoves is one of the reasons for households not to invest in improved stoves or to contemplate fuel switching (Schlag & Zuzarte, 2008; CHAPOSA, 2002; Gill, 1985). According to Kaale (2005), ceramic liners are the main component contributing to improvement of energy efficiency of charcoal stoves. However, production of the ceramic stove liners requires suitable clay soil and curing kiln (Kaale, 2005). Without suitable clay soil and proper curing kiln the ceramic liners break easily. Other reasons for the low adoption rate which are being shared among the respondents of the study include: the perceived fragility and shorter lifespan of the improved charcoal stoves, and the mismatch between the felt needs of the user and the assumptions of the institutions and individuals designing and promoting improved stoves. Stove users in a number of developing countries are concerned about speeding cooking whilst stove programs emphasize fuel savings. According to Peter & Sander (2008), stove efficiency is contingent on variables

within four broad categories: a) fuel types and characteristics, b) combustion efficiency, c) heat transfer efficiency, and b) behavior of the user. This high use of inefficiency charcoal stoves, therefore, explains why there is higher charcoal usage in both Ndirande and Chirimba Townships in Blantyre city (Table 13).

Table 13: Type of Charcoal Stoves currently in use in the study Area

Location	Types of charcoal stoves used				
	Local Charcoal stoves	Percentage (%)	Improved charcoal stoves	Percentage (%)	Total
Ndirande	67	93.1	5	6.9	72
Chirimba	35	92.1	3	7.9	38
Total	102	92.7	8	7.3	110

4.8 Do the charcoal producers in the study area understand and adopt sustainable charcoal production practices?

The results of this study revealed that, the charcoal production process (Carbonization) in all production cites studied is done using traditional earth kilns which are inefficient (Figure 15). In this report carbonisation is defined as the heating of wood in the presence of limited supply of air, whereby water vapor and other volatile products are driven off as gas or smoke (distillation process), and charcoal remains as the end product (Olson & Hicock, 1941). Literature shows that in earth-mound kiln, between five and ten tons of wood are needed to make 1 ton of charcoal (at a mass-based conversion efficiency of 10-20%). Thus, using such kiln between 60-80% of the wood's energy is lost in the production process of charcoal (Bailis, 2003). With improved brick kilns less wood is needed to produce the same amount of charcoal (3-4 tons of wood per ton of charcoal) (Malimbwi et al., 2004). Thus the current charcoal production technology (traditional earth kilns) being practiced by the producers in the study area which is

also being used in other parts of Malawi is inefficient resulting in massive wastages during wood conversion to charcoal (Figure 15). Consequently this is resulting in massive deforestation in the surrounding areas which are the main suppliers of charcoal to Blantyre city.

All producers interviewed indicated that they don't have any knowledge of sustainable charcoal production technologies which are more efficient than the traditional earth kilns. Thus the results revealed that there is no adoption of sustainable charcoal technologies in the study area and the producers do not have any idea of the existence of sustainable charcoal production technologies. All the producers use traditional earth kilns to produce their charcoal (figure 15).

For conversion of wood into charcoal, people use "kilns". One of these kilns is the traditional kiln (earth pit or mound kilns) with efficiencies ranging between 8% and 12 %. In addition to the traditional kilns, there are improved charcoal kilns such as the Casamance Kiln, Brick Kilns Steel Kilns as well as the Adam-Retort Kilns. In charcoal production, improved kilns contribute significantly to efficient production. According to Seidel (2008), efficiency of some of these improved kilns can be as high as 40 % and noxious emission are reduced by almost 70 %. In addition, the production cycle is completed within a short time (24 to 30 hours).

Figure 15: The traditional earth - mould Kiln at Sezani in Ntcheu

According to CHAPOSA (2002) Charcoal conversion efficiency is the ratio of charcoal produced to wood in the expressed as:

$$E_k(\%) = \left(M_c / M_{wk}\right) * 100 \quad \text{...} (1)$$

Where E_k is conversion efficiency, M_c and M_{wk} are mass of charcoal produced and kiln wood, respectively. To calculate the charcoal conversion efficiency the following variables were used.

1. Oven-dry mass of wood in the kiln (M_{wk}).
2. Mass of un-carbonized wood after carbonization (M_{uc}).
3. Mass of charcoal bagged or recovered from the kiln (M_{cr}).
4. Mass of charcoal not recovered (M_{cur}), usually in form of fines in the kiln soil.

From these variables, the charcoal conversion efficiency equation is as follows:

$$E_k(\%) = \left[\left(M_{cr} + M_{cur}\right) / \left(M_{wk} - M_{uc}\right)\right] * 100 \quad \text{.....................................} (2)$$

According to Herd (2007), the relationship between timber input and charcoal is expressed by the charcoal production efficiency equation (3) below;

$$y = 3.87x - 0.26 \quad \text{...} (3)$$

Therefore from the traditional earthen kilns using the mean wood density of the five most used species for charcoal production in the area of 788 kg m^{-3} we can calculate that 1 bag of charcoal (45 kg) is equal to 256 kg of wood (0.33 m^3 * 778 kg m^{-3}). Therefore 1 kg of charcoal is produced from 5.7 kg of wood giving a conversion rate of 17.6 %.

4.9 What are the barriers to sustainable charcoal production in the study area?

The study revealed that one of the barriers to the adoption of sustainable charcoal production technologies is lack of knowledge of the exisistency of these improved charcoal technologies among the charcoal producers in the study area. When the producers were asked on whether they have ever received any training on improved charcoal kilns, it was reported that no any formal training has been offered to them and as the result they just use the traditional earth kilns.

It was also discovered that all the charcoal producers in the study area have never been issued a license to be producing charcoal, as a result all of them do their business illegally although charcoal burning is allowed in Malawi under license from a sustainable source (Section 81 of the 1997 Forestry Act). Since these charcoal producers do their business in secrecy they do not have time to think of sustainable charcoal production practices. When forestry officials were contacted it was observed that, the Government of Malawi has not yet identified the control mechanisms on charcoal extraction and no indigenous forests have been certified as a sustainable forest source, suggesting that charcoal making from forest reserves is illegal. This also explains why forestry officials confiscate charcoal in the roads of Malawi because most it is being extracted illegally (figure 16). Consequently charcoal producers in Malawi do not use improved kilns, because they do their business illegally (without a license).

Figure 16: Charcoal confiscated by forestry officials at Zalewa road block (Mwanza district)

4.10 Summary

This chapter has presented and discussed the findings of the study on issues surrounding charcoal production, transportation, trade and consumption in Ndirande and Chirimba Townships (Blantyre city). Based on these results, it was observed that, there is a link between the use of charcoal (dependent variable) and the 5 main predictor variables, namely; Literacy level of household head, Number of persons in the household, Gender of the household head, Age of the household head, and Monthly income of household head although the correlation is not very significant. This little correlation was due to the other reasons which are promoting the use of charcoal in the study area like the frequent black outs which are currently being

experienced. Similar results were also observed from the charcoal producers, transporters as well as the traders. All of them explained that they are engaged in charcoal bussines due to these social – economic factors, especially illiteracy level which in most cases contributes these other factors.

The study also revealed that, there is high demand for charcoal in the study area as it was noted that the majority of the households in both Ndirande and Chirimba Townships depend on charcoal as their main source of energy for cooking. Most of these charcoal consumers use traditional charcoal stoves which are less efficient. It was also noted that, the charcoal production process in all production cites studied is done using traditional earth kilns which are inefficient and not environmentally friendly.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings, conclusions, recommendations, areas for further research as well as a summary of the chapter.

5.2 Summary of the findings

Below is a summary of the findings versus the research objectives:

5.2.1 Research objective 1: To study socio-economic factors that influence charcoal production, transportation, trade and use of charcoal in the study area

The study indicates that charcoal production, transportation, trade as well as consumption in the study area is being influenced by these social – economic factors namely: literacy level, size of the family, gender, age, as well as monthly income of household head, although there are other contributing factors. For instance other factors which are influencing charcoal usage apart from those social – economic factors include: frequent black outs, demands of different methods of cooking according to taste and availability. For the charcoal producers, transporters and traders, the financial returns they receive from their activities is main reason why they engage in charcoal production. Charcoal business is an important economic activity, providing employment to a number of people in the study areas and the industry enables them to acquire basic items necessary for their sustenance.

5.2.2 Research objective 2: To assess current charcoal demand in the study area

The findings revealed that there is more demand for charcoal in the study area as the majority of the households in both Ndirande and Chirimba Townships depend on charcoal as their main source of energy for cooking. This is putting much pressure on the forest resources within the

district as well as the surrounding areas like Mwanza and Neno which are the major suppliers of charcoal in Blantyre city.

5.2.3 Research objective 3: To identify the proportion of the charcoal consumers who are currently using improved charcoal stoves

In this study it was revealed that the majority of the charcoal consumers are not using improving charcoal stoves which uses less charcoal as compared to the local charcoal stoves, although a number of NGOs have been advocating for these fuel-efficient charcoal stoves. According to Sepp, (2008), the thermal efficiency of the commonly used metal charcoal stoves in Malawi is between 12 – 15% compared to over 35% of improved ceramic charcoal. Due to that, majority households in the study area are using a lot of charcoal as compared to other countries which are using improved charcoal stoves. This is resulting in more pressure to forest resources. The higher initial investment cost, the perceived fragility, shorter lifespan of the improved charcoal stoves, and the mismatch between the felt needs of the user and the assumptions of the institutions and individuals designing and promoting improved stoves are some of the factors which are contributing to low adoption rate. It was discovered that these stove users are concerned about speeding cooking whilst stove programs emphasize fuel savings.

5.2.4 Research objective 4: To establish the extent to which charcoal producers in Malawi understand and adopt sustainable practices of charcoal production

It was discovered that, the charcoal production process in all production cites studied is done using traditional earth kilns which are inefficient. This clearly shows that a lot of trees are being wasted during the charcoal production process as some literature shows that in earth-mound kiln, between five and ten tons of wood are needed to make 1 ton of charcoal. Consequently this is resulting in massive deforestation in the surrounding areas which are the main suppliers of charcoal to Blantyre city. All producers interviewed indicated that they don’t have any knowledge of sustainable charcoal production technologies which are more efficient than the traditional earth kilns. Thus the results revealed that there is no adoption of sustainable charcoal

technologies in the study area and the producers do not have any idea of the existence of sustainable charcoal production technologies.

5.2.5 Research objective 5: To identify the barriers to sustainable charcoal production

The study revealed that one of the barriers to the adoption of sustainable charcoal production technologies among the charcoal producers in the study area is lack of knowledge of the exisistency of these improved charcoal technologies among the charcoal producers in the study area. No any formal training has been offered to the charcoal producers and as the result they just use the traditional earth kilns which are simple because it doesn't require any expertise in construction and use. It was also discovered that all the charcoal producers in the study area have never been issued a license to be producing charcoal, as a result all of them do their business illegally although charcoal burning is allowed in Malawi under license from a sustainable source (Section 81 of the 1997 Forestry Act).

5.3 Conclusions

The study was aimed at finding the social – economic background of charcoal production, transportation, trade and consumption in some of the low income areas in Blantyre city (namely: Ndirande and Chirimba Townships). Based on the findings of the study below are some of the conclusions.

This study has identified some of the socio-economic factors that are motivating charcoal production, transportation, trade and consumption in Blantyre low income settlements (namely: Ndirande and Chirimba Townships). Some of these factors include: literacy level of household head; number of persons in the household; gender of the household head; age of the household head as well as the monthly income of household. Although charcoal usage is motivated by these social – economic factors, the study further discovered there are other factors that promote the popularity of charcoal usage. Some these other factor include: the unreliability of the electricity, demands of different methods of cooking according to taste and availability. Charcoal business is an important economic activity, providing employment to the charcoal producers, transporters as well as the traders in the study areas. Thus the industry enables them to acquire basic items necessary for their sustenance.

The study clearly indicated that there is more demand for charcoal in the study area as the majority of the households in the study area depend on charcoal as their main source of energy for cooking. Very few respondents reported that they use electricity as their main source of energy for cooking and others use both. This high demand on charcoal is putting much pressure on the forest resources within the district as well as the surrounding areas like Mwanza and Neno which supply charcoal in Blantyre. Majority of the households are still using traditional charcoal stoves which are less efficient and the charcoal production process in all production cites studied is done using inefficient traditional earth kilns which are not environmentally friendly.

5.4 Recommendations

Based on the findings of the study the following recommendations are made:

- They should be promotion of alternative sources of income by the Government, Non Governmental Organisations and other stakeholders to reduce current pressure on the forestry resources, as poverty plus other social – economic factors being experienced in these low income areas seems to be a major compelling factor for a decision to engage in charcoal business.

- There should also be a political will to improve the socio-economic conditions of the residents in the low income settlements of the country to facilitate fuel transition from charcoal to alternative sources of energy. If the social- economic conditions of the residents in the low income settlements like in the study area improves, the will be able to appreciate importance of reducing the overdependence on charcoal as a source of energy and start using cleaner sources of energy which are environmentally friendly.

- In addition, the study recommends that there should be an introduction and promotion of affordable energy saving stoves by the Government and other stakeholders as measures of reducing over use of charcoal and firewood. The use of improved stoves and alternative energy sources should be promoted through subsidization.

- It is further recommended that, there should be an improvement in charcoal extraction

methods. This is can only be effective if Government of Malawi, through the Department of Environment Affairs can start issuing more licenses on sustainable charcoal extraction as stated in the 1997 Forestry Act. This will promote the use of improved charcoal extraction methods, because concerned stakeholders will be legally empowered to civic educate the charcoal producers on the available improved charcoal extraction methods. Reports indicate that, as of February 4, 2016, license has only been granted to Kwandama Hills Plantations (KHP) in Viphya Forests in the Northern Region because it plants its own trees and has timber as a bi-product (Chirambo, 2016).

5.5 Areas for further research

In order to complement the study and the above proposed strategies, further research is required to determine the environmental effects of charcoal business in the study area.

Since this study was just done in only two Townships of Blantyre city (Ndirande and Chirimba), similar studies should also be carried in other areas to compare the findings from these study with others.

5.6. Summary of the chapter

In this chapter it has been shown that, charcoal production, transportation, trade as well as consumption in the study area is being influenced by these social – economic factors namely: literacy level, size of the family, gender, age, as well as monthly income of household head, although there are other contributing factors. In order to reduce the overdependence on charcoal as a source of income and as the main source of energy, socio-economic conditions of the producers, transporters, traders and consumers in these low income settlements should be improved. This will help them to find other sources of income not just relying on charcoal business and for charcoal consumer improvement in their social – economic status will help them in fuel transition from charcoal to alternative sources of energy. Consequently, this will reduce the pressure on the forest resources surrounding Blantyre city. The improvement in the social – economic status should be coupled with introduction and promotion of affordable energy saving stoves as well as improvement in charcoal extraction method.

REFERENCES

Abebaw, D. (2003). Household Determinants of Fuel wood Choice in Urban Ethiopia: A Case Study of Jimma Town. Ethiopian Economic Policy Research Institute, Ethiopia.

Abeyasekera, S., & Ward, P. (2002). Models for Predicting Expenditure per Adult Equivalent. Adult Morbidity and Mortality Project, Ministry of Health, Dar es Salaam, Tanzania.

Acheampong, E. (2005). "Forest Resources and Sustainable Rural livelihoods". Paper presented at Tropenbos International Workshop on Alternative Livelihoods and Natural Resource Management. College of Agriculture and Natural Resources, KNUST, Kumasi, Ghana. (Pp. 8- 9).

Agresti, A. (1996). *An introduction to categorical data analysis,* New York: John Wiley & Sons.

Ali, O. J, & Victor, A. (2013). Assessment of Socio-economic Factors Affecting Household Charcoal use in Makurdi Urban Area of Benue State, Nigeria. Journal of Environmental Research and Management 3(7), 0180-0188. 2013. 03.

Arnold, J. E. M., Köhlin, G., & Persson, R. (2006). Wood fuels, livelihoods, and policy interventions: Changing Perspectives. *World Development*. *34*(3), 596–611.

Ayodele, A. P., Oguntunde, A., & Dias, M. D. (2009). *Numerical Analysis of the Impact of Charcoal Production on Soil Hydrological Behavior, Runoff, Response and Erosion Susceptibility*. *RevistaBrasileira De Ciencia Do Solo,* 33**,** 137-145.

Babbie, E. & Mouton, J. (2004). *The Practice of Social Research.* Cape Town: Oxford University Press Southern Africa.

Bailis, R. (2003). *Environmental and Socioeconomic Impacts of Charcoal Production in Kenya*. Paper presented in The International Seminar on Bioenergy and Sustainable Rural

Development Morella, México, 26–28 June 2003.

Barry, M., Steyn, H., & Brent, A. (2011). *Renewable energy systems Technology*: selection Case studies, xxx, 2011, 1-8, Retrieved from http://repository.up.ac.za/xmlui/bitstream/handle/2263/16612/Barry_Selection%282011%29.pdf?sequ_ence=1 24 June 2014.

Bell, J. (1993). *Doing Your Research Project*. Buckingham: Oxford University Press.

Berg, B.L. (2001). Qualitative Research methods for the Social Sciences. *California State University, Long Beach.*

Best, J.W., & Kahn, J.V. (1993). *Research in Education*. 7th Edition. Boston: Allyn and Bacon Press.

Boateng, K. (1999). "The Forest and Renewable Resource and System". A paper presented at the Workshop for Media Personel on forestry and Wildlife reporting at Akyawkrom.

Borg, W.R. & Gall, M.D. (1993). *Education Research*: An Introduction. New York: Longman.

Botkin & Keller. (2008). The Biogeochemical Cycles, Environmental Science. John Wiley and Sons Publishers.

Brooks, D. H., Pajuoja, H., Peck, T.J., Solberg, B., & Wardle, P.A. (1996). Long term trends in World demand and supply for wood (2nd ed.). In Solberg, B. (Ed.). Long term trends and prospects in world supply and demand for wood and implications for sustainable forest Management. Research Report No 6. European Forest Institute. Joensuu, Finland.

Burchinal L.G. (2008). Methods of social researchers in developing countries, http://www.srmdc.net/index.htm.

CHAPOSA. (2002). *Charcoal Potential in Southern Africa – Final Report*; Stockholm Environment Institute.

Chaturvedi, K. **(**n.d.). Sampling Method. Retrieved from www.pitt.edu/~super7/43011.../439.pp...

Chidumayo, E.N. (2001). Land cover transformation in central Zambia: role of agriculture, biomass energy and rural livelihoods. Paper to an international symposium on 'area studies: past experiences and future visions', Kyoto University, Kyoto, Japan. 19–22 January.

Chidumayo, E.N. (2010). Strategies for combating deforestation in Zambia. Makeni Savanna Research Project. Mimeo. Lusaka, Zambia.

Chirambo, M. (2016, February, 4). Govt rejects 50 charcoal license applications. The Nation News Paper, P. 7.

Creswell, J. W. (2009). Research design: Qualitative, quantitative, and mixed methods approach (3rd ed.). Los Angeles, USA: SAGE Publications India Pvt. Ltd.

Community Markets for Conservation (COMACO). (2010). Reversing trends of charcoal making a growing challenge for COMACO. www.itswild.org/no6o8/reversingtrends (9 December 2011).

Drew, C. J., Hardman, M. L., & Hosp, J. L. (2008). *Designing and Conducting Research in Education*. LA: Sage Publications, London.

Falcão, M. P. (2005). Policy impact on stakeholder benefits and resource use and conservation in Mozambique: the case study of MOFLOR forest concession area and Pindanganga community area. Thesis presented for the degree of Ph.D. in Forestry at the University of

Stellenbosch.

Falcão, M. P. (2008). Charcoal production and use in Mozambique, Malawi, Tanzania, and Zambia: historical overview, present situation and outlook. *In:* Kwaschik, R. (ed.). 2008. Proceedings of the conference on charcoal and communities in Africa. Maputo, Mozambique, 16–18 June.

FAO. (2000). "*The challenge of rural energy and poverty in developing countries*", World Energy Council/Food and Agriculture Organization of the United Nations, London.

FAO. (2004). *Unified Bioenergy Terminology–UBET*.FAO Forestry Department. Wood Energy Programme.VialedelleTerme di Caracalla, Rome, Italy. Accessed through the web: ftp://ftp.fao.org/docrep/fao/007/j4504e/j4504e00.pdf

Forestry Act 1997 (MOFFEA) s.81 (Mw).

Fraenkel, J.R. & Wallen, N.E. (1993). *How to Design and Evaluate Research in Education.* New York: Mc-Graw-Hill Inc.

Frye, M. (2013). Carbon Markets in Malawi. Kusamala Institutes of Agriculture & Ecology. http://www.kusamala.org.

Gill, J. (1985). *Stoves and Deforestation in Developing Countries*; paper presented to the UKISES Conference, Energy for Development - what are the solutions? Reading University, December 13th 1985.

Gumbo, D.J., Moombe, K.B., Kandulu, M.M., Kabwe, G., Ojanen, M., Ndhlovu, E., & Sunderland, T. C. H. (2013). Dynamics of the charcoal and indigenous timber trade in Zambia A scoping study in Eastern, Northern and Northwestern provinces. Indonesia CIFOR.

Heltberg R., (2005). Factors determining households' fuel choice in Guatemala. *Env. and Dev.*

Econs. 10: 337 – 361.

Herd, A.R.C. (2007). Exploring the socio-economic role of charcoal and the potential for sustainable production in the Chicale Regulado, Master's thesis. University of Edinburgh Alastair, Mozambique.

Hibajene, S.H., Chidumayo, E.N., & Ellegard, A. (1993). The Zambia charcoal industry. Inventory of wood used in charcoal production in Zambia. http://www.bcnet.org/bsp/bcn/learning/african/chidumay.htm 22 March, 2014.

Hibajene, S.H. & Kalumiana, O.S. (2003). Manual for charcoal production in earth kilns in Zambia. Department of Energy, Ministry of Energy and Water Development, Lusaka, Zambia. www.bioquest.se/reports/ Charcoal%20production%20manual%2 ENGLISH.pdf.

Hofstad, O., Kohlin, G. & Namaalwa, J. (2009). How can emissions from wood fuel be reduced? *In:* Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W. and Wertz-Kanounnikoff, S. (Eds.): Realising REDD+: National strategy and policy options, 237–249. CIFOR, Bogor, Indonesia.

Inkoom, D.K.B. (1999). "Management of non- reserve forest in Ghana a case study of Mpohor Wasa East District". SPRING Research Series No 24, University of Dortmund.

Israel, G.D. (2009). *Determining sample size.* University of Florida. http://edis.ifas.ufl.edu.

Jones, B. (2015). Social and environmental impacts of charcoal production in Liberia (Published Master's thesis). University of Michigan. Canada.

Jumbe, C., Bwalya, S., & Husselman, M. (2008). Contribution of dry forests to rural livelihoods and the national economy in Zambia. Paper to Governing shared resources: Connecting local experience to global challenges. 12th Biennial Conference of the International Association for the Study of Commons, Cheltenham, UK, 14–18 July.

Kaale, B.K. (2005). Baseline study on biomass energy conservation in Tanzania. SADC Programme for Biomass Energy Conservation (ProBEC) Report: 55.

Kalinda, K., Bwalya, S., Mulolwa, A. & Haantuba, H. (2008). Use of integrated land use of integrated land use assessment (ILUA) data for forestry and agricultural policy review and analysis in Zambia. Forest Management and Planning Unit of the Forestry Department, FAO and the Zambian Forestry Department Ministry of Tourism, Environment and Natural Resources, Zambia.

Kambewa, P., Mataya, B., Sichinga, K., & Johnson, T. (2007). *Charcoal: the reality – A study of charcoal consumption, trade and production in Malawi*; Small and Medium Size Enterprise Series No. 21, IIED, London.

Kenya Forest Service (KFS). (2013). Analysis of the charcoal value chain in Kenya Camco Advisory Services (Kenya) Limited, Kenya.

Kilahama, F.B. (1983) Wood as a Source of Energy in Tanzania: A substantial Essay Submitted in Partial fulfillment of the Requirements for the Degree of Master of Science (Forest Management) by course work at the Australia National University, Canberra, Australia.

Kindt, R., Kalinganire, A., Larwanou, M., Belem, J. M., Dakouo, M. Bayle, J., & Karee, M. (2008). Species accumulation within land use and tree diameter categories in Burkina Faso, Mali, Niger and Senegal. *Biodiversity and Conservation*, 17, 1883-1905.

Kohlin, G. (2003). Preference in urban domestic fuel demand: The case of kolkata, India. Env. Econs. Unit. Dept. of Econs. Goteborg Univ. Sweden. Lurimuah S, L. (2011).The Economic and Environmental effects of commercial charcoal production in the upper west Region of Ghana, Master's thesis, Kwame Nkrumah University of Science and Technology Kumasi, College of Architecture and Planning, Ghana.

Kwaschik, R. (ed.). (2008). Foreword. In: Proceedings of the Conference on Charcoal and Communities in Africa. Global Non-timber Forest Products; International Network for Bamboo and Rattan (INBAR); International Fund for Agricultural Development (IFAD) and Ministry of Agriculture, Mozambique. 16–18 June.

Lew, J.D., & Kammen, D.M. (1997). Review of social and environmental impacts of charcoal in Africa. Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ. 120 pp.

Makungwa, S.D. (1997). Charcoal production study in Blantyre area, Report for the Forestry Research Institute of Malawi, Zomba, Malawi.

Malimbwi, R.E., Nduwamungu, J., Misana, S., Jambiya, G.C. & Monela, G.C. (2004).Charcoal supply in Dar es Salaam City, Tanzania. *The Tanzania Journal of Forestry and Nature Conservation*, 75: 108-118.

Malimbwi, R.E., Zahabu, E., Monela, G.C., Misana, S., Jambiya, G.C. & Mchome, B. (2005). Charcoal potential of miombo woodlands at Kitulangalo, Tanzania. Journal of Tropical Science 17(2): 197–210.

Manahan, S.E. (2000). Environmental chemistry (7th ed.). Washington D.C. Lewis Publishers.

Manda, A.K. (2001). *Energy choices among households in the municipality of Zomba: an application of Logistic regression.* MSc dissertation, Chancellor College, Zomba.

Maoulidi M. (2012).Water and Sanitation needs assessment for Blantyre city, Malawi. New York, NY, 10115, United States: Columbia University.

Markus Knöpfle, M. (2004). A Study on Charcoal Supply in Kampala-*Final Report.* Kampala, Uganda: Ministry of Energy and Mineral Development (MEMD).

Matovu, G. (2000). Upgrading urban low-income settlements in Africa: constraints, potentials and policy options. Municipal Development Programme, Johannesburg, South Africa.

Matthews, E. & Hammond, A. (19990 Critical consumption trends and implications degrading Earth's ecosystems. World Resources Institute, Washington, DC.

Mekonnen, A., & Kohlin, G. (2009). Determinants of Household Fuel Choice in Major Cities in Ethiopia. Working Papers in Economics No 399, University of Gothenburg, Sweden.

Mickels-Kokwe, G. (2005). The forest contribution to rural small-scale household income in Zambia. *In:* The contribution of the forest sector to the national economy and poverty reduction in Zambia. SAVCOR INDUFOR – Forestry Department, Zambia and Ministry for Foreign Affairs of Finland. Lusaka, Zambia.

Ministry of Energy, Mines and Natural Resources. (2009). Malawi Biomass Energy Strategy. Lilongwe. Malawi: Author.

Ministry of Environment and Climate Change Management. (2012). Malawi National Climate Change Policy: Draft White paper. Lilongwe. Malawi: Author.

Ministry of Natural Resources and Environmental Affairs. (2001). National action programe for Malawi for the United Nations Convention to Combat Desertification. Lilongwe. Malawi: Author.

Ministry of Natural Resources and Environmental affairs. (2004). National Environmental Policy. Lilongwe. Malawi: Author.

Ministry of Natural Resources, Energy and Environment. (2010). Environment for Sustainable Economic Growth, Malawi State of Environment and Outlook Report. Lilongwe. Malawi: Author.

Monela, G.C., OKtingáti, A. & Kiwele, P.M., (1993). Socioeconomic aspects of charcoal consumption and environmental consequences along Dar es Salaam – Morogoro highway, Tanzania. *Journal of Forest Ecology and Management,* 58: 249-258.

Monela G. C. ; Zahabu E.: Malimbwi R.E. Jambiya G & Misana S. (1999). Socio-economics of

charcoal extraction in Tanzania: a case of eastern part of Tanzania. Sokoine University of Agriculture Dar es Salaam.

Mugenda & Mugenda. (1999). Research Methods: *Qualitative and Quantitative Approaches.* Nairobi: Act Press.

Mutamba, M. (2007). Farming or foraging? Aspects of rural livelihoods in Mufulira and Kabompo districts of Zambia. CIFOR, Bogor, Indonesia.

Muwamba, E. (2010). "Blantyre Water Board Fights Blantyre's Sanitation Woes," *The Nation* December 10, 2010.

National Statistics Office and UNICEF [NSO & UNICEF]. (2008). *Blantyre Multiple Indicator Cluster Survey 2006.* Zomba: Malawi.

Newman, I., & Benz, C.R. (1998). *Qualitative-Quantitative Research Methodology: Exploring the Interactive Continuum*. Carbondale: University of Illinois Press.

Nkonoki, S.R. (1983). The Poor Man's Energy Crisis: A Report of the Tanzania Rural Energy Consumption Survey: Dar es Salaam, TANZANIA.

NL Agency. (2010). Making charcoal production in Sub Sahara Africa sustainable. BTG Biomass Technology Group BV, Netherlands.

Nworgu, B. O. (2005). Introduction to Educational Research. Ibadan, Longman Publishers.

Nyembe, M. (2011). An econometric analysis of factors determining charcoal consumption by urban households: The case of Zambia. Uppsala, Sweden, Swedish University of Agricultural Sciences.

Okello, B. D.; O'Connor, T. G. and Young, T. P. (2001). Growth, biomass estimates, and Charcoal production of Acacia drepanolobium in Laikipia, Kenya. Forest Ecology and Management, 142(1-3):143-153. Pages 33-45.

Olson, A.R & Hicock, H. W. (1941). A Portable Charcoal Kiln: Using the Chimney Principle. Connectcut Agricultural Experiment Station, New Haven, Yale University.

Ouedraogo, B. (2006). Household Energy Preferences for cooking in Urban Ouagadougou Burkina Faso. *Energy policy 34:3787 – 3795.*

Peter, C., & Sander, K. (2008). Policy Note Moving towards a Sustainable Charcoal Sector in Tanzania.

Rivers, D. Huggins, V., & Slotwiner, D. (2003). Combining random and non-random samples. New York: American Statistical Association.

Roop, Taylor, J. (2013). "Moving Toward Sustainable Production of Charcoal in Sub-Saharan Africa: A Teaching Case Study". *Chemistry Publications and Other Works.* http://trace.tennessee.edu/utk_chempubs/38. [Accessed 14-11-2014].

Schlag, N., Zuzarte, F. (2008). *Market Barriers to Clean Cooking Fuels in Sub-Saharan Africa: A Review of Literature*; Working Paper, Stockholm Environment Institute.

Seidel, A. (2008). Charcoal in Africa Importance, Problems and Possible Solution Strategies, (GTZ), Eschborn.

Sepp, S. (2008). *The way ahead – Creating a formal and sustainable charcoal sector.* Discussion paper.

Sibale, B. & Banda, G. (2004) A study on livelihoods, governance and illegality: law enforcement, illegality and the forest dependent poor in Malawi. Centre for Development Management, Lilongwe, Malawi.

Stassen, H.E. (2002). Nuevas technologies de production de carbon vegetal. Unasylva 211(53): 34- 35.

Stephen, L. (2011). The Economic and Environmental effects of commercial charcoal production in the upper west region of Ghana (master's thesis). Kwame Nkrumah

University of Science and Technology Kumasi, Ghana.

Tesot, A. K. (2012). Environmental Implications of the Charcoal business in Narok-south sub -county, Narok county (Master's thesis), Kenyatta University, Kenya.

Tobin, C.M. (2011). The Root of the problem: What's Driving Tropical Deforestation Today. Washington, DC.

Turner, A. G. (2003). Sampling frames and master samples. UNITED NATIONS SECRETARIAT, Statistics Division: New York.

U N - H A B I T A T. (2007). Sustainable Urbanization: local action for urban poverty reduction, emphasis on finance and planning. Nairobi, Kenya.

UN-HABITAT. (2011). Malawi: *Blantyre Urban Profile* (Nairobi: UN-HABITAT).

USAID. (2007). *Fuel Efficient Stove Programs in IDP Settings – Summary Evaluation Report, Uganda*; USAID, September 2007.

World Bank. (2009). Environmental Crisis or Sustainable Development Opportunity? Transforming the Charcoal Sector in Tanzania. Environmental and Natural Resources Unit for the Africa Region. Washington, DC.

Yin, R. K. (2003). Case study research: Design and methods (3rd ed.). Thousand Oaks, CA: Sage.

Zahabu, E. (2001). *Impact of charcoal extraction on the miombo woodlands: the case of Kitulangalo Area, Tanzania* (MSc Thesis).Sokoine University of Agriculture.

Zulu, L, C, & Richardson, R. B. (2013). Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. *Energy for Sustainable Development*. 17, 127–137.

APPENDICES

APPENDIX A: CALCULATION OF SAMPLE SIZE FOR CHARCOAL CONSUMERS

Location	Number of Households	Sample Size	Questionnaires administered	Response rate (%)
Ndirande	7451	72	72	100
Chirimba	4000	38	38	100
Total	11451	110	110	

$n=N/1+N*ð^2$, where n=sample size, N=sample frame and ð=margin of error

with a confidence level of 95%

Sample frame=11451

Margin of error=0.05

Therefore $n=11451/ (1+11451*0.05^2)$

= 386.499= 386

Hence 386 charcoal consumers constituted the sample size.

APPENDIX B: QUESTIONAIRE FOR CHARCOAL PRODUCERS

Introduction:

This questionnaire is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

(I) PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19 ☐ (b) 20-29 ☐ (c) 30-39 ☐ (d) 40-49 ☐ (e) 50-59 ☐ (f) 61 + ☐

3. How long have you been in charcoal production?

_____

(II) SOURCES OF TREES/WOOD FOR CHARCOAL PRODUCTION

4. (i) Is charcoal burning your main economic activity?

(a) Yes (b) No

4. (ii) Are all trees/wood favorable for charcoal burning?

(a) Yes (b) No

4. (iii) (If no) is it possible for you to mention the various types/species of trees used for charcoal production (Local or English name)?

(a)_____

(b)_____

(c)_____

(d)_____

(e)_____

5. (a)(If yes to 4 (ii), Are there some preferred species of trees/wood to others?

(a) Yes (b) No

(b) If yes can you list them and state the reasons why this is so.?

(i)_____

(ii)_____

(iii)_____

(iv)_____

(v)_____

6. (a) Do consumers prefer some category of charcoal to others? (a) Yes ☐ (b) No ☐

(b) If so, why?

_____

_____

7. What are the sources of wood for charcoal production?

(a)

_____

(b)_____

(c)_____

(d)_____

(e)_____

8. (a) which of the above sources is the most viable and why?

(i)_____ (ii)_____(iii)_____

(iv)_____

Why?_____

9. What methods do you use for charcoal processing?

(a) Traditional earth or saw dust mound procedure (b) Mobile metal kiln method

(c) Pit kiln method (d) Others

(specify)_____

10. Which of the above is most preferred and why?

(a)_____ (b)_____

(c)_____

Why?_____

11. Which specific parts of the tree/ wood are mostly used in charcoal processing?

(a) Branches (b) stems (c) leaves (d) Roots (e) All the above

12. Which part is usually preferred? Please specify and why?_____

_____

_____

(III) WELFARE ISSUES RELATING TO CHARCOAL PRODUCTION

13. (i) Do you think Charcoal business contributes to your welfare?

(a) Yes (b) No

(ii) If yes, in what ways does it support you?

(a)_____

(b)_____

(c)_____

(d)_____

(e)_____

14. How many bags of charcoal do you usually harvest from a single production?

(a) 1-4 ☐ (b) 5-7 ☐ (c) 8-10 ☐ (d) 11-15 ☐

15. At what price do you usually sell a 50 bag of charcoal?_____

16. About how much income do you usually generate per production?_____

17. How often do you engage in charcoal production in a year?

(a) When in need of money ☐ (b) Summer ☐

(c). Winter ☐ (d) All year round ☐

18. Where do you often burn/produce the charcoal?

(a) Around the house ☐ (b) In the bush ☐ (c) Farm plots ☐

19. Could you give some reasons to your answer in the above question 18?

(a)_____

(b)_____

20. Where do you usually sell the charcoal produced?

(a) District capital market ☐ (b) Outside the district ☐

(IV) LOCAL PERCEPTIONS & KNOWLEDGE ON SUSTAINABLE USE OF RESOURCE; TREE SPECIES

21 a. Do you sometimes experience difficulties in obtaining the wood you need for charcoal production?

(a) Yes ☐ (b) No ☐

b. If yes, what do you think has accounted for this?

_____

_____

_____

22. Have you ever received training on how to improve upon your charcoal business?

(a) Yes ☐ (b) No ☐

23. Do you replant trees sometimes after cutting some for charcoal production?

(a) Yes ☐ (b) No ☐

24. (i) In your own view do you think it's necessary to be planting trees purposely for charcoal production? (a)Yes ☐ (b) No ☐

(ii) Give reasons for your answer

_____

_____

25. Do you have any knowledge on wood-lots?

(a) Yes ☐ (b) No ☐

26. If yes, how many wood-lots are in your area?

_____

27. Do you think it is beneficial for charcoal burners to form themselves into associations?

(a) Yes ☐ (b) No ☐

28. Give reasons for your answer

_____

_____

(V)IMPACTS OF CHARCOAL PRODUCTION ON THE ENVIRONMENT

29. Is there any impact of charcoal production on the environment?

(a) Yes (b) No

30. If yes to 29, what is the impact?

_____

_____

31. Do you get permission to extract/produce charcoal? (a) Yes / (b) No

32. If YES, where do *producers* get permission to produce and/or sell charcoal?

(a). Self (b). Household (c). Village Headman

(d). Area chief (e). Forestry Department (f). Other

33. If no, is it necessary to legalise charcoal production and transportation in Malawi?

(a) Yes (b) No

34. Explain your answer_____

_____

35. In your own way, what needs to be done?

(a)_____

(b)_____

(c)_____

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX C: QUESTIONAIRE FOR CHARCOAL TRANSPOTERS

Introduction:

This questionnaire is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19 ☐ (b) 20-29 ☐ (c) 30-39 ☐

(d) 40-49 ☐ (e) 50-59 ☐ (f) 61 + ☐

3. How long have you been in charcoal business?

---

4. Is charcoal business your main economic activity?

(a) Yes ☐ (b) No ☐

5 (i).Do consumers prefer some category of charcoal to others?

(a) Yes ☐ (b) No ☐

(ii). If so, why?----------

(III) WELFARE ISSUES RELATING TO CHARCOAL PRODUCTION

6. (i) Do you think Charcoal business contributes to your welfare?

(a) Yes ☐ (b) No ☐

(ii) If yes, in what ways does it support you?

(a)----------

(b)----------

(c)----------

(d)----------

(e)----------

(f)----------

7. How many bags of charcoal do you usually transport from a single trip?

(a) 1-4 ☐ (b) 5-7 ☐ (c) 8-10 ☐ (d) 11-15 ☐

8. About how much do you usually sell a 50 kg bag of charcoal?

---

9. About how much income do you usually generate per trip?

---

10. How often do you engage in charcoal business in a year?

(a) When in need of money ☐ (b) Summer ☐

(c). Winter ☐ (d) All year round ☐

11. Where do you usually sell the charcoal produced?

(a) District capital market ☐ (b) Outside the district ☐

(V)IMPACTS OF CHARCOAL PRODUCTION ON THE ENVIRONMENT

12 Do you know whether charcoal production reduces forest cover?

(a) Yes ☐ (b) No ☐

If yes, what are some other possible reasons for this? ----------

---

---

13. What do you think is the cause for difference?

(a) Charcoal activities ☐ (b) Bush Fire ☐

14. In your own way, what needs to be done?

(a)----------

(b)----------

(c)----------

15. Do you get permission to transport charcoal? (a) Yes / (b) No

16. If YES, where do *producers* get permission to produce and/or sell charcoal?

(a). Self (b). Household (c). Village Headman

(d). Area chief (e). Forestry Department (f). Other

17. If no, is it necessary to legalise charcoal production and transportation in Malawi?

(a) Yes (b) No

18. Explain your answer_____

_____

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX D: QUESTIONAIRE FOR CHARCOAL TRADERS

Introduction:

This questionnaire is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

(I) PERSONAL DATA OF RESPONDENT

1. Sex: a) male ☐ (b) female ☐

2. Age: (a) 10-19 ☐ (d) 40-49 ☐ (b) 20-29 ☐

(c) 30-39 ☐ (e) 50-59 ☐ (f) 61 + ☐

3. How long have you been in charcoal business?

_____

4. Is charcoal business your main economic activity?

(a) Yes ☐ (b) No ☐

5 (a) Do consumers prefer some category of charcoal to others?

(a) Yes ☐ (b) No ☐

(b) If so, why? ----------

(III) WELFARE ISSUES RELATING TO CHARCOAL PRODUCTION

6. (i) Do you think Charcoal business contributes to your welfare?

(a) Yes ☐ (b) No ☐

(ii) If yes, in what ways does it support you?

(a)----------

(b)----------

(c)----------

(d)----------

(e)----------

7. How many bags of charcoal do you usually sell per day?

(a) less than 1 bag ☐ (b) 1-4 ☐ (c) 5-7 ☐ (d) 8-10 ☐ (e) 11☐

8. About how much do you usually sell a bag of charcoal?

_____

9. About how much income do you usually generate per Day?

_____

10. How often do you engage in charcoal business in a year?

(a) When in need of money ☐ (b) Summer ☐

(c). Winter ☐ (d) All year round ☐

11. Where do you usually sell the charcoal produced?

(a) Township market ☐ (b) Outside the Township Market ☐

12. Do you get permission to sell charcoal in your district? (a) Yes / (b) No

13. If YES, where do you get permission to sell charcoal in your district?

(a). Self (b). Household (c). Village Headman

(d). Area chief (e). Forestry Department (f). Other

14. If no, is it necessary to legalise charcoal business in Malawi?

(a) Yes (b) No

15. Explain your answer_____

_____

(V) IMPACTS OF CHARCOAL PRODUCTION ON THE ENVIRONMENT

16 Do you know whether charcoal production reduces forest cover?

(a) Yes ☐ (b) No ☐

17. If yes, what are some other possible reasons for this?

---

18. What do you think is the cause for difference?

(a) Charcoal activities ☐ (b) Bush Fire ☐

19. In your own way, what needs to be done to conserve the environment?

(a)----------

(b)----------

(c)----------

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX E: QUESTIONNAIRE FOR URBAN ENERGY CONSUMERS

Blantyre Low Income Areas energy study

This questionnaire is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

Confidential **Questionnaire number_____**

DEMOGRAPHICS

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19☐ (b) 20-29 ☐ (c) 30-39 ☐ (d) 40-49☐ (e) 50-59 ☐ (f) 61 + ☐

3. Marital status:

1. Married 2. Single 3. Divorced 4. Widowed 5. Children only

4. Type of household:

1. Male-headed 2. Female-headed 3. Child-headed 4. Elderly-headed

5. Contact phone (optional) _____

6. Number of people living in the household_____

7. Contact address/work (optional) _____

_____

8. Highest educational level of head of household/spouse

(1). University (2). College (3). Secondary (4). Primary (5). None

9. Main occupation of head of household: _____

10. Main occupation of spouse: _____

11. Occupations of other members over 18 years old: _____

LOCATION

12. Township: _____

13. House type: [circle/ Tick]

(a). baked bricks (b). un baked bricks

14. How many bedrooms are in your home?

(a). one (b). Two (c) Three (d). Four (e).Five or more

ENERGY USE

15. Is the household connected to electricity?

(1). Yes, (2). No

16 Is the household connected to water?

(1) Yes (2) No

17. Does the household have the following?

(1). DSTV/TV (2). Phone (3). Fridge 4. Electronic iron

18. How important are each of the factors when you are selecting which appliance, electronic device, or other energy-related product or service to purchase for your home?

a. Cost savings you might get from reduced electricity usage.

(1= *Not very important* 2=*Not important*, 3= *Not sure*, 4= *Important*, 5= *Very Important*)

1 2 3 4 5

b. Purchase discounts offered for purchasing energy efficient devices, like rebates or tax credits.

(1= *Not very important* 2=*Not important*, 3= *Not sure*, 4= *Important*, 5= *Very Important*)

1 2 3 4 5

19. If your house is connected to electricity, what is your average monthly bill?

MK_____

20. What is your main source of energy for cooking?

(1).Electricity (2).Charcoal (3).Firewood (4).Gas (5).Other (specify)

21. If you are not using electricity for cooking, why not?

1. Disconnected 2. Landlord does not allow 3. Cannot afford

4. Use cheaper alternative (specify) 5. Other (specify

22. What is your main source of energy for lighting?

(1).Electricity (2).Charcoal (3).Firewood (4).Gas (5).Other (specify)

23. What is your main source of energy for space heating?

(1).Electricity (2).Charcoal (3).Firewood (4).Gas (5).Other (specify)

24. Do you use hot water in your home? (a). Yes (b). No

25. Which fuel do you use to heat water in your home for washing or bathing?

(1).Electricity (2).Charcoal (3).Firewood (4).Gas (5).Other (specify)

26. What size is your hot water heater? _____ liters

_____

27. What other sources of energy are available to the house?

Energy Source	**Usage**
Charcoal	
Paraffin	
Candles	
Gas	
Firewood	
Solar Power	

Others (Specify)	

28. If you use charcoal, estimate the value and quantities per day, week or month, or indicate if free (If no charcoal is used, go to Q8)

Total estimated cost MK_____

Period	**Units (Size of package e.g. 5, 10, 20, 50kg**	**Unit price**	**No. of units**	**Total cost (MK)**
Per day				
Per Week				
Per Month				
Per year				

29. If firewood is used, estimate:

Total value_____

Specify container/quantity/units used_____

How long does this quantity last? _____

30. Estimate the value of paraffin or gas used per month

Item	**Amount (Units)**	**Cost**	**Period(per day. week or month)**
Paraffin			
Gas			
Candles			

31. Please estimate the proportion of energy used

Energy source	**Proportions**
Charcoal	25% 50% 75% 100%
Electricity	25% 50% 75% 100%
Firewood/Charcoal	25% 50% 75% 100%

32. Please give expenditure per month in kwacha, and the proportion of your energy bill this represents

Fuel	**MK**	**Proportion**
Electricity		
Charcoal		
Firewood		
Gas		

33. Discuss and record below where the charcoal comes from

_____

34. Discuss and record below where the household buys charcoal

_____

35. Discuss and record what qualities they look for when buying charcoal

_____

_____

36. Are you using more or less charcoal now than in the past?

(1).More (2).Less (3).Same (4).Do not know (5).Other (specify)

37 Explain your answer

_____

_____

38. Do you expect to use more or less charcoal in future?

(1).More (2).Less (3).Same (4).Do not know (5).Other (specify)

39. Explain your answer_____

_____

40. What do you think the government should do to ensure that electricity is made available to every household in Malawi? _____

_____

_____

41. If you want to use electricity for cooking and lighting

How much are you willing to pay per month? MK_____

How much are you willing to pay per week? MK_____

How much are you willing to pay per day? MK_____

42. What is your normal average expenditure on household expenses (MK)?

Item	**Day**	**Week**	**Month**
Food			
Rent			
Water			

43. What is your monthly income range? (Optional)

Mk(000)			
0-1		30-49	
2-4		50-79	
5-9		80-99	
10-19		100-199	
20-29		Above 200	

44. Please indicate how much you disagree or agree with each of the following statements.

a. It is very important for me to find ways to control my energy costs.

*(*1= *strongly disagree,* 2= disagree, 3= agree, 4= not sure *5*= strongly *agree*

1 2 3 4 5

b. I am very concerned about the environmental effects of electric generating power-plants.

*(*1= *strongly disagree,* 2= disagree, 3= agree, 4= not sure *5*= strongly *agree*

1 2 3 4 5

c. I regularly review my home's energy usage.

*(*1= *strongly disagree,* 2= disagree, 3= agree, 4= not sure *5*= strongly *agree*

1 2 3 4 5

d. I pay attention to energy-related issues because they affect both my home and the country as a whole.

*(*1= *strongly disagree,* 2= disagree, 3= agree, 4= not sure *5*= strongly *agree*

1 2 3 4 5

45. Do you know whether charcoal use as a source of energy contributes to the reduction of the forest cover?

(a) Yes ☐ (b) No ☐

46. If yes, what are some other possible reasons for this?

30. If you use Charcoal as a source of energy what type of Mbaula (cooking stove) do you use?

31. In your own way, what needs to be done to protect the environment?

(a)_____

(b)_____

(c)_____

END OF QUESTIONNAIRE –Thank you for your response

APPENDIX F: CHECKLIST FOR THE ASSESSMENT OF DEPARTMENT OF FORESTRY

NAME OF INSTITUTION/DEPARTMENT_____

Introduction

This checklist is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19☐ (b) 20-29 ☐ (c) 30-39 ☐ (d) 40-49☐ (e) 50-59 ☐ (f) 61 + ☐

A. Production of charcoal

3. Is charcoal produced in the district? Yes☐ / No ☐ [circle/ mark]

4. In which of these months is charcoal produced? [Circle as applicable using the table below]

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

5. Have you noticed any change in charcoal production?

(a). Decrease ☐ (b). Increase ☐ (c). Same or no change ☐

6. Give reasons for your answer

_____

_____

7. In a given year, which months have you observed higher inflows of charcoal to the district center?

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

8. What are the sources of charcoal coming into the district center? [Circle applicable]

(a). Villages ☐ (b). Chiefdoms ☐ (c). Other districts☐ (d). State land ☐

9. Who is involved in making charcoal?

(a). Households ☐ (b). Groups ☐ (c). Organizations☐ (d). Individuals ☐

(e). Hired labour☐

10. What markets exist for charcoal?

_____

11. Why are people involved in charcoal production in your district?

_____

_____

12. Are there any areas where charcoal has been produced consistently for the last 10 years in your district?

_____

13. Which tree species are used in charcoal production in the district?

_____

B. Distribution of charcoal

14. Who is involved in the movement of charcoal from production sites to the marketplaces?

a. Producer household☐

b. Transporters

(i). Trucks☐ (ii). Cyclists ☐ (iii). Oxcarts ☐

(iv). Head load ☐ (v). Others ☐ (vi).Traders ☐

C. Markets for charcoal (formal or informal)

15. Who are the buyers of charcoal in the district?

(a). Retailers-individuals☐

(b). Retailer-institutions☐

(c). End consumer☐

(i). Institutions (e.g. schools, hospitals, police, prison, etc.)☐

(ii). Households☐

(d). Wholesalers ☐

16. What is the average price of a 50 kg Bag of charcoal in your district? ☐

17. What is the most common mode of payment for charcoal in the district?

(a). Cash ☐ (b). Credit ☐ (c). In-kind ☐

18. In which three (3) months of the year is the price for charcoal highest in the district? *Circle all that apply*

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

19. In which three (3) months of the year is price for charcoal lowest in the district? *Circle all that apply*

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

D. Institutional/governance framework

20. Do producers get permission to produce charcoal in your district? (a) Yes☐ / (b) No☐

21. If YES, where do *producers* get permission to produce and/or sell charcoal?

(a). Self☐

(b). Household ☐

(c). Village Headman☐

(d). Area chief☐

(e). Forestry Department☐

(f). Other ☐

22. If no, is it necessary to legalise charcoal production in Malawi? (a) Yes ☐ (b) No ☐

23. Explain your answer_____

_____

24. Do traders get permission to sell charcoal in your district?

(a).Yes ☐ (b).No ☐

25. If YES, where do *traders* get permission to sell charcoal?

(a). Self ☐

(b). Household ☐

(c). Village Headman ☐

(d). Area chief ☐

(e). Forestry Department ☐

(f). Other ☐

26. As a government establishment, what is your mission statement? _____

_____

_____

_____

Do you have some bye laws regarding charcoal extraction and business in your district?

(a) Yes ☐ (b) No ☐

27. What are the goals and objectives of the bye laws_____?

_____

_____

_____

_____

28. Could you outline the strategies for their enforcement_____?

_____

_____

_____

29. Do you have any challenges in the implementation of these bye laws?

(a) Yes ☐ (b) No ☐

30. If yes, could you describe them_____?

_____

_____

31. What measures are in place to address the challenges? _____

_____

_____

E. General issues around charcoal and energy

32. What do people think about charcoal production? *This question is about perceptions about charcoal, e.g.:*

a. As a livelihood source ☐

b. As a business / occupation ☐

c. As a symbol in society ☐

33. What types of energy are *available* in the district?

a. Charcoal ☐ b. Coal ☐ c. Cow dung ☐ d. Electricity ☐ e. Firewood ☐ f. Gas ☐

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX G: CHECKLIST FOR THE ASSESSMENT OF DISTRICT ASSEMBLY'S REGULATIONS ON COMMERCIAL CHARCOAL PRODUCTION

NAME OF INSTITUTION/DEPARTMENT_____

Introduction

This checklist is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19☐ (b) 20-29 ☐ (c) 30-39 ☐ (d) 40-49☐ (e) 50-59 ☐ (f) 61 ☐

A. Production of charcoal

3. Is charcoal produced in the district? Yes / No [circle]

4. In which of these months is charcoal produced? [Circle as applicable using the table below]

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

5. Have you noticed any change in charcoal production?

a. Decrease b. Increase c. same or no change

6. Give reasons for your answer

_____

_____

7. In a given year, which months have you observed higher inflows of charcoal to the district center?

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

8. What are the sources of charcoal coming into the district center? [Circle applicable]

a. Villages b. Chiefdoms c. Other districts d. State land

9. Who is involved in making charcoal?

a. Households b. Groups c. Organizations d. Individuals e. Hired labour

10. What markets exist for charcoal in the district?

_____

11. Why are people involved in charcoal production in your district?

_____

_____

12. Are there any areas where charcoal has been produced consistently for the last 10 years in your district?

_____

B. Distribution of charcoal

13. Who is involved in the movement of charcoal from production sites to the marketplaces?

a. Producer household

b. Transporters

i. Trucks ii. Cyclists iii. Oxcarts iv. Head load v. Others f. Traders

C. Markets for charcoal (formal or informal)

14. Who are the buyers of charcoal in the district?

a. Retailers-individuals

b. Retailer-institutions

c. End consumer

i. Institutions (e.g. schools, hospitals, police, prison, etc.)

ii. Households

d. Wholesalers

16. What is the average price of charcoal in the district of a 50 kg Bag?

17. What is the most common mode of payment for charcoal in the district?

a. Cash b. Credit c. In-kind

18. In which three (3) months in the year is the price for charcoal highest in the district? *Circle all that apply*

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

19. In which three (3) months in the year is price for charcoal lowest in the district? *Circle all that apply*

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

D. Institutional/governance framework

20. Do you allow charcoal business in your district? (a). Yes (b). No

21. If YES, where do producers, transporters and vendors get permission to produce and/or sell charcoal?

a. Self

b. Household

c. Village Headman

d. Area chief

e. Forestry Department

f. Other

22. If no, is it necessary to legalise charcoal production in Malawi? (a) Yes (b) No

23. Explain your answer_____

24. As a government establishment, what is your mission statement? _____

_____

_____

_____

Do you have some bye laws regarding charcoal extraction and business in your district?

(a) Yes (b) No

25 What are the goals and objectives of the bye laws_____?

_____

_____

_____

_____

26. Could you outline the strategies for their enforcement_____?

_____

_____

_____

27 Do you have any challenges in the implementation of these bye laws?

(a) Yes ☐ (b) No ☐

28. If yes, could you describe them_____?

_____

_____

29 What measures are in place to address the challenges? _____

_____

_____

E. General issues around charcoal and energy

30. What do people think about charcoal production? *This question is about perceptions about charcoal, e.g.:*

a. As a livelihood source

b. As a business / occupation

c. As a symbol in society

31. What types of energy are *available* in the district?

a. Charcoal b. Coal c. Cow dung d. Electricity e. Firewood f. Gas

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX H: CHECKLIST FOR THE ASSESSMENT OF NGO'S ADVOCATING FOR IMPROVED CHARCOAL STOVES IN BLANTYRE DISTRICT

NAME OF INSTITUTION/DEPARTMENT_____

Introduction

This checklist is to help the researcher examine the Socio-Economic Background of Charcoal Production and Household Use in Blantyre urban fringe settlements. Therefore the questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of a Master of Science in Environmental Protection and Management degree at the Polytechnic College (University of Malawi). In the light of this, I hope you would furnish me with quality information to make this study successful please. Please kindly write in the space provided where applicable and tick in the box where appropriate.

PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b) female ☐

2. Age: (a) 10-19☐ (b) 20-29 ☐ (c) 30-39 ☐ (d) 40-49☐ (e) 50-59 ☐ (f) 61 ☐

A. Types of Charcoal Stoves currently being advocated

3. Which type of charcoal stoves are currently in use?

a. Traditional charcoal, b. improved charcoal stoves c. More improved charcoal stoves

4. Which type of charcoal stoves are you advocating among the households?

a. Traditional charcoal, b. improved charcoal stoves c. More improved charcoal stoves

5. What is the adoption rate of the improved charcoal stoves among the households?

_____

6. Give a reason to your answer on question 5.

_____

_____

B. Production of charcoal

7. Is charcoal produced in the district? Yes / No [circle]

8. In which of these months is charcoal produced? [Circle as applicable using the table below]

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

9. In a given year, which months have you observed higher inflows of charcoal to the district center?

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec

10. What are the sources of charcoal coming into the district center? [Circle applicable]

a. Villages b. Chiefdoms c. Other districts d. State land

11. Who is involved in making charcoal?

a. Households b. Groups c. Organizations d. Individuals e. Hired labour

12. What markets exist for charcoal in the district?

_____

13. Why are people involved in charcoal production in your district?

_____

_____

B. Distribution of charcoal

14. Who is involved in the movement of charcoal from production sites to the marketplaces?

a. Producer household

b. Transporters

i. Trucks ii. Cyclists iii. Oxcarts iv. Head load v. Others f. Traders

C. Markets for charcoal (formal or informal)

15. Who are the buyers of charcoal in the district?

a. Retailers-individuals

b. Retailer-institutions

c. End consumer

i. Institutions (e.g. schools, hospitals, police, prison, etc.)

ii. Households

d. Wholesalers

16. What is the average price of charcoal in the district of a 50 kg Bag?

17. What is the most common mode of payment for charcoal in the district?

a. Cash b. Credit c. In-kind

18. Is it necessary to legalise charcoal production in Malawi? (a) Yes (b) No

19. Explain your answer_____

20. As a Non-Governmental Organisation, what is your mission statement?

_____

_____

_____

THANK YOU VERY MUCH FOR YOUR EFFORT

APPENDIX I: CHARCOAL PRODUCTION & TRADE IN PICTURES IN THE STUDY AREA

(a). A charcoal producer at production site in Sezani, Ntcheu District

(b). Data collection at the charcoal production site in Neno along the M1 Road

(c). The remains at the charcoal production site (Sezani Ntcheu)

(d) Roadside Seller at Chitala, Sezani in Ntcheu district

(e). Charcoal bags confiscated at Zalewa Road Block along the M1 Road

(f) Charcoal transporters at Chirimba Market in Blantyre

(g). A charcoal vendor selling charcoal to consumers at Ndirande Market, Blantyre