

**ENVIRONMENTAL IMPLICATIONS OF THE CHARCOAL BUSINESS IN
NAROK-SOUTH SUB-COUNTY, NAROK COUNTY**

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Degree of Environmental Planning and Management in the School of Environmental
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DECLARATION

This research project project is my own original work and has not been submitted for another examination neither degree nor any other award.

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DEDICATION

This research work is dedicated to all Environmental activists and advocates, my brothers and my parents Tangus and Norah.

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ABSTRACT

The forest cover in Kenya which is below the international required standard of 10% coverage is rapidly becoming depleted due to the ever increasing human demand for fuel wood. Unsustainable exploitation of forest resources for commercial charcoal production is a worrying phenomenon in Narok-South Sub-County, Narok County of Kenya. The fast disappearance of tree cover may influence climate change which may in the long run affect crop yields, tourism activities and deepen poverty levels, of which Narok County is not an exception. The research covered Narok-South Sub-County commercial charcoal production areas as the study area. The study assumed a descriptive design which employed Pre field work, Field work, Review of relevant documents, Data collection, analysis and interpretation as study approaches. The study aimed at assessing the socio-economic impacts of charcoal enterprise in Narok-South Sub-County, Narok County, the sustainability of the charcoal business, to examine the environmental implications of charcoal production in the Sub-County, and to come up with recommendations on sustainable management of charcoal business in Narok-South-Sub-County.

The study found out that the charcoal enterprise activities as currently practiced in Narok south sub county is unsustainable The annual estimation was informed by the response of majority (76%) of the charcoal producers, who engage in production at all times throughout the year. According to the 50 charcoal producers surveyed, an estimated 28,800 bags of charcoals each weighing 50kg on average are produced over the course of the year, this is equivalent to 1440 tonnes. The ACACIA xanthaphloea trees locally known as ‘Olerai’ is an important food stock for livestock are vastly harvested for charcoal production making the community vulnerable to drought effects. The other tree species preferred for charcoal production include: ACACIA lahal, OLEA Africans, WARBUGIA ugandensis,

TARCHONANTHUS camphorates, and EUCLEA schimperi. This has led to forest cover reduction and environmental degradation and is a threat to biological diversity in the area which attracts tourists. Although commercial charcoal production and movement has been banned in the study area, the main factors driving the enterprise are land clearance and the socio-economic benefits associated with charcoal industry. Data analysis was done using statistical package for social sciences software (SPSS) Version 20. Presentation involved use of tables, charts and graphs.

LIST OF ABBREVIATIONS

ESMAP	Energy Sector Management Assistance Program
ESDA	Energy for Sustainable Development Africa
ICRAF	International Centre for Research in Agro Forestry
KIPPRA	Kenya Institute for Public Policy Research and Analysis
FGD	Focused Group Discussion
NEMA	National Environment Management Authority
SPSS	Statistical Package for Social Sciences Software
FAO	Food and Agriculture Organisation of United Nations
KEFRI	Kenya Forest Research Institute
DEAP	District Environmental Action Plan
LPG	Liquid Petroleum Gas
ASALs	Arid and Semi Arid Lands
CIDP	County Integrated Development Plan
RoK	Republic of Kenya
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
KNBS	Kenya National Bureau of Statistics
KIHBS	Kenya Integrated Household Budget Survey

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CHAPTER ONE

1.1 Background to the Problem

Humankind's first source of energy is considered to be wood-fuel (Hosier, 1993). Fuel wood and charcoal are the most globally used for energy supply. Wood is an important type of biomass, with annual global utilization at 3.3 billion m³, of which more than half is used for energy (FAO, 2007).

The use of natural wood charcoal is approximately dated back to 30,000 years ago commonly in cave drawings (van Beukering et al, 2007). Over 2 billion people globally rely on fuel wood as their main energy supply, especially rural households in developing countries (FAO, 2010). Wood charcoal production globally was in the year 2009, estimated at 47 million metric tons; 9% increase since 2004 (FAO 2009). Fuel wood and charcoal, provides more than 14% of the world's total primary energy and more significant in developing countries (ibid). This demonstrates the importance wood-fuel plays in meeting the energy requirements of developing countries.

Africa accounts for 63% of the global charcoal production (FAO, 2011). About 94% of the African rural population and 73% of the urban population use wood-fuels as their primary energy source (Bailis et al, 2007) with the urban area heavily dependent on charcoal and rural areas dependent on firewood (Seidel, 2008).

Charcoal production in Kenya dates back to colonial period, around 1932 (Chlala, 1972). Charcoal, wood-fuel and agricultural wastes provides for more than 90% of rural household energy requirements and contributes to about 70% of Kenya's final energy demand (RoK,

2011). According to 2005 National Charcoal Survey of Kenya, charcoal provides 82% of urban and 34% of rural household energy requirements in Kenya (ESDA, 2005).

Charcoal industry contributes to economic development by providing rural incomes, tax revenue and employment (FAO, 2012). The annual charcoal consumption was estimated at 1.6 million tones, amounting to Ksh. 32 billion (ESDA, 2005). The Kenyan charcoal industry represents an estimated annual market value of over Ksh. 32billion (ibid). With availability of wood, it is possible for an individual medium scale charcoal producers and traders to earn between Ksh. 240,000 and Ksh. 720,000 per year (ICRAF, 2005). Kenyan charcoal industry generates revenue for the government through the issuance of licenses and business permits and the potential government revenue stood at over Kshs. 5.1 billion (ESDA, 2005).

Charcoal production is a labor-intensive process (World Bank, 2009). A large number of people are employed in different phases of charcoal making and distribution: collection; sizing the wood; preparation of kilns; loading and unloading wood into kilns, bundling, packaging, transportation; marketing and utilization (Kituyi, 2002; Mwampamba, 2007). The Kenyan charcoal industry employs about 200,000 in production and over 500,000 wood producers, transporters and vendors and supports 2.5 million dependants (ESDA 2005).

Charcoal industry has led to increased destruction of trees and vegetation due to increased charcoal demand and inappropriate technologies used in charcoal production (FAO, 2008). Use of traditional charcoal kiln accelerates the destruction due to low efficiency (Müller et al, 2011). There is therefore need to look at the technologies used in charcoal production and proper implementation charcoal regulations of 2009 to ensure that charcoal industry is sustainable.

1.2 Problem Statement

Global modernization and revolution in the energy sector has been significant although majority of the population in developing countries still depend on wood-fuel for their day-to-day energy requirements (Smith et al, 2004). Unsustainable charcoal production can undermine production of ecosystem services, agricultural production, and human health (Zulu, 2012). This is as a result of high poverty prevalence that leads to deforestation through indiscriminate extraction of wood and other resources for charcoal production. Charcoal is used in cooking, heating, housing and crafts in order to earn a living. Environmental degradation thus deprives vulnerable groups from essential goods and accelerating both the downwards spiral of poverty and environmental degradation. Poverty plays a key role in the type of energy use, and therefore poverty reduction has increasingly been the focus of many development agenda world over (FAO 2012). Since the world's social summit of Copenhagen in 1994, the Millennium Development Goals (MDGs) identified poverty reduction as a goal. The Kenya national government efforts began through the Sessional Paper No. 10 of 1965 in which the government identified poverty as one of the enemies of development. In its subsequent plans and blueprints, the government has realized that only through sustained economic growth can national wealth be created to provide the means to eliminate poverty (Kenya poverty eradication commission, 2009).

Eastern African countries have a large proportion of the people in the rural areas that can be categorized as poor or very poor (UNDP 2010) and in Kenyan, 44-46% of the total population, which is an improvement from 56% in 2000 are poor with 82% in rural areas (World Bank 2012). Therefore charcoal industry, which is prevalent in rural settings due to its affordability and accessibility to the poor, could contribute to poverty reduction through alternative income-generation opportunities (Zulu 2012).

Environmental degradation, lack of adequate forest cover, clean water and land suitable for farming; leads to more hunger, illness, poverty and reduced opportunities to make a living. This is brought about by in-appropriate technology adoption in charcoal production and insufficient access to education, information, making it difficult for poor people to manage available natural resources sustainably, thus creating loss of livelihood opportunities and of biological diversity (UNEP 2012). Narok-South Sub-County charcoal enterprise is not an exception for the adverse environmental impacts associated with unsustainable charcoal production activities.

1.3 Research Questions

- i) How sustainable is the charcoal business in Narok-South Sub-County?
- ii) What are the socio-economic implications of charcoal production in Narok-South Sub-County development?
- iii) What are the environmental impacts associated with charcoal industry?
- iv) What measures can be put in place to ensure sustainable charcoal business?

1.4 Objectives

- i) To assess the sustainability of the charcoal business in Narok-South Sub-County.
- ii) To determine the socio-economic impacts of the charcoal production industry in Narok-South Sub-County.
- iii) To examine the environmental implications of charcoal production in Narok-South Sub-County.

iv) To come up with recommendations on sustainable management of charcoal business in Narok-South-Sub-County.

1.5 Research Premise

The existing initiatives and interventions for environmental conservation in charcoal production industry are not effective and efficient.

Charcoal industry contributes to socio-economic development in Narok-South Sub-County.

Charcoal production has adverse impacts on the Narok-South Sub-County environment.

1.6 Justification of the Study

Global call for nations to shift to alternative clean development mechanisms or green energy use is a motivation to sustainable development (UNEP, 2012). Initiatives aimed at sustainable development and nation's strategy to build healthier community and creation of wealth will be realistic with a paradigm shift from unsustainable energy sources to cleaner renewable energy sources (Müller et al., 2011). According to Kenya national energy survey of 2009 analysis of fuel types in Kenya by urban and rural areas, the most popular fuel types in terms of their various uses are: kerosene (80%), charcoal (60%), fuel wood (55%), electricity (37%) and LPG (21%) respectively. The usage of fuel wood, charcoal and kerosene in rural areas is higher, compared to urban areas (RoK, 2011).

The poor and middle income populations, who are the majority of wood charcoal users, cannot afford to use electricity or liquid petroleum gas for cooking because of the high investments needed in fuel and cooking appliances (Mugo et al. 2007). Charcoal production is the single largest end-use of wood, surpassing wood consumed directly as firewood, and wood used in construction and for pulp and paper (ESDA 2005). Therefore it is imperative to

create an enabling environment for proper management and sustainability of charcoal production. Effective wood resources management could save on the environment and the associate cost to reverse degraded environment and global warming (Sander et al., 2011).

Narok-South Sub-County rural development indicators signifies low development with electricity estimated to cover 5.9% of the households (KNBS, 2009). Therefore wood fuel is the main source of energy in the county, which is utilized by more than 99% of the households (NEMA, 2013). This form of energy may contributes to the annual deforestation rate that stood at 12,000ha per year in 1999-2005, leading to reduced forest cover and land degradation (Rockstrom et al., 2009).

1.7 Significance of the Study

- This study may contribute to research on charcoal production at local, national and global scale.
- The study may contribute ideas to policy makers at the county government and national government in providing information and data about the adverse impacts of charcoal business which might be used for designing a more effective and sustainable charcoal business management.
- The study may also contribute to the identification and formulation of strategies, plans and programmes of action that could be applicable to global, regional, national and local conservation and sustainable exploitation of biological resources.
- The entire study could serve as one of the reference materials for future researches and contribute to the body of knowledge for academic success and policy.
- The study may also help in identifying opportunities in sustainable charcoal business management.

1.8 Scope of Study

This study area was Narok-South Sub-County which covers an area of approximately 10,412.10 Sq. Km., Narok County. The study examined the socio-economic contributions of commercial charcoal production in local population, its impacts on the local physical environment, assessed the status of the existing kiln technologies adopted, explored the ecological status of biophysical environment and evaluated the sustainability of charcoal enterprise.

The study examined the following variables in order to achieve its objectives; the sustainability issues affecting charcoal enterprise, the social-economic characteristics of charcoal enterprise and capacities of improvement of the physical infrastructure and the physical environment.

1.9 Limitations of the Study

- The time allocated for the study was not adequate given the nature of the research study.
- The weather was also problematic since it is a rural setting accessed by poor road networks in case of rainfall.
- Finance was also a limiting factor also since it was a self funded research.

1.10 Operational Definition of Terms

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

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).

Sustainable development: is a system of development that meets the needs of the present generation without compromising the ability of future generation to meet their needs.

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

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

Poverty: is general scarcity or dearth, or the state of one who lacks a certain amount of material possessions or money.

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

Physical environment: is the section of the human environment that has physical factors, for instance soil, water supply and climate. The term can also be defined as the material surroundings of a process, system or organism.

Social environment: is the immediate physical and social surrounding that people live or in which something happens or manifests. It includes factors such as education, living conditions, nutrition and work.

Economic environment: is the economic factors that have effects on the working of the business. It includes system, policies and nature of an economy, trade cycles, economic resources, level of income, distribution of income and wealth. It is very dynamic and complex in nature and does not remain the same.

Ecological environment: is the ecological system that involves the relations and interactions between organisms and their environment including other organisms. It also involves spacing and interdependence of people and institutions.

Ecosystem services: are the benefits people obtain from ecosystems which includes: provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth

Biodiversity: is the variability among living organisms. It includes diversity within and among species and diversity within and among ecosystems.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Charcoal Production and Technologies

Charcoal production systems are also characterized by the production technology that is used. Charcoal can be produced by a range of methods, from simple earth kilns to brick or metal kilns. The three most common methods of charcoal production are earth kilns, masonry kilns and metal kilns. The earth kiln is the most common method of making charcoal in Kenya, as well as in the rest of sub-Saharan Africa. Earth kilns are of various types but the most common are the traditional earth kiln, improved earth kiln and the Casamance kiln.



Plate 1: Casamance kiln

Source: (KEFRI, 2012)

Masonry kilns are usually of the beehive and half orange type; they are recommended for charcoal conversion in areas where fuelwood is available for prolonged periods, such as in large-scale land clearing or in fuelwood plantations.



Plate 2: Half orange kiln type

Source: (KEFRI, 2012)

Metal kilns include the drum kiln, meko kiln and Mark V type. In more industrialized settings, retorts can be used to capture condensable compounds, which can be redirected into the kiln and burned to generate needed for the charcoal-making process. In addition, some of the condensable compounds have value in other markets and can be extracted and sold (FAO, 1983; 1985; Foley, 1986).



Plate 3: A new meko kiln

Source: (KEFRI, 2012)

Improved charcoal production technologies have been introduced in order to increase production efficiency and reduce the emissions of potentially harmful pollutants. However, the use of these technologies remains very low because of limited awareness, weak technical capacity, and high risks to investment. Traditionally, charcoal is being made in mound or pit kilns (Amanor *et al.*, 2002). This technology is still used in both developing countries and in industrialized countries (*ibid*). Improved kilning techniques are widely used currently for instance the beehive kilns found in Brazil large industrial complexes used for making charcoal for the steel industry. In the USA this technique was also widely used for the manufacture of metallurgic charcoal, but abandoned during the first half of the 20th century. Missouri kilns were widespread up until 1975 in the state Missouri with yields are usually in the range of 5%-20%, and they vary with the skills of the operators.

Kenya's charcoal production is a threat to the environment as over 99% still use inefficient carbonization processes (Mutimba and Barasa 2005). Charcoal production is by use of traditional earth kiln of low efficiencies in the range of 10-13% (Walubengo and Kimani, 1993). This implies that the technology adopted is of low efficiency and therefore greater percentage of wood is wasted and the resultant charcoal quality being low (Smith et al, 2009). Production is scattered across thousands of locations, primarily in the country's expansive woodlands and shrublands which constitute over two thirds of Kenya's total land area and in some cases wood are available from land clearing for agriculture (Bailis, 2005). Charcoal productions are by small scale producers in rural settings with the preferred tree species varying according to the region but are mainly indigenous species (Kituyi et al, 2001).

2.2 Implications of Charcoal production on Environment and Biodiversity

Charcoal making involves felling down of trees and subsequent removal of vegetation cover that leads to loss of biodiversity (Timberlake, 1985). Trees removal results in alteration of plant community structures in terms of species diversity, distribution of different species and plant density (Kgathi *et al.*, 1997). According to Jacobs (1988), possible disruption of essential ecological processes is associated with accelerated and irreplaceable depletion of genes, populations, species and ecosystems. Biodiversity is the basis of ecosystem health and of the provision of ecosystem services (Rockstrom *et al.* 2009). There exist species inter-dependence in an ecosystem therefore decline or loss of a species population impacts on the life cycle of other species and the ecosystem at large (IUCN, 1997a).

Selective cutting of trees for charcoal making results simplification of the habitat linked with observed thinning of woodlands (Campbell, 1996; IUCN 1997a). For instance a tree species can support many plant and animal species on an obligatory basis and one fruit tree can provide food for many birds and mammals (Kiage, 1998). Charcoal industry if unsustainable may lead to deforestation and environmental degradation therefore disrupting the rich biodiversity ecosystem (Mugo *et al.*, 2007). Nearly all charcoal consumed in Kenya and elsewhere in sub-Saharan Africa is made from local indigenous tree species (Mutimba and Barasa, 2005). Forestry or trees are endowed with important ecological benefits including soil erosion control, catchment protection and wildlife conservation (O'keefe, 1979).

According to Bailis (2005) unsustainable charcoal production activities could lead to:

- Reduced biodiversity as a result of deforestation and forest degradation. When forest cover is removed, wildlife is deprived of habitat and becomes more vulnerable to hunting.

- Deforestation which causes 15% of global greenhouse gas emissions. Carbon dioxide emissions represent up to one-third of total carbon dioxide emissions released because of human causes.
- Disrupted water cycles as a result of deforestation, trees no longer evaporate groundwater, which can cause the local climate to be much drier.
- Increased soil erosion as deforestation accelerates the rate of soil erosion, by increasing runoff and reducing the protection of the soil from tree litter.
- Disruption of livelihoods as millions of people relies directly on forests, through small-scale agriculture, hunting and gathering, and by harvesting forest products such as rubber. Deforestation continues to pose severe social problems, sometimes leading to violent conflict.

The indigenous tree species take long to mature and therefore this implies that there will be adverse shortage of wood fuel in Kenya if dependence is only focused on this tree species to meet its charcoal demand. The total area under woodland in Kenya is estimated at 48.6 million hectares. Of these, 1.3 million are under natural forests, 0.17 million are forest plantations, and 9.5 million are farmlands. Arid and semi-arid lands, which are a major source of charcoal in Kenya, cover 80% of the land and cattle production is one of the most important livelihoods. Kenya annual deforestation rate 1990–2005 was 12,000ha/year, while the total remaining forest stood at 3.5 m ha. Charcoal production in Narok-South Sub-County is a form of land management practice to individual land recipients of subdivided land (Bailis, 2005).

Alternative advanced technology adoption in charcoal production and enhancing sustainable income opportunities for farmers, affordable alternative energy sources for urban households,

and more efficient and sustainable approaches for producing and using charcoal (Zulu 2012), could effectively ensure sustainable livelihood for the locals.

2.3 Wood fuel situation and Charcoal consumption

The global wood production in 2000 reached approximately 3.9 billion m³ whereby 2.3 billion m³ was used as woodfuels implying that approximately 60% of world's total wood removals from forest and trees are used for energy purpose (FAO, 2008). Asia and Africa produces over 75% of woodfuel (Emily, 2001). The global projection of consumption of woodfuel by 2010 ranged from 1.5 billion m³ to 4.25 billion m³ (Brooks, 1996).

In Africa over 90% of the wood taken from forest is woodfuel. The majority is of wood is consumed as fuelwood, however, a varying but significant amount is transformed into charcoal. more than 80% of the fuelwood is consumed in urban areas making charcoal the most important source of household energy in many Africa cities (Siedel, 2008; Kammen et al,2005, Amour, 1997). There will be a greater demand for wood fuel by the year 2030 in Africa and yet there is shortage in its supply as shown in the table 2.1.

Table 1: FAO projection of woodfuel consumption to 2030 in Africa.

	1970	1980	1990	2000	2010	2020	2030
Fuelwood (million m ³)							
Africa	261.1	305.1	346.6	440.0	485.7	526.0	544.7
Charcoal (million tons)							
Africa	8.1	11	16.1	23	30.2	38.4	46.1

Source: Arnold& Pearsson (2003).

Statistics provided by Camco global shows wood-fuel as one of the major causes of environmental degradation and accounts for almost 18% of world's green house gas emission (Mangat, 2009). According to Sokona (2008), it is estimated that over 11 million hectares of tropical forest are annually lost as a result of excessive clearance and mismanagement.

The current annual charcoal consumption in Kenya stands at about 6850 metric tons of charcoal daily, which translates to an annual consumption of about 2.5 million metric tons of unsustainably harvested wood (ICRAF, 2013). In 2010 about 70% of the consumers use biomass while 30% use other fuels (KIPPRA, 2010). This makes charcoal usage popular in Kenya and common amongst the urban poor and its demand is expected to increase over time due to population increase (Rockstrom et al. 2009). There are a number of reasons why people in dense urban settlements favor charcoal over wood: it has a higher energy density, it burns more cleanly reducing exposure to harmful pollutants, and it is easier to transport, handle, and store (FAO, 1983; van der Plas, 1995). Charcoal can be purchased in small amounts, making it flexible and affordable even for the poorest households. Similarly, charcoal-burning stoves are quite inexpensive, making it a more attractive fuel for the urban poor than other fuels available in urban markets such as LPG and electricity.

The spiraling demand for charcoal fuel is also as a result of highly fluctuating kerosene prices and increased LPG gas prices, with an estimated 60% of Kenyans unable to afford LPG gas (KIPPRA, 2010). To satisfy Kenyans' annual charcoal demand, establishment of fast growing tree species and adoption of modern technology in production is inevitable (Rockstrom *et al.* 2009).

2.4 Charcoal Industry contribution to Development and Employment in Kenya

Charcoal production and trade contributes to the national economy by providing rural incomes, tax revenue and employment (ICRAF, 2013). Kenya's charcoal industry represents an estimated annual market value of Ksh.32 billion, which is not visible to the government because of its informal nature (ESDA, 2005). The industry contributes to government revenues through licences and business permits. The energy sector contributes about 9.49 % to GDP; with the petroleum sector, electricity and fuel wood sector contributing 8.4%, 0.6 % and 0.4% respectively (RoK, 2009). Total final energy consumption in Kenya in 2009 was 14,353.58 thousand tonnes of oil equivalent; petroleum fuel accounted for about 28.57% of the total final energy consumption while electricity and combustible renewable accounts for about 3.11% and 67.65% respectively of the total final energy consumption (ibid).

Sustainable charcoal production and trade is an important means of satisfying the energy demand as well as generating income to some members of society thus contributing extensively to rural economies (ICRAF, 2013). It also saves the country foreign exchange that would otherwise be used to import fuel. Charcoal industry offers employment in various phases of the charcoal value chain: collection and sizing of wood, preparation of charcoal kilns, loading the wood into kilns and unloading charcoal after conversion, unloading, bundling, packaging and transportation and marketing (Bailis, 2005). Indirect employment is generated by the activities that use charcoal (Kambewa et al, 2007). In Kenya, there are approximately 200,000 charcoal producers operating in the industry implying to a total over 700,000 being employed in this industry with over 2 million dependants (ESDA, 2005). World Bank and ESMAP (2013) estimates for the generation of employment per TJ Energy consumed, it indicates that charcoal creates between 200 and 350 jobs per TJ, electricity 80-110 jobs, LPG 10-20 jobs and kerosene 10 jobs. The figures suggest that promoting charcoal

can create more jobs than the other forms of energy and a strong contributor to the national economy; hence its enhancement and growth could contribute to the growth of Kenya's economy.

2.5 Theoretical Framework

The tragedy of the commons concept is important in understanding of environmental degradation of our society. It is a dilemma in itself rooted to the situation in which multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared scarce resource, even when it is clear that it is not in anyone's long-term interest for this to happen (Hardin, 1968).

The basic idea espoused by the tragedy of the commons concept is that if a resource is held in common for use by all, then ultimately that resource will be destroyed (Hardin, 1968). The resource shared in common in this case is the trees that are cut down for charcoal production. To avoid the ultimate destruction, the human values and ideas of morality must be changed (Foddy *et al.*, 1999). This theory assumes that every human exploiter of the shared common resources is driven by self-interest (Ostrom *et al.*, 2002). When the carrying capacity of the commons is fully reached, the exploiters might find themselves in a dilemma of whether to continue with their actions or not. The gain of doing so would go solely to them, but the loss from their actions would be "Communized", therefore they will not give up their actions (Hardin, 1968). Because the privatized gain would exceed his share of the communized loss, a self-seeking exploiter would not change his behavior (Hardin, 1968). Others reasoning in the same way, would follow the suit and ultimately, the common property would be ruined (Ostrom *et al.*, 2002).

Exploiters could be aware of the long term consequences of their actions, but generally they are powerless to prevent such damage without some coercive means of controlling the actions of each individual (Foddy *et al.*, 1999). Idealists may appeal to individuals caught in such a system, asking them to let the long term effects govern their actions (Foddy *et al.*, 1999). But each individual must first survive in the short run (Ostrom *et al.*, 2002). If all decision makers were unselfish and idealistic calculators, a distribution governed by the rule “to each according to his needs” might work (Foddy *et al.*, 1999).

The spoilage process comes in two stages. First, the non-angel gains from competitive advantage of pursuing own interest at the expense of others. Then, once the noble angels realize that they are losing out, they try to get a share out of the commons before competitors do. This shows that, every workable distribution system must meet the challenge of human self-interest. An unmanaged commons in a world of limited material wealth and unlimited desires inevitably ends in ruin. Inevitability justifies the epithet “tragedy,” (Hardin,1968).

This theory underpins the activity of charcoal producers. Unsustainable fuel wood exploitation for charcoal burning results in forest destruction which charcoal producers are aware of but continue because of the selfish economic gains which however have general ramifications. The long term adverse impacts of their actions thus do not matter to them. The theory is therefore relevant to the study as it explains how unsustainability comes in charcoal business as a result of the need to fulfill self interest.

2.6 Conceptual Framework

The theory of tragedy of the commons asserts that every individual tries to meet his/her self interest by exploiting the available scarce common resource. Rapid population increase results into poverty as it puts pressure on the available scarce environmental resources. As a

consequence, poverty and lack of adequate skills in venturing in new alternative sources of income, most people exploit forest resources to produce charcoal that is sold to generate income and at the same time used as fuel. The income generated improves livelihoods of the people. Forest resource exploitation is done unsustainably without considering the future as every person wants to fulfill his/her short term self interest. The competition for these scarce resources leads to its degradation. With the initiatives such as adoption of principle of cutting one and planting two, diversification of income generation, use of alternative sources of energy such as solar and adoption of advanced technology, sustainable charcoal production will be realized. Figure (1) summarizes the conceptual framework discussed.

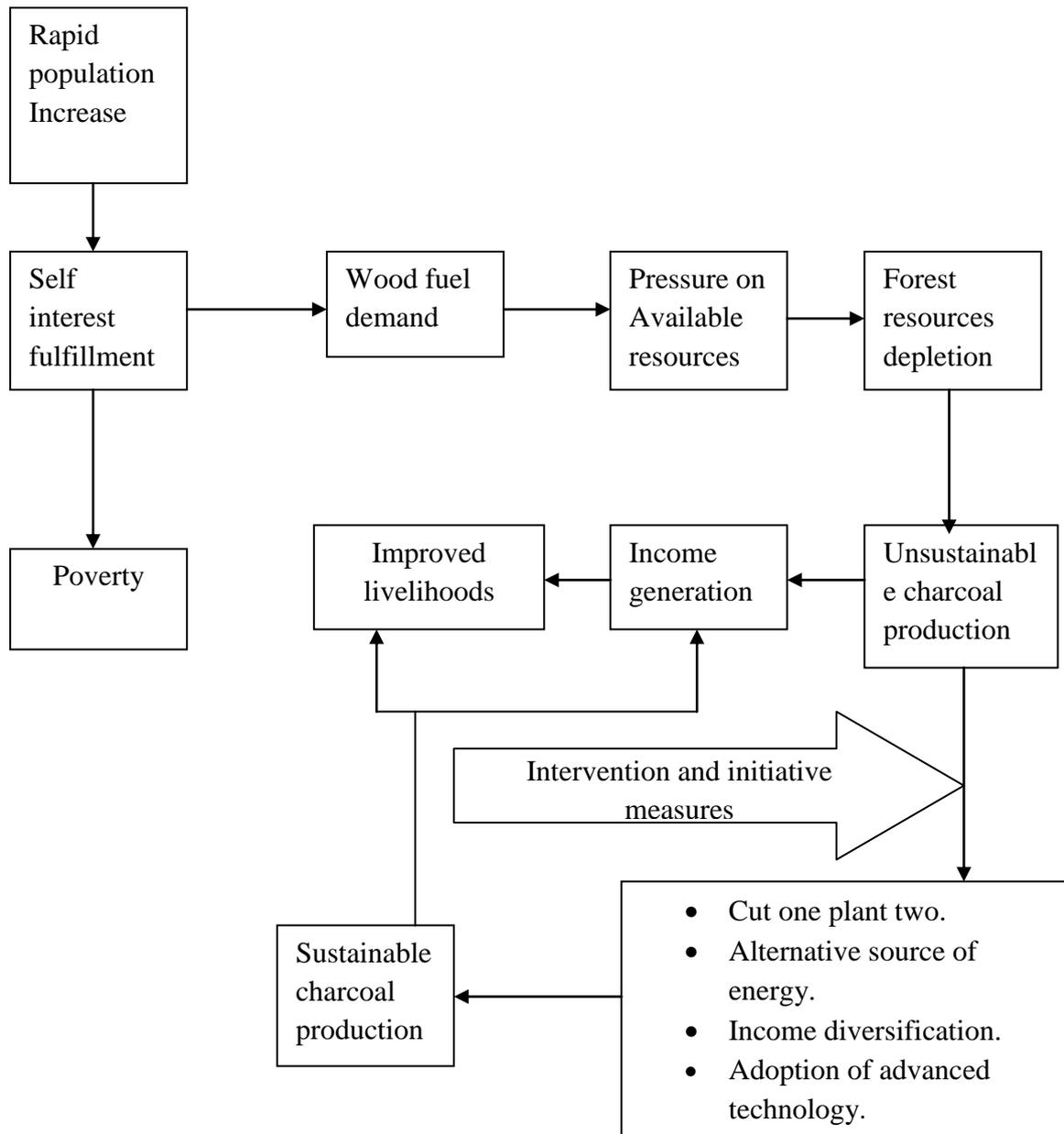


Figure 1: Conceptual model on sustainable charcoal production

Source: Author, 2014

CHAPTER THREE

3.0 STUDY AREA

3.1 Location and Extent

Narok County is one of the 47 counties of Kenya and is located to the south-western part of the country and in the southern part of Great Rift Valley. Narok County constitutes of 4 sub-counties namely; Narok North, Narok South, Transmara East and Transmara West Sub-Counties. Narok-South Sub-County which is the study area borders the Republic of Tanzania to the South, Transmara Sub-County to the West, Bomet County to the North and Narok-North Sub-County to the East. It lies between latitudes $0^{\circ} 50'$ and $2^{\circ} 05'$ South and longitudes $35^{\circ} 58'$ and $36^{\circ} 00'$ East. The sub-county is sub-divided into the following administrative units: 5 divisions, 28 locations and 52 sub-locations. It comprises of 6 County Assembly Wards namely Maji Moto, Melelo, Sogoo, Sagamian, Ololunga and Loita with Ololunga town as the Sub-County headquarters.

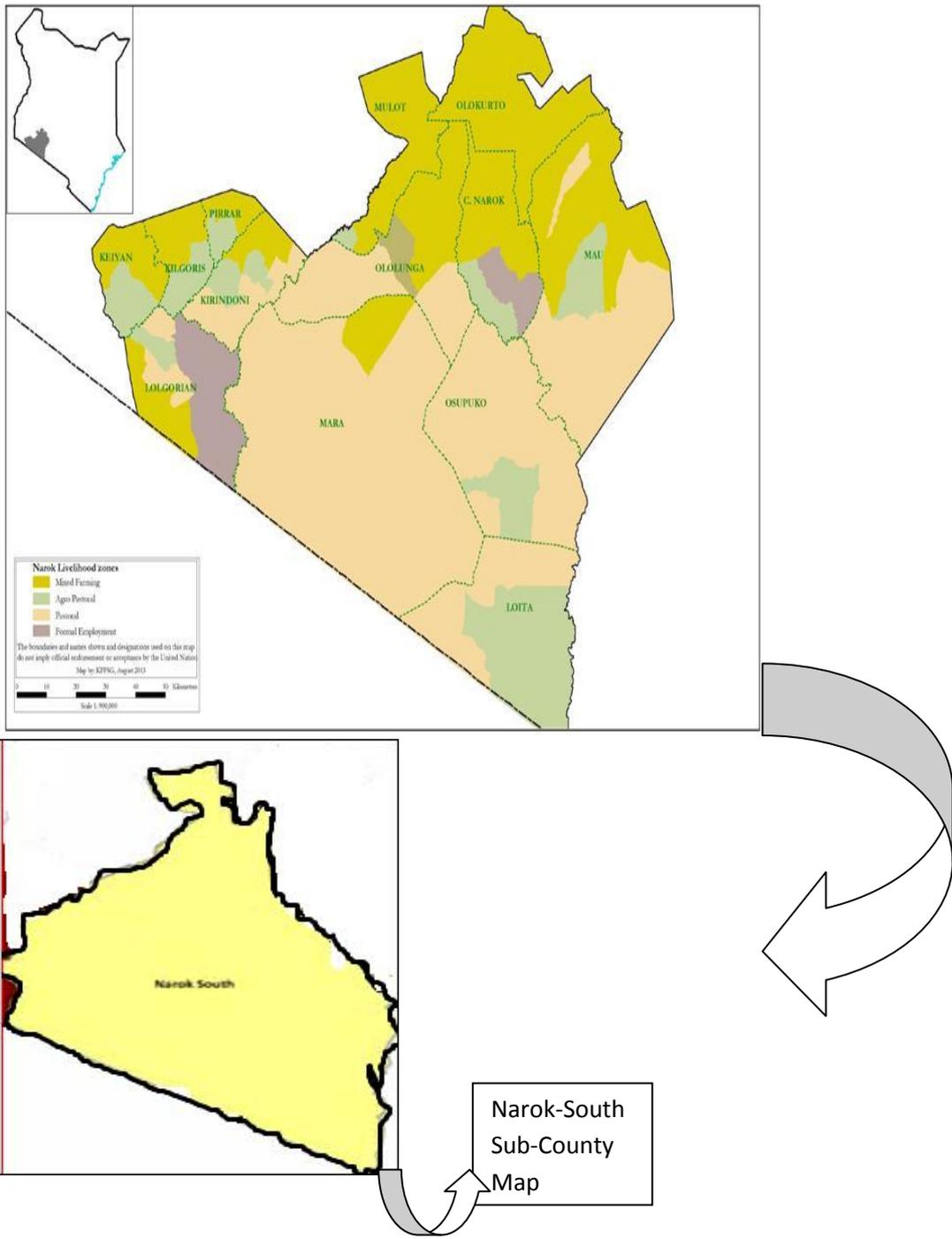


Figure 3.1: Narok County and Narok-South Sub-County maps

Source: Regional Centre for Mapping, 2014.

3.2 Climate

Narok-South Sub-County has diversified topography, which ranges from a plateau with altitudes ranging from 1000-2350 M.A.S.L at the Southern parts to mountainous landscape ranging to about 3098 M A.S.L at the highest peak of Mau escarpment in the North.

The Sub-County has five agro-climatic zones namely humid, sub-humid, semi-humid to arid and semi-arid. Two-thirds of the county is classified as semi arid (Narok DEAP, 2009-2013).

The agro-ecological zones found in the Sub-County include: Tropical Alpine (TA), Upper Highland zones (UH) Lower Highland zones (LH) and upper-midland zones (UM) (ibid).

Table 2: Average monthly minimum and maximum temperatures and precipitation

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Average high in °C	26	26	27	27	26	23	23	23	25	26	25	25
Average low in °C	9	9	9	9	9	8	8	8	8	9	8	9
Av. precipitation - mm	85	80	96	152	94	34	22	21	26	32	71	84

Source: NEMA, 2012

3.3 Socio-Economic Profile

Narok-South Sub-County has a population of approximately 176,764. It covers an area is approximately 10,412.10 Sq. Km (Narok CIDP, 2014) with about 62, 412 households and a population density of about 31 persons per sq.km (KNBS, 2010). More than 90% of the

settlement is in rural with only 6.9% comprising urban population (Ibid). More than one third (33.8%) of the population in Sub-County lives under Poverty line (KIHBS 2008) in spite the Sub-County being endowed with Natural resources such as Maasai Mara Reserve, and Arable Land suitable for agriculture. In addition, Narok-South is home to a rapidly growing number of agricultural communities, as well as one of Kenya's most important wildlife conservation areas (Bailis, 2005).

The study area is home to Kipsigis and Maasai ethnic groups, Maasai originally relied on extreme pastoral dependency on livestock, having virtually no agricultural investment in land and a minimal reliance on non-pastoral produce for their daily diet (Galaty, 1980). However, the Maasai have undergone significant socioeconomic transitions driven, in large part, by their incorporation into the Kenya's market economy. For example, land and livestock, the two mainstays of Maasai culture and economy, have become very heavily commoditized (Kituyi, 1990; Zaal and Dietz, 1999), a process which has introduced new relations of exchange and new pathways for accumulation into the pastoral economy.

The major land use types in the Sub-County livestock, agriculture, forestry, ranching and tourism. The Sub-County has a significant cash crop farming which ranges from sunflower, maize, horticultural crops and fruits and also subsistence crops production. Other land uses include brick making, pasture for livestock rearing, settlement, sand harvesting and quarrying. The rural development indicators in the study area despite its wealth in natural resources signifies low development with electricity coverage estimated to cover 5.9% of the households (KNBS 2010) hence wood fuel is the main source of energy in the Sub-County, which is utilized by more than 99% of the households (NEMA, 2013).

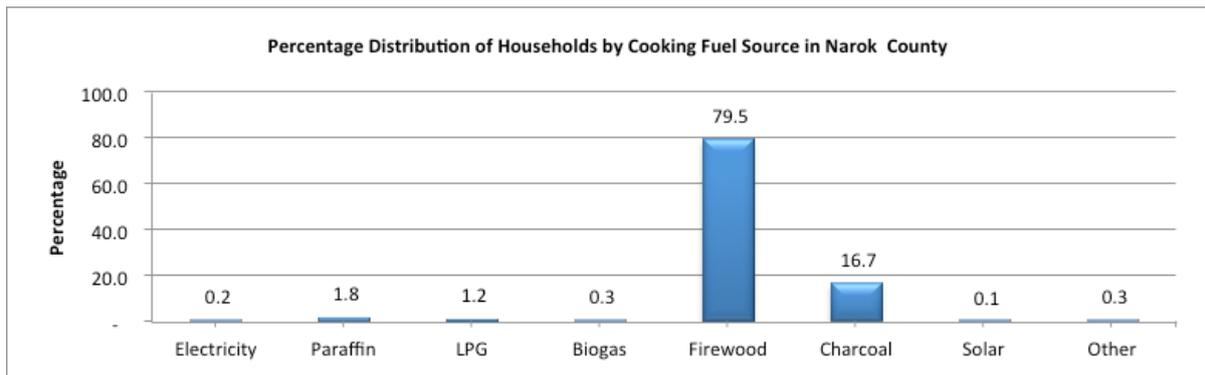


Figure 2: Households cooking fuel in Narok County

Source: KNBS and SID, 2013.

The major economic activities in the Sub-County are commercial crop farming, livestock farming and tourism in Maasai mara. Agricultural products includes maize, wheat, barley and livestock and the social and cultural activities involves the maasai traditional practice.

Crop Farming

The Sub-County enjoys rich volcanic and black loam soils that favor the growth of both cereal and cash crops; maize, potatoes, green peas, pyrethrum, carrots, wheat and barley. In the lowlands, maize and bean are grown for domestic use. Other main crops include onions and tomatoes. The main crops maize, barley and wheat are mainly grown in belts with the requisite climatic conditions ideal for that crop. Wheat is the main crop grown in large scale farms on the flat lowlands with farms averaging 8000 hectares.

Livestock Keeping

The keeping of livestock is a long held practice maintained by the Maasai and it accounts to about 80% of their livelihood incomes as a result of the pastoralist lifestyle.

Table 3: Livestock, fishery and bee keeping

Constituency	Cattle	Sheep	Goat Farming	Poultry Commercial	Poultry Indigenous	Bee Hives	Camels	Pigs	Donkeys
1.Narok North	255,881	529,492	219,394	17,324	113,328	19,402	116	3959	38,796
2.Narok South	701,899	935,757	510,328	8,731	172,644	22,730	449	2275	38,934
3.Kilgoris	459,106	184,780	150,496	11,468	275,347	22,335	43	1097	20,466
Totals	1,416,886	1,650,029	880,218	37,523	561,319	64,467	608	7,331	98,196

Source: KNBS, 2009.

Tourism Industry

The Sub-County is home to Maasai Mara game reserve that defines the Tanzania-Kenya boarder to the south west. The Reserve has different wildlife species that includes: elephants, lions, cheaters, Buffaloes, antelopes, hyenas, rhinos, leopards, wildebeest and all kind of birds among others. The reserve has historically been a tourist attraction where both locals and international tourist visit for recreation and sports.

Maasai Mara Game Reserve and the Mara Triangle have neighboring group ranches and conservancies. The tourism sector has highly contributed to the economic standards of the

Sub-County through employment in the hotel industry, game ranging, revenue collection, beadwork, curio shops and cultural practices in the Manyattas among others.

Table 4: Hotels, Group Ranches and Conservancies distribution in the county

Constituency/ Minerals	Hotels	Conservancies	Group Ranches	Airstrips
1.Narok North	2	0	5	1
2.Narok south	13	4	13	3
3.Kilgoris	5	2	4	3
Total Coverage	20	6	22	7

Source: KNBS, 2009.

3.4 Biophysical characteristics

Land cover in Narok-South Sub-County is dominated by shrubland and savanna, interspersed with isolated patches of riverine forest. The landscape has a varied topography, with well forested mountainous uplands rising over 3000m-asl in the northern part of the Sub-County. These uplands descend to volcanic footslopes and a large central plateau with deep well-drained soils (Jaetzold and Schmidt, 1983). Soil types in the Sub-County are determined by characteristics of the underlying basement rock and range from those developed on mountains to those developed on plains and swamps. The main soil types in the Sub-County include: Mollic andosols, luvisols, chromic luvisols, luvic and ando-luvic, phaeozems, chromic vertisols and chromic aerosols.

Forest resources are exploited mainly for timber, charcoal posts, culinary utensils, fodder, medicine and cultural purposes. The County's forest types and size in (ha) includes: Government Forests (Gazetted); Transmara 35270.3, Olpusimoru 16832.7, South Mau 136, Trust land Forest; (Managed by Narok County government) Maasai Mau 45,794 Loita 20,000 Enosupukia 10,772 and Private/Group Ranch Forests Located in all administrative divisions 34,000.

The Sub-County is endowed with rich diversity of both flora and fauna. There are over 54 species of wildlife mammals, 300 species of birds and over 123 species of plants and several species of insects, fish, amphibious and reptiles.

3.5 Land use change and charcoal making

Narok-South Sub-County has experienced a rapid increase in the extraction of forest products, including the development of an informal, but highly commercialized charcoal trade (NEMA, 2013). This has drawn the attention of a number of local and national government agencies that are attempting, through various means, to limit the flow of commodities like charcoal, which are widely associated with environmental degradation (Government of Kenya, 1980-2002; Ecoforum, 2002; Okwemba, 2003). Charcoal production thrives exclusively in lands that are being opened for new agricultural production (Bailis, 2005). Landowners, who have benefited from the recent subdivision of group ranches rely on charcoal to finance the opening-up of new agricultural land, an activity that many would not be willing or able to pay for through other means (ibid). Despite the strong link between charcoal and agricultural production in Narok, most administrators perceive the two activities very differently as agricultural production being considered an ideal development path for the Sub-County that used to be dominated by pastoralist.

Small and large-scale agricultural activities are supported to varying degrees by government and donor-funded projects (Government of Kenya, 1980-2002). In contrast, charcoal production is viewed as a menace and steps are taken to restrict it, if not entirely stamp it out (Government of Kenya, 1980-2002, 2002-2008 edition). According to Kenya Forest Service officer interviewed during field survey, commercial charcoal production and movement in Narok-South Sub-County has been banned since 2008 to date but it is still thriving illegally.

Narok-South Sub-County gradual reforms in land tenure over the past century, first from communal to corporate tenure and then to individual freehold tenure, created the conditions in which the charcoal trade now thrives, aided by an influx of migrants from neighboring counties who supply both their technical knowledge and their labor to the industry. In spite of the popular discourse that portrays charcoal as an agent of environmental destruction, charcoal plays a specific role in land management for recipients of subdivided land. There are a wide range of social benefits flowing from the Sub-County's charcoal trade which constitutes an important source of income for charcoal makers throughout the Sub-County and Kenya at large. It also forms part of a land management strategy for thousands of landowners who supply trees to the charcoal kilns.

Charcoal production represents the least-cost means to clear newly acquired land. Landowners face several motivations to clear their newly acquired land, ranging from opening up forested land for more economic benefits and settlement purposes. In addition, not only do landowners have multiple reasons to clear land, subdivision made it far more easy to do so. Upon subdivision, former group ranch members became titled landowners. The presence of charcoal makers in Narok substantially lowers the cost to landowners of clearing land deemed to have arrived in Narok in large numbers in the late 1990s.

CHAPTER FOUR

4.0 RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

This chapter describes the research design, nature and source of data, the target population, sample size, sampling procedures, data collection tools, methods of data collection, analysis and presentation of data.

4.2 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). It provides for the collection of relevant data with minimal expenditure of effort, time and money (Burns, 2000). 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 and 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 the choice of household and energy and energy sources (Best and 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 factors contributing to charcoal production activities, the impacts of charcoal production on the environment, and determines the socio-economic contribution of charcoal industry as seen in chapter five of this report.

4.3 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 technologies used in charcoal production, photography of degraded environment and the means used in charcoal transportation, interviewing key resource persons, household heads, business community merchants, 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 from institutions in the study area. This included Kenya Forest Service, Kenya Wildlife Service, Ministry of Agriculture, Livestock and Fisheries and National Environment Management Authority and also spatial information inform of map of the study area from Regional Centre for Mapping.

4.4 Methods of Data Collection

The study employed various methods of data collection including:

4.4.1 Direct Interviewing

The researcher used this as a method of data collection by use of questionnaire and interview schedule as the research tools. Questionnaires with both open ended and close ended questions were administered by means of personal interviews to 50 household heads and 40 business community merchants. Interview schedules with specific lead questions for each institution were used on acquiring information from Kenya Forest Service, Kenya Wildlife Service, Ministry of Agriculture, Livestock and Fisheries and National Environment Management Authority. This informed the study through availing data in to address the study objectives including: education levels, age, gender, sources of livelihood for the community, potential opportunities for investment and threats to environmental conservation, existing initiatives and programmes to ensure sustainability of charcoal industry and the constraints affecting charcoal industry.

4.4.2 Observation

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

4.4.3 Key Informant Interviews

This method involved collection of data by interviewing the key resource persons including the local chief, chairman of Enkutuk Endim CPA, Kenya forest officer, Kenya wildlife officer, and environmental officer at Sub-County level. This method provided indepth

information pertaining status of charcoal production, socio-economic contributions of charcoal industry and the impacts of charcoal production on local environment as discussed in chapter five of this report.

4.4.4 Focused Group Discussions

A group interview was done to find out positive and negative impacts of charcoal enterprise and the economic benefits from the industry to the residents of the study area. A focused group discussion was conducted amongst Maa youth group and Endim community forest association group members selected through random sampling. The research used open-ended questions to obtain wide range information from the groups.

4.4.5 Photography

Physical features were photographed so as to capture information on degraded and deforested areas and alternative source of livelihoods were also photographed. Digital camera was used as a tool for taking photographs.

4.5 Instruments for Data Collection

4.5.1 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 study used two different kinds of questionnaires, one for households and the other one for business community. Questionnaires were developed by adopting constructs from various previous related studies and household questionnaire was divided into five sections. Section I was used in collecting household characteristic data, section II-IV focused on material source, well-fair issues, sustainability and impacts of charcoal production respectively.

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.

4.5.2 Observation Guides

This was used for quick recording and in verifying information as data collected using the questionnaires. Observations as a method of data collection also increased the precision and reliability of data collected. Observation guides as shown in the appendix 2 was used in collecting data on height at which the trees for charcoal are felt and the species preferred.

4.5.3 Interview Schedules

This method involved collection of data through pre-coded questions. The interviewer explained the purpose of the study and the information required. This was carried out amongst relevant institutions including: Kenya Forest Service, Kenya Wildlife Service, National Environment Management Authority, Ministry of Agriculture, Livestock and Fisheries and Non-Governmental organization and community based organizations. various groups and individuals in the charcoal industry to acquire diverse information pertaining the study area including: sources of livelihood for the community, potential opportunities for investment and threats to environmental conservation, existing institutional framework and enforcement capacity and the constraints to charcoal industry.

4.5.4 Cameras

Digital camera was used to record real on-site images during the field study in order to be used during the report writing and data analysis. This method was used to collect information on the means of transport used, kiln types, and the degraded environment variables.

4.6 Target Population

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 and Wallen, 1993). The study targeted the residents of Narok-South Sub-County represented the target study population comprised of households, local businesses, Enkutuk Endim CPA and relevant government agencies and institutions and key relevant resource person in Narok-South Sub-County. Below is a formula used in determining the sample size for the study,

$$n = \frac{Ncv^2}{cv^2 + (N-1)e^2}$$

whereby n=sample size, N=population is 176,764 (KNBS, 2009), cv=coefficient of variation (took 0.5), e=tolerance at desired level of confidence, took 0.05 at 95% confidence level (Neuman, 2000).

Based on the formula above and the variables indicated, the sample size of n=99.96 was selected, which was rounded-off to 100. This comprised of 50 charcoal producers households, 40 charcoal business merchants, 4 institutions, 1 CPA, 5 Key resource persons.

4.7 Sampling Techniques and Procedures

The following sampling techniques and procedures were used in the study area;

4.7.1 Cluster sampling

It is a random sampling technique in which the population is subdivided into groups called clusters so that there is small variability within clusters and large variability between clusters (Orodho, 2004). The researcher selects groups or clusters, and then from each cluster, the researcher selects the individual subjects by either simple random or systematic random

sampling (ibid). This technique ensured that the relevant respondents are targeted as the researcher can opt to include the entire cluster and not just a subset of it. This research had 4 clusters: the households, the business community, relevant institutions and key resource persons.

4.7.2 Simple Random sampling

During the administration of household questionnaires major transects were identified along the administrative boundaries of the 5 administrative divisions of the study area. Along these transects 10 household questionnaires were administered at random amongst charcoal producer households in each of the 5 administrative locations of the sub county.

4.7.3 Purposive Sampling

A purposive sampling is a non-representative subset of some larger population, and is constructed to serve a very specific need or purpose (Mugenda and Mugenda, 1999). 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 (Begi, 2009). 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 and Wallen, 1993). Usually, the sample being investigated is quite small, especially when compared with probability sampling techniques (Mugenda and 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 50 charcoal production household in the study area

and the key resource persons which included Kenya forest service office, ministry of agriculture, fisheries and livestock office, Kenya wildlife service office and NEMA office within the sub-county.

4.7. 4 Snowball sampling

Snowball sampling begins with identification of someone who meets the criteria for inclusion in your study (Berg 2006). 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 study as charcoal producers in the study area could not be easily located as they could not be at all time be found in the kiln site. Charcoal producers therefore found in the kiln sites directed the researcher to where other charcoal producers they knew of could be located.

4.8 Methods of Data Analysis

The primary data collected from the field was coded and analyzed using statistical package for social sciences (SPSS) version 20.0 and Excel spreadsheet software. 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 20. The frequencies generated by SPSS were then transferred to Excel and figures generated.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Sustainability of Charcoal Enterprise in Narok-South Sub-County

Narok South Sub County forest cover includes; Government Forests (Gazetted) in Olpusimoru 16832.7 hectares, approximately 1,000km² of the 1,500 km² Maasai Mara National park reserve is in Narok South sub-county, Trust land Forests; western side of the Maasai Mau Forest approximately 12327 hectares, Loita hills forest 20,000 hectares and Private/Group Ranch Forests of approximately 8,400 hectares in all administrative divisions of the Narok-South Sub-County.

As observed during field survey and according to the charcoal producer's respondents as shown in **Figure 3**, a variety of wood material required for production of charcoal are obtained from indigenous tree species. The survey revealed that as many as 72% of respondents obtained trees for charcoal production from private owned land, 24% obtained trees from community land and the remaining 4% of the respondents obtained trees for charcoal production from government gazzeted forest. The privately owned farms (72%) was the most preferred for sourcing trees for charcoal production due to accessibility as opposed to communal and government forest which are guarded by the community and KFS respectively.

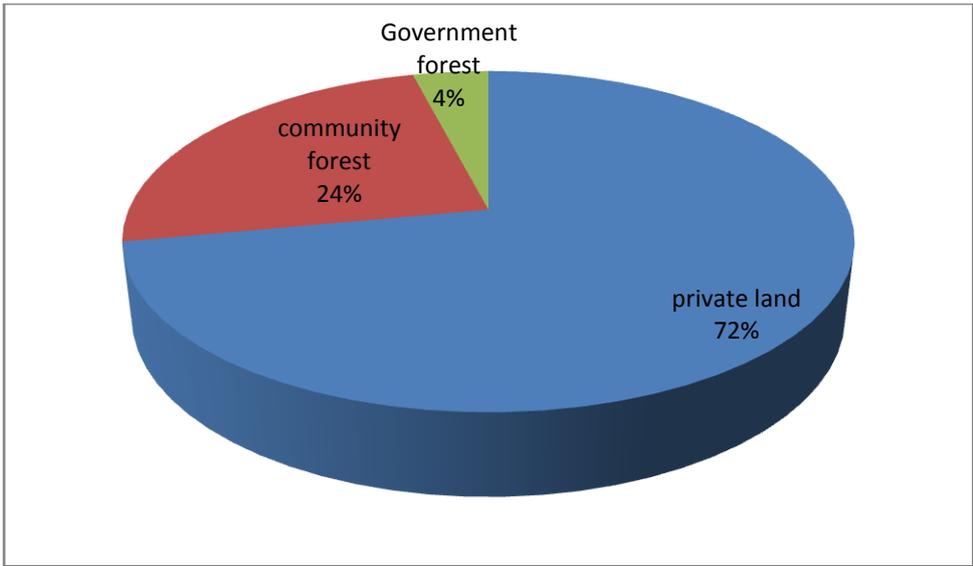


Figure 3: Forest type in the study area

Source: Field survey, 2014

Charcoal producers in the study area used indigenous local trees in charcoal production. They have strong preference for *Acacia xanthaphloea* (34%) known as Olerai in the local maasai language for charcoal production as indicated in Figure 4. The *Acacia xanthaphloea*, which is crucial for the sustenance of the vegetation and livelihoods in the area, is mostly destroyed. With this prevailing situation, the *Acacia xanthaphloea* is faced with exhaustion in the study area.

The *OLEA africanas*, is another important tree, mostly used in the housing industry is also used for charcoal production. Charcoal producers (22%) interviewed indicated their strong preference for the *OLEA africanas*. As indicated in Figure 4, other trees used for charcoal productions are as shown in table 5. Uncontrolled cutting down of these indigenous tree species for charcoal burning is unsustainable therefore pose a threat to the Sub-County's wildlife and agricultural activities due to environmental degradation.

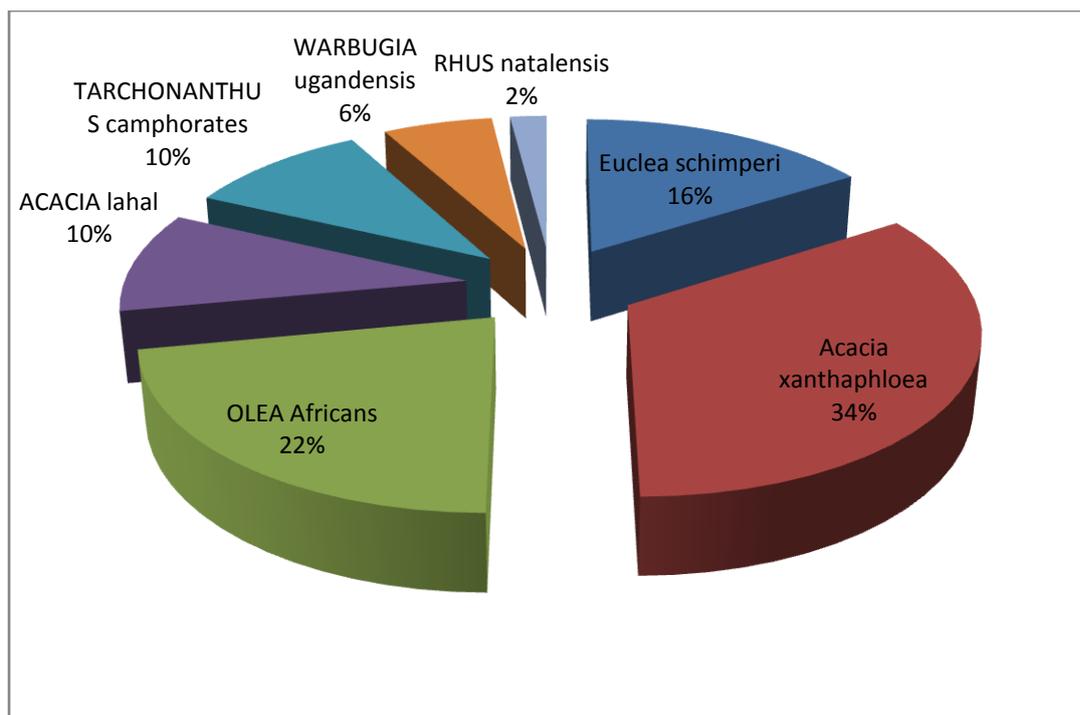


Figure 4: Preferred tree species for charcoal production

Source: Field survey, 2014

Table 5: Indigenous tree species preferred and used charcoal production

TREE SPECIES	
Scientific names	Local Maasai names
ACACIA lahal	Olchepita
OLEA Africans (Wild Olive)	Oloirien
WARBUGIA.ugandensis	osokonis
TARCHONANTHUS camphorates	Oleleshwa
EUCLEA schimperi	Olkinyei
ACACIA xanthaphloea	olerai
RHUS natalensis	Olumisingiyo

Source: Beentje, 1994

The technologies used for charcoal production in Narok-South Sub-County are traditional earth mound kilns (Plate 4). KFS had trained/ built capacity amongst the members of the CPAs on efficient charcoal production techniques and best practices to ensure sustainable charcoal production. However, all charcoal producers surveyed used traditional earth kiln technology in charcoal production in the study area.



Plate 4: Traditional earth mound kilntechnology in Narok-South Sub-County.

Source: Field survey, 2014

The woodland often selected for charcoal production are private or family owned and communal lands. Thus they often harvest without acquiring a permit. Charcoal producers (28%) interviewed had a strong feeling that establishment of specific tree species plantations in the study area would improve and make the charcoal industry sustainable as shown in Figure 5. legalization (22%) of sustainable commercial charcoal production and movement will be a boost to the industry and an end to illegal and unsustainable charcoal practise in the study area. Strengthening and formation of more charcoal producers associations(16%) in the

study area will ensure sustainable charcoal production as members are trained and equipped with necessary knowledge to ensure sustainability in charcoal industry as shown in Figure 5.

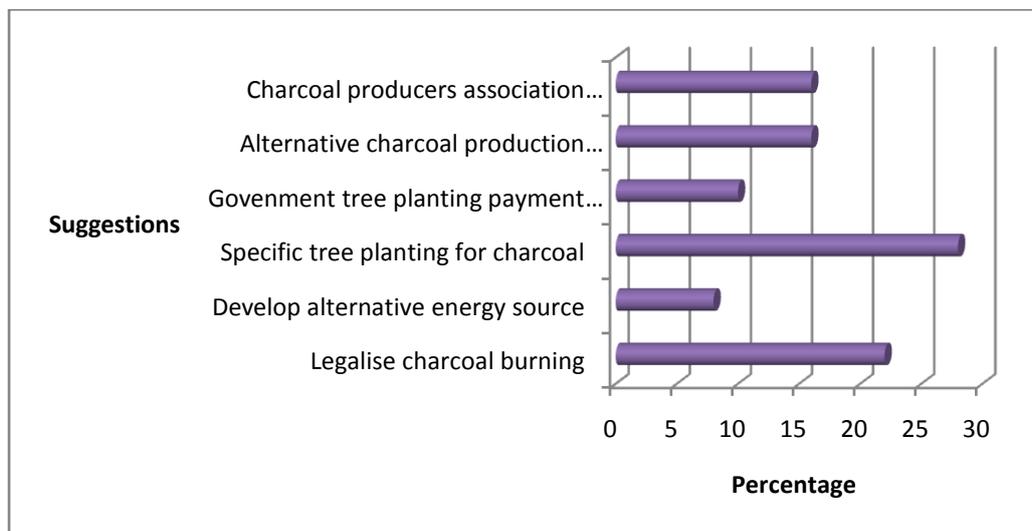


Figure 5: Suggestions for sustainable charcoal production

Source: Field survey, 2014

Kenya forest service has been in the fore front in ensuring sustainable charcoal enterprise through the Forest Act (2005) and Forest (Charcoal) Regulations (2009). The Forest Act of 2005 entrenches participatory forest management, which enhances partnerships and livelihoods. Section 7(1) of charcoal regulations, 2009 states that “No person shall undertake or engage in any activity relating to commercial charcoal production and transportation without a valid license, issued by the Service under these regulations”. The regulation in section 5, requires commercial charcoal producers to form charcoal producers associations (CPAs) which are then registered by Kenya Forest Service (KFS). Registered CPAs and community forest associations (CFA’s) are eligible to engage in sustainable charcoal production. Under the regulation any person or group wishing to produce charcoal for commercial purpose shall be required to have a license from KFS. Charcoal regulations, 2009 section 5(3), An association registered under this regulation shall–

(a) Facilitate sustainable production of charcoal by her members;

- (b) Ensure that its members implement the reforestation conservation plans;
- (c) Develop and implement a Code of Practice for the purposes of self regulation;
- (d) Assist the Service in enforcing the provisions of the Act relating to sustainable charcoal production, transportation and marketing; and
- (e) Do any other thing that is necessary for sustainable charcoal production and transportation.

Narok County has three CPAs, Induat, Enkutuk Endim, and Oloshonyok. Induat and Oloshonyok CPAs operate at Narok-North while Enkutuk Endim CPA is located and operates in Narok-South Sub-county. The CPAs were yet to meet requirements provided under regulations; thus were yet to be registered. None of the CPAsubmitted a conservation plan, which is mandatory before registration

Narok South Sub-County Kenya Forest Service office has been promoting bio-energy related interventions at the sub-county level. This includes promotion of efficient energy jiko's through Community Forest Associations (CFAs), establishment of woodlots nurseries, educating and creating awareness of modern charcoal production technologies amongst the members of Enkutum Endim CPA. KFS is also implementing charcoal legislation, 2009 through assisting in CPAs formation amongst charcoal producers. Tree planting campaigns to conserve western side of Mau encroached by the people. As a consequence 250 ares of land have been planted with trees.

Charcoal burning not only depletes the forest resources but also affects the wildlife through habitat destruction. Narok south sub county community seems not to realize the importance of forests. A discussion with Mr. Rono, Kenya Wildlife Officer, revealed that a lot of efforts have been put in place to ensure sustainability of wildlife forest inclusive being affected

through charcoal burning. He asserted that KWS had single handedly attended to all problem animal incidents to mitigate human wildlife conflicts in the area. They also engage in corporate social responsibility projects in the area which include construction of three schools Katakala (Ksh.3 Million), Enoomparbali (Ksh.3.4 Million) and Olkeri (Ksh.2.4 Million). These interventions are meant to encourage the residents of Narok-South Sub-County to conserve and actively participate in management of natural resources in the area as they enjoy the benefits arising from the rich biodiversity as a result of tourism boost.

Enkutum Endim charcoal producers association ensures active forest conservation, realization of optimum levels of desirable forest products through the application of appropriate measures and planned ways to achieve objectives of forest resources management, which gives room for the indulgence of local needs and inspiration in the management plan. The association has plans to increase efforts towards sustainable natural resource utilization. This will involve embarking on building green business solution through focusing on biogas energy, solar energy, wind energy, sustainable charcoal production and charcoal briquettes from recycled materials as alternative energy sources to the community. However these measures have not taken off, as the association is yet to be issued with the necessary licenses by KFS in order to operate.

The association has put up a central tree nursery with 200,000 seedlings of which 100,000 are indigenous tree species as shown Table 6.

Table 6: Indigenous tree species

Scientific Name	Local Maasai Name	Quantity (Number of seedlings)
FICUS wakefieldii	Olngaboli	8900
VERNONIA sp	Olmesekekua	12100
GARCINIA huillensis	Ososomeki	7900
ACACIA lahal	Olchepita	9150
OLEA Africans	Oloirien	13050
WARBUGIA ugandensis.	osokonis	3250
TARCHONANTHUS camphorates	Oleleshwa	6750
RHAMNUS prinoides	Olkonyil	4050
Acacia xanthaphloea	olerai	21,000
RHUS natalensis	Olumisingiyoi	3550
PSIADJA Arabica	Olalui	4350
Euclea schimperi	Olkinyei	5950

Source: Enkutuk Endim CPA, 2014

The association has been creating awareness and building the capacity of its members on sustainable charcoal production. The association, with the guidance of KFS and NEMA, has been participating in promoting environmental stewardship programmes/actions amongst schools and community in the sub-county level. The awareness creation and motivation programmes they organize is shown in plate 5.

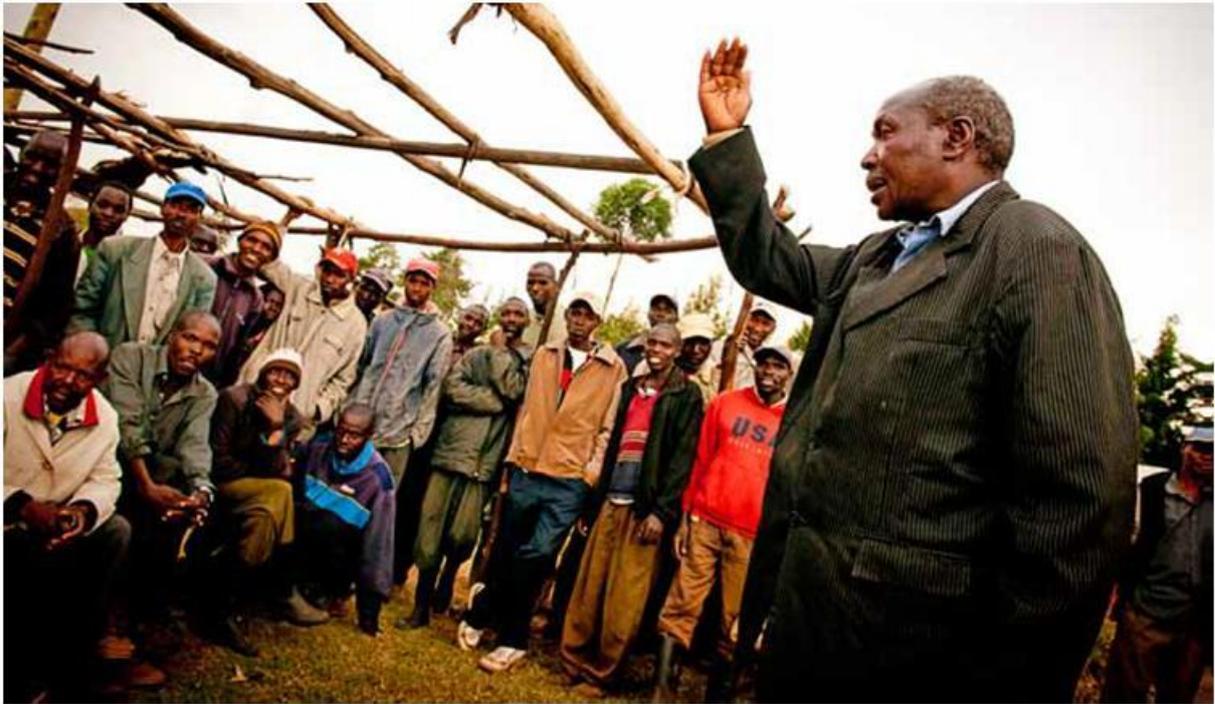


Plate 5: Mr. Nkuruna, CPA. Chairperson sensitizes Endim CFA members on charcoal production sustainability.

Source: Enkutuk Endim CPA, 2014

The annual estimation was informed by the response of majority (76%) of the charcoal producers, who engage in production at all times throughout the year (Figure 13). According to the 50 charcoal producers surveyed, an estimated 28,800 bags of charcoals each weighing 50kg on average are produced over the course of the year, this is equivalent to 1440 tonnes.

5.2. Socio-Economic Impacts of Charcoal Production Enterprise in Narok-South Sub-County

5.2.1 Age & Sex

Charcoal production is dominated by males (76%) compared to females (24%) (Figure 6). The age spread between charcoal producers' respondents is large and varied between 10 to 60 years (Figure 7). However it is dominated by 20-29 age group (Figure 7). Charcoal production in Narok-South Sub-County is labor intensive and requires much energy input during kiln

preparation, especially arranging huge bulky wood stems, which attributes dominance of 20-29 and low engagement by females.

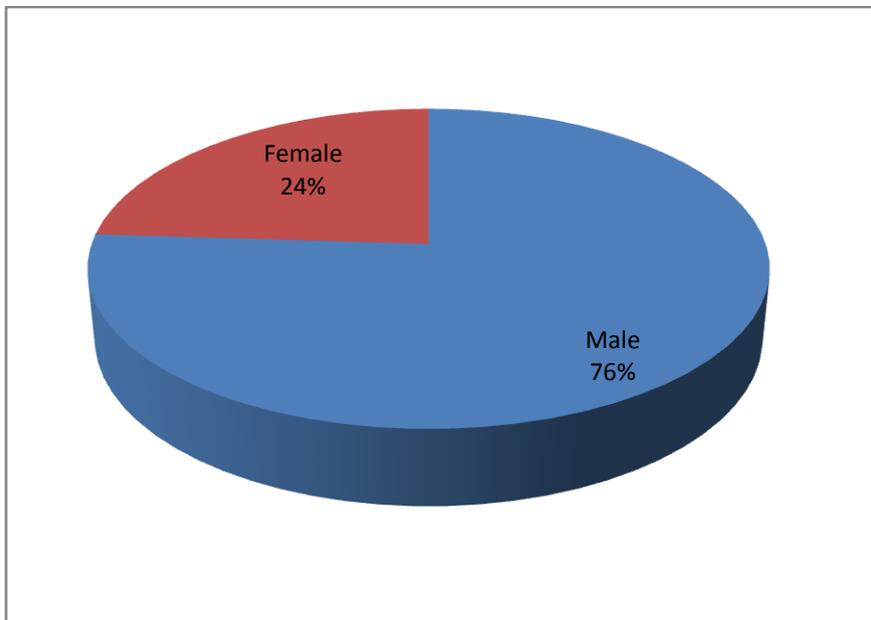


Figure 6: Charcoal producers Gender

Source: Field survey, 2014

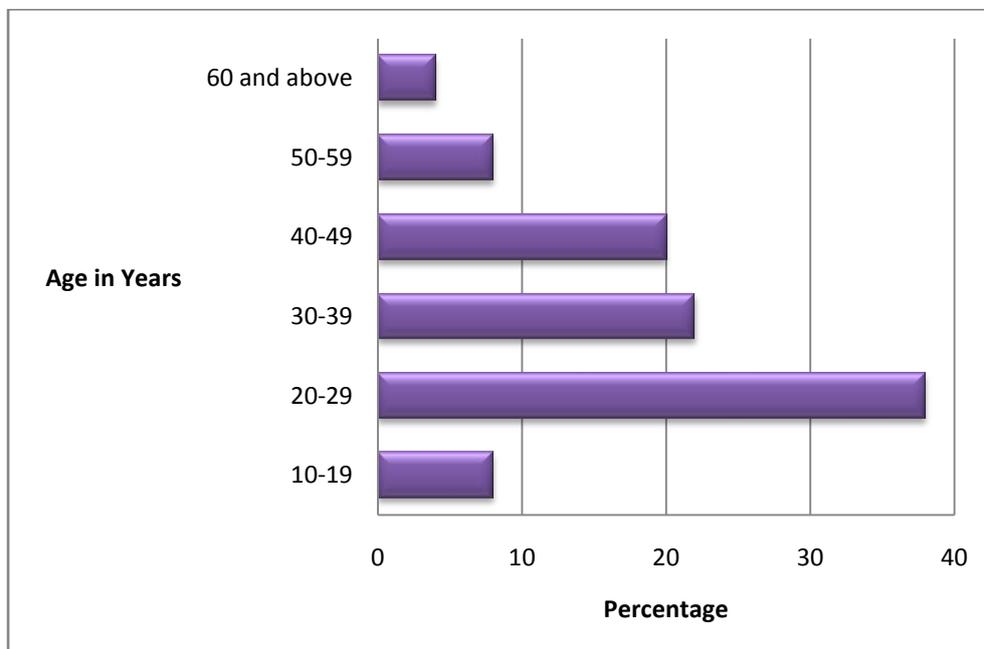


Figure 7: Charcoal producers Age distribution

Source: Field survey, 2014

Charcoal production seems to be driven by large family size (Figure 8) against low households monthly incomes (Figure 10) and low education level (Figure 9). Charcoal producers as indicated have a larger household size and (66%) had attained basic primary school and secondary school education, 14% had not attended school, 6% had attained tertiary level education and 4% had gone through informal education. This indicates a lower educational level which is directly or indirectly as a result of charcoal production in the study area (figure 9).

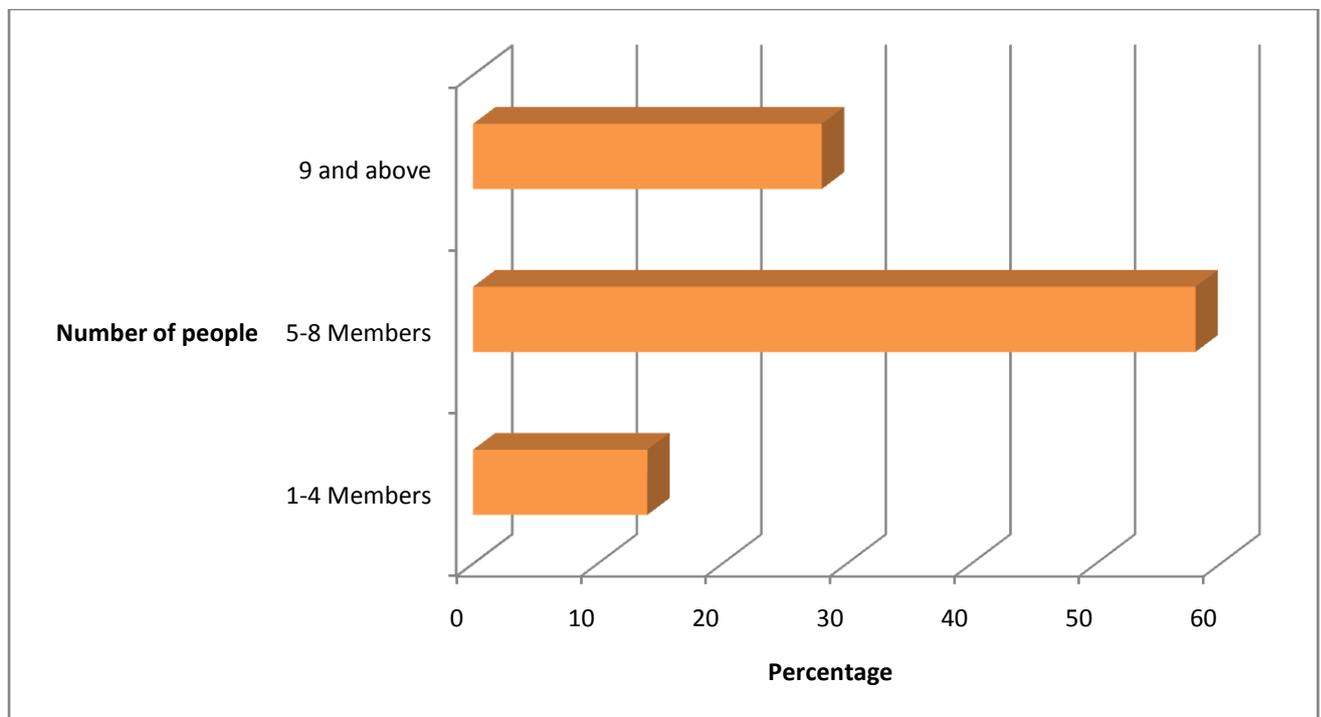


Figure 8: Household size of charcoal producers

Source: Field survey, 2014

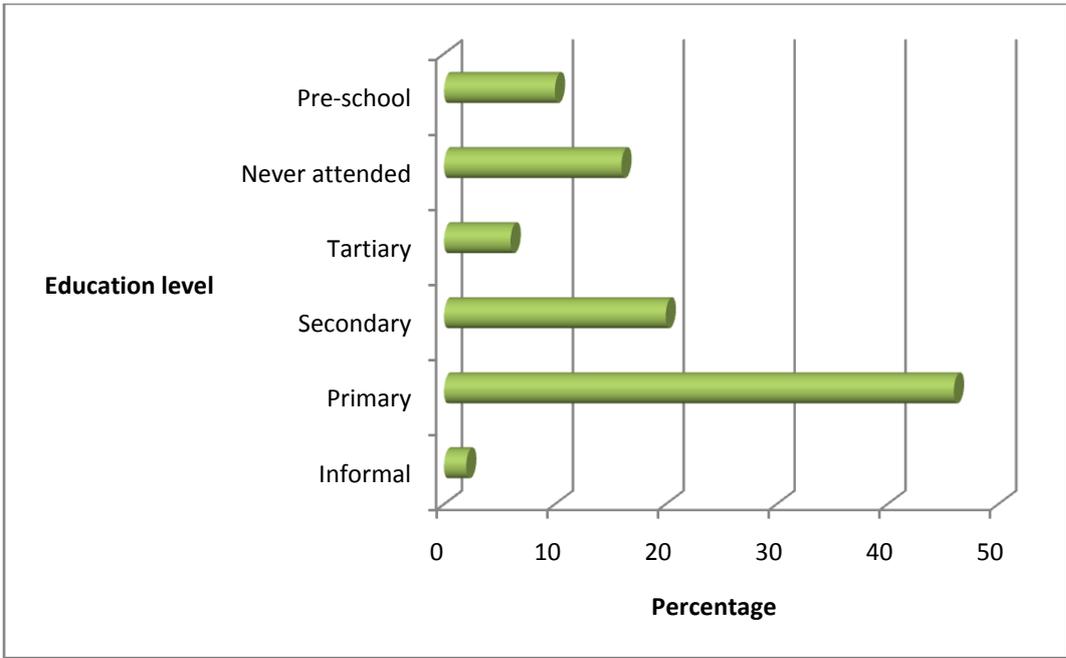


Figure 9: Charcoal producers educational level

Source: Field survey, 2014

There is a difference between income earned by charcoal producers and those by charcoal business Figure 10 and 11 respectively. Thus charcoal producers earn lower income from their ventures compared to charcoal business.

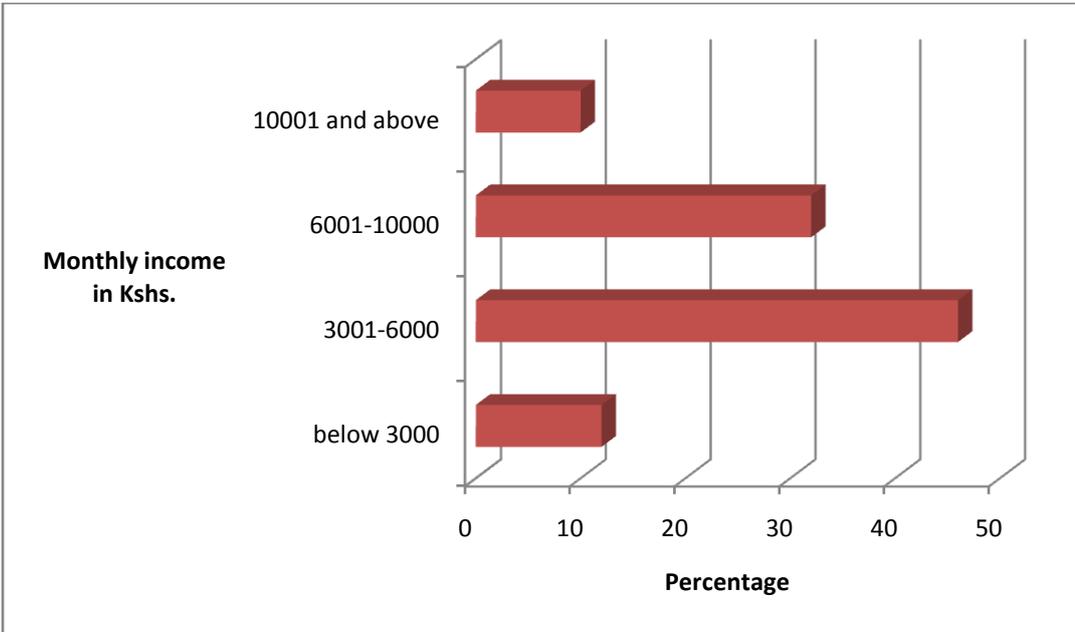


Figure 10: Charcoal producers monthly income

Source: Field survey, 2014

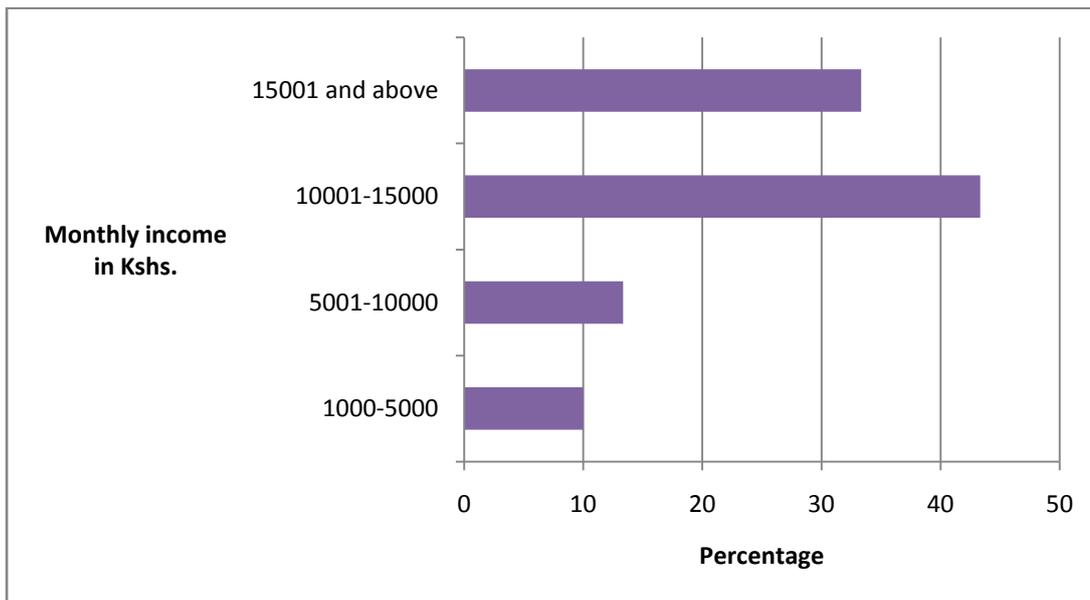


Figure 11: Charcoal merchants monthly income

Source: Field survey, 2014

The business merchants (53.3%) noted that profitability of charcoal business depends on supply and demand and varies with seasons (Figure 12). About 30% noted that charcoal is profitable during rainy season, and festive seasons due to its high demand. However, 6.7% of business merchants noted that charcoal business is not influence by any of season's activities and felt that business returns were constant throughout the year. Majority (76%) of the charcoal producers engaged in charcoal production at a relatively constant sequence throughout the year irrespective of the season (Figure 13).

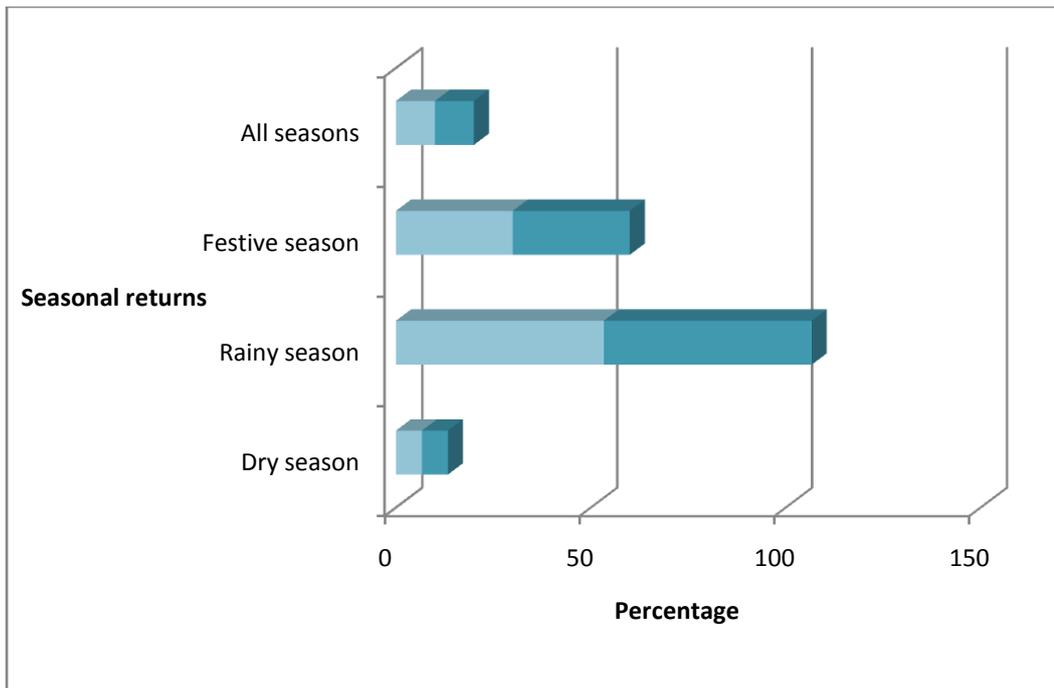


Figure 12: Seasonal charcoal business returns

Source: Field survey, 2014

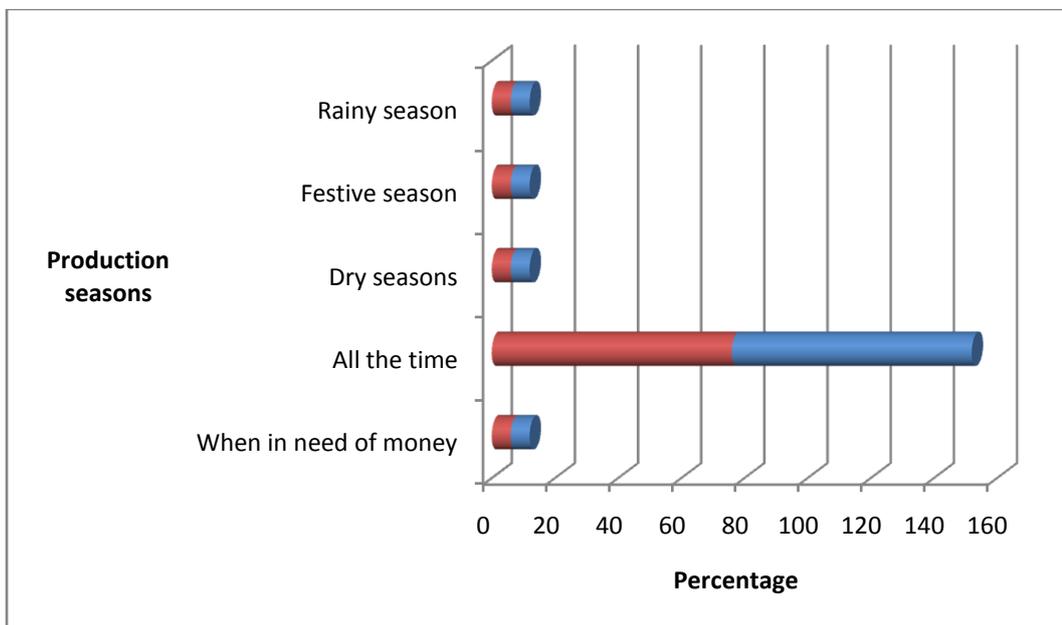


Figure 13: Seasons of charcoal production

Source: Field survey, 2014

The charcoal enterprise in Narok-South Sub-County benefited 21,000 individuals either directly or indirectly as per Enkutuk Endim CPA chairman Mr. Nkuruna. He noted that if charcoal enterprise is managed sustainably, it could offer a solution to the ever increasing number of unemployed youths in the area. Charcoal business offered job opportunity for the majority of the youth (Figure 7) as the business (80%) employs 1-6 employees and 20% of the businesses employ 7 and above employees (Figure 14).

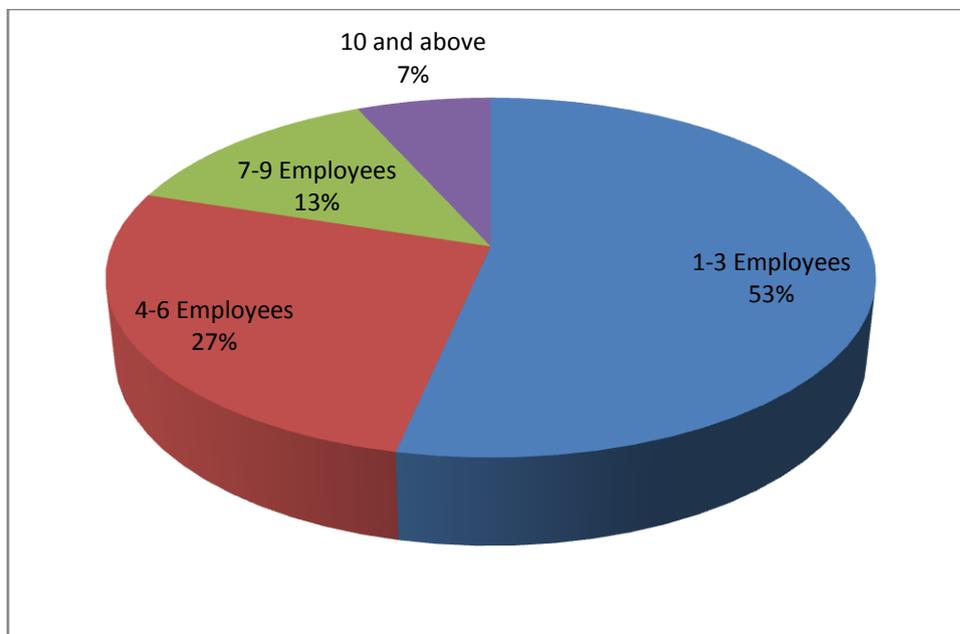


Figure 14: Charcoal business employment rate

Source: Field survey, 2014

As shown in figure 15, charcoal industry has been beneficial to the lives of charcoal producers. The industry enables them to acquire basic items necessary for their sustenance (Figure 15). They have acquired such assets as bicycles, motor bikes, and roofing materials with charcoal money. They use charcoal money to buy livestock for keeping, and source capital for farming. Charcoal has also made it possible to buy consumer goods like food stuffs, clothing, children’s educational needs, and hospitals bills.

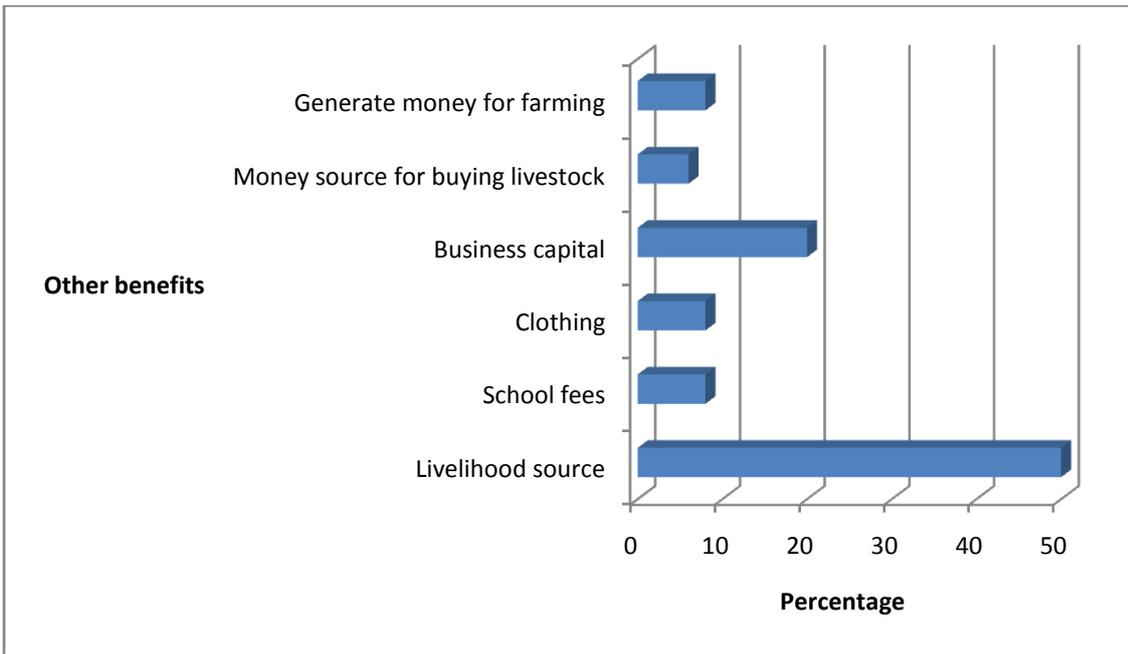


Figure 15: Benefits associated with charcoal enterprise in Narok-South Sub-County

Source: Field survey, 2014

5.3 Environmental Impacts of Charcoal Production in Narok-South Sub-County

Charcoal production (24%) is second to land clearance (66%) in its negative contribution to vegetation degradation in Narok-South sub county (Figure 16). Narok County is known for large scale wheat, barley and maize farming, which causes opening up of more land to meet demand for agricultural production. Other drivers of forest degradation in the study area are livestock grazing (6%) and bush fires (4%).

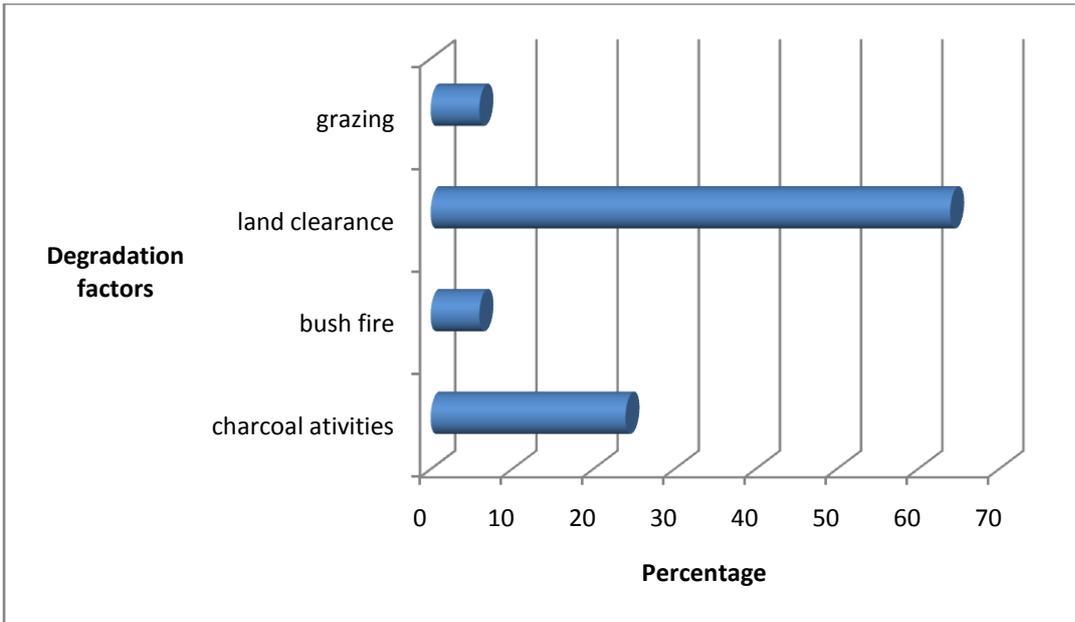


Figure 16: Causes of forest degradation

Source: Field survey, 2014

Further interrogation of participants about the past status of forest in area, at a Focused Group Discussion made possible by Mr. Nkuruna the Chairman of Enkutuk Endim CPA. The participants talked about the past 10 to 15 years when the area was largely covered by natural forest with large trees like Acacia, Podo etc; times when big wild animals like elephants were part of the community, times when venturing into the forest was a risky affair due to wide range of predators and even crossing over to the near village was discouraged amongst young children as it was dangerous. This is seen in plate 6, showing the changes that have occurred in Maasai Mau forest and its neighborhood.

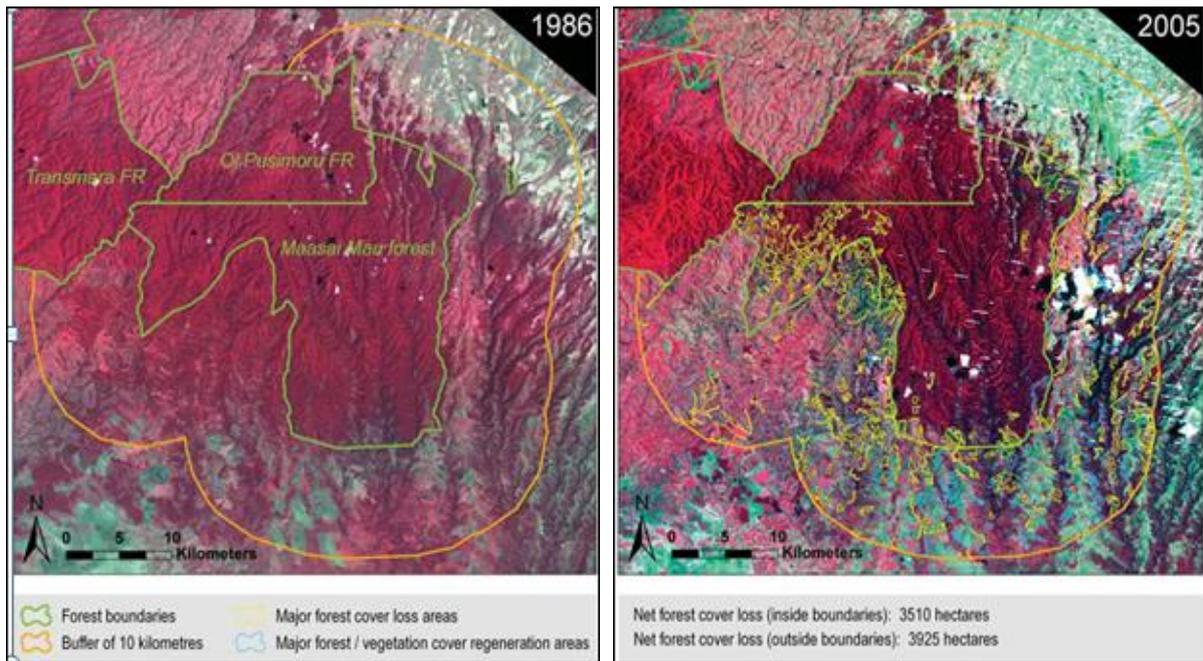


Plate 6: Forest cover changes between 1986 and 2005 in Maasai Mau forest environs

Source: Maasai Mau Forest Report, 2005

The ever increasing demand for large farms for wheat and other agricultural activities is the major driving force for forest cover destruction and reduction in the area. Charcoal production is one of the factors leading to forest destruction in the study area. Wildlife which used to be in the study area has been forced to move to the Maasai Mara game reserve, private conservancies and Mau forest environs.

The remaining bushes in the area is just a fraction of what the area used to have and are mostly concentrated at hilly areas, relatively flat grounds are bare and only scarce trees could be seen as it was suitable for large scale wheat and maize farms. This was the opinion of majority of participants and also it could be observed during the field survey as shown in plate 7.



Plate 7: Extensive land cleared for maize production

Source: Field survey, 2014

Majority of charcoal producers (76%) have limited knowledge of impacts of their activities on forest status (Figure 16). Only 24% believed charcoal production activities was a factor responsible for forest degradation in the area. They attributed the change in forest status to other causes (76%) such as grazing, land clearance, and bush fires (Figure 16). The charcoal producers surveyed acknowledged that deforestation was associated with negative impacts on their day to day livelihood activities. Narok-South Sub-County is heavily reliant on rain fed agriculture as majority (36%) of the respondents talked of ever declining rainfall amount as compared to past relatively high amount of rainfall experienced in the area before clearance of the lands. The respondents also listed some of the impacts they experience directly or indirectly as a result of deforestation including loss of livestock pastures(22%), soil

erosion(14%), loss of biodiversity(8%), loss of wild food/fruits(4%), loss of medicinal plants(4%), and flash floods(12%) as shown in Figure 17.

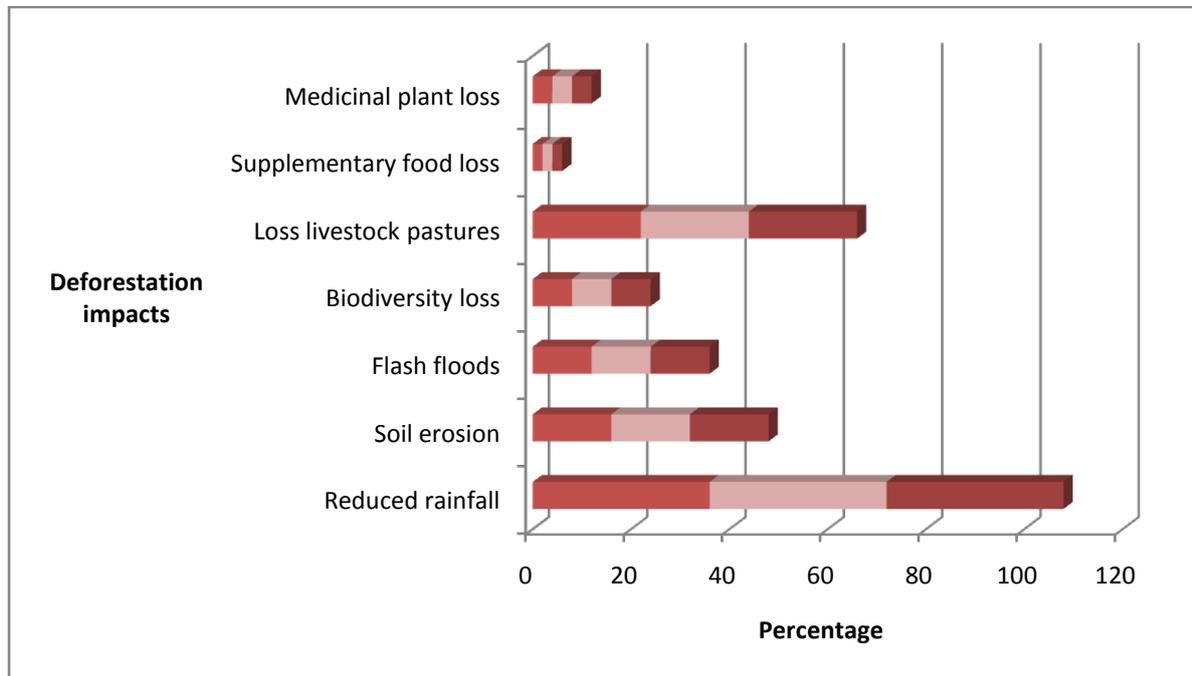


Figure 17: Negative impacts of deforestation

Source: Field survey, 2014

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of the findings

Charcoal producers in Narok-South Sub-County use traditional earth mound kiln method of charcoal production. This technology negatively impacts on re-vegetation as abandoned kiln sites takes years for vegetation to regenerate. It also damages top soils as a result of digging and burning in charcoal production process. This study revealed that the charcoal industry in the study area is unsustainable. The Charcoal producers' saw no need of replanting trees as they believed in natural regeneration of trees and stuck to traditional earth mound kilns (Plate 4) with less motivation to adopt efficient improved kiln technologies. Land clearing for new agricultural activities by land owners has made charcoal production is the major factor causing forest degradation and driving charcoal production in the study area. Others factors causing forest degradation includes; charcoal activities, uncontrolled grazing, and bush fires (Figure 16). Charcoal production has been used to fund land clearance as it is deemed the cheapest option to meet the cost of clearance.

Charcoal producers in Narok-South Sub-County preferred the use of local indigenous tree species for charcoal production. Acacia trees are mainly preferred for charcoal production and with the current rate of destruction, this tree species could be in danger of extinction in future (Figure 4). The ACACIA xanthaphloea trees locally known as 'Olerai' is an important food stock for livestock and wildlife are vastly harvested for charcoal production. This makes community vulnerable to drought effects as the low plains of Narok-South Sub-County are ASAL areas affected by occasional droughts. The other tree species targeted by charcoal

producers includes: ACACIA lahal, OLEA Africans, WARBUGIA ugandensis, TARCHONANTHUS camphorates, and EUCLEA schimperi.

The study further looked at the benefits of charcoal production has on the economic situations of charcoal producers. This was the motivation behind the vast majority of charcoal producers engaging in charcoal production activities.

The research indicated that charcoal is often sold in maxi bags. Depending on the type and quality of charcoal, the weight may range from 45 to 60 kg, but usually the average is 50 kg for charcoal from the study area. It was also determined that, an average of twenty four (24) bags of charcoal is usually obtained from a single production per producer. According to the study findings and assessments from Focus Group Discussion, charcoal producers engage in charcoal production two time (Figure 13) in a month on average, which translates to 48 bags of charcoal per producer. The yearly charcoal production estimates as per the charcoal producers surveyed was 28,800 bags with an average weight of 50kg each in the year 2014.

The study again identified that a maxi bag of charcoal was sold at average of kshs.400 in 2014 in charcoal production site. Charcoal producers on average produce twenty four (24) maxi bags of charcoal per single production. Again, they are able to undertake two productions on average within a month and this earns them an average monthly income of Kshs. 18,400 per producer but almost a half this goes to the owner of the land being cleared. The charcoal production averagely contributed Kshs.11,040,000 to the micro economy of producers in the study area per year in 2014.

According to players in charcoal enterprise, the industry enables them to acquire basic items necessary for their sustenance. Incomes from charcoal production enable them to acquire assets, such as bicycles, motor bikes, roofing materials among others. Again charcoal

producers and merchants pointed out how the business makes it possible for them to buy consumer goods like food stuffs, clothing, children's educational needs; raising capital for agriculture activities, and also source of capital for investing in other business ventures.

Deforestation resulting from charcoal production activities and other anthropogenic factors is critical to global, regional, national and local economies. The effects resulting from deforestation are usually difficult to reverse this includes but not limited to global warming. In the study area as shown in chapter five, several indigenous trees of vast importance are fast disappearing as a result of commercial charcoal production activities. Other factors escalating this disappearance of indigenous trees cover and vegetation destruction as indicated in Figure 16 includes: land clearance, bush fires, and uncontrolled grazing.

The study revealed that private or family owned lands as seen in Figure 3 is the major (76%) source of indigenous trees for the illegal commercial charcoal production. According to the charcoal producers surveyed, they used live indigenous trees which are felled by use of axes, pangas and power saws depending on the size and type of the tree. Charcoal producers preferred own farms or privately owned rangelands as limited restriction were imposed on them as opposed to government forests which were guarded KFS (Figure 3) and also community land that was monitored by the community members. As observed during the field survey, trees harvested were mainly cut at about 60cm above the ground level. These methods employed for tree harvesting for charcoal production limits the possibility of trees rejuvenating

6.2 Conclusion

Land clearance for new agricultural activities in the study area has been the major factors driving charcoal production. The extensive indigenous tree species extraction to facilitate

charcoal production has resulted in environmental degradation. Degradation of natural forest without adequate measures to restore or conserve reduces its ecological and economic benefits capacity. Charcoal producers are motivated by the financial benefits arising from their activities to carry on with the destruction of natural environment. Further uncontrolled indigenous wood species extraction without corresponding replacement measures will reduce the capacity of trees cover to provide pasture, control soil erosion, medicine and energy requirement for society and livestock. Therefore alleviate the existing human sufferings.

The resultant impacts from vegetation cover destruction will be imminent and adversarial on ecological balance and wildlife survival. The reduction of natural forest cover and subsequent destruction of plant species will mean threatening of wildlife species as a result of continuous destruction of their habitats. The unsustainable charcoal enterprise may disadvantage the future generations from enjoying benefits associated with natural forest. However, modern technological adoption in charcoal production methods is evolving and widely improving over time in order to ensure efficient and effective output for sustainable charcoal enterprise. The traditional earth mound kiln method adopted by charcoal producers in the study area is inefficient and often triggers accidental bush fires causing damage to already degraded forests. The national and county governments should effectively implement the forest (charcoal) regulation of 2009 and the international forest cover requirement of 10% of the land cover. This will ensure protection and conservation of forest resources, development of sustainable charcoal sector, awareness creation and capacity building amongst charcoal producers association members, availing of subsidized improved kilns to charcoal producers and promote avenues for dissemination of new technologies. With effective charcoal regulations implementation and controlled utilization of forest resources, charcoal production impacts on vegetation will be minimized whilst maximizing on economic benefits from the

enterprise. Development of good poverty reduction interventions and enhancement of alternative income sources (crop farming, ecotourism and livestock farming) in Narok-South Sub-County will also prevent the situation of many people venturing in charcoal production which could have dire impacts on natural environment.

6.3 Recommendations

The study is putting forward the following recommendations based on the study findings.

6.3.1 Recommendation on the Sustainability of the Charcoal Enterprise in Narok-South Sub-County.

- ❖ Adoption of efficient modern charcoal production methods in the producing areas.
- ❖ Boosting of wood supply through agro-forestry farming by introducing own farm and community woodlots.
- ❖ Multi-stakeholder collaboration in prevention of uncontrolled harvesting of live trees and indiscriminate destruction of natural forest in order to conserve the environment.
- ❖ Implementation of practical conservation plan by CPAs and CFAs to ensure sustainable utilization of forest resources.

6.3.2 Recommendation on the Socio-economic Impacts of the Charcoal Enterprise in Narok-South Sub-County.

- ❖ Formation of more charcoal producers association and institutionalization of an information database system.
- ❖ Extensive awareness creation on benefits of sustainable forest resource management amongst the general public.
- ❖ Capacity building and empowerment of communities to take full responsibility of managing their environmental resources.

- ❖ Forest resource management should be integrated into educational curricular as part of being considered a civic education to bring into attention the importance forest resource to the country's' economy.

- ❖ Stakeholders involved in forest resource conservation should emphasize on collaboration with local people in forest conservation.

6.3.3 Recommendation on the Environmental Implications of Charcoal Production in Narok-South Sub-County.

- ❖ Strengthening of Natural Environment Trust Fund Allocation Systems and creation of degraded forest and woodland environment rehabilitation programmes.

- ❖ Establishment of grazing reserves, biodiversity reserves and rotational tree harvesting planting programme.

- ❖ Active involvement of community leaders forest management through voluntary patrolling of the production sites to avoid indiscriminate felling of trees for charcoal production.

- ❖ Conservation plans and practical measures of replacing the extracted trees from the forest for charcoal production should form the basis for license issuance for charcoal production.

6.4 Areas of further research

The charcoal production and business problem is multifaceted and cannot be singly addressed by studying the environmental implication of charcoal enterprise. With the knowledge of environmental impacts associated with charcoal production from the study, examining climate change impacts of charcoal activities will be important. This is in line with the United Nations Framework Convention on Climate Change (UNFCCC) Article 2, aimed at

achieving, in conformity with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. These levels should be attained within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that livelihoods sources are not threatened and enable sustainable economic development growth. This could be relevant and may inform the consideration of Article 2 of the UNFCCC on the key vulnerabilities and multinational development impact of the charcoal industry.

References

- Bailis, R., Berrueta, V., Chengappa, C., Dutta, K., Masera, O., Patara, S., (2007). *Performance testing as a tool to monitor improved stove interventions: Experiences of the Shell Foundation's Household Energy and Health Project*. *Energy for Sustainable Development*, X1(2), 57–70.
- Bailis, R., Ezzati, M. and Kammen, D. (2005). "Greenhouse Gas Implications of Household Energy Technologies in Kenya." *Environmental Science and Technology* 37(10): 2051-2059.
- Barklund, E. and Palmstiema, M. (2005). *Charcoal production and processing in Kenya: opportunities for improving supply*. A RELMA and KEFRI Report.
- Beentje, H.J. (1994). *Kenya Trees, Shrubs and Lianas*. National Museums of Kenya, Nairobi.
- Bell, J., (1993). *Doing Your Research Project*. Buckingham: Oxford University Press.
- Best, J.W., and Kahn, J.V., (1993). *Research in Education*. 7th Edition. Boston: Allyn and Bacon Press.
- Chikamai, B.N (1987). *Charcoal production in Kenya: status and development initiatives*. Nairobi. KEFRI. Unpublished.
- Borg, W.R. and Gall, M.D., (1993). *Education Research: An Introduction*. New York: Longman.
- Burns, R., (2000). *Introduction to Research Methods*. Sage publishers, London.
- Chidumayo, E. N. (1993). "Zambian Charcoal Production: Miombo Woodland Recovery." *Energy Policy* 21(5): 586-597.
- Chlala, H.C, (1972). *Market Demand for Charcoal in Kenya*. Nairobi: Ministry of Commerce and Industry; Industrial Survey and Promotion Centre.
- Delahunty, A. (2011). *Gender Equity, Charcoal and the Value Chain in Western Kenya*. PISCES Working Brief. Centre for African Studies, University of Edinburgh press.
- Drew, C. J., Hardman, M. L., & Hosp, J. L. (2008). *Designing and Conducting Research in Education*. LA: Sage Publications, London.

Ecoforum (2002). *Hot and Dirty: Inside Kenya's 23 Billion Shilling Charcoal Industry*. EcoForum. Nairobi. 25: 16-22.

ESDA., (2005). *National Charcoal Survey: Exploring the potential for a sustainable charcoal industry in Kenya*. A product of the Kenya Charcoal Working Group. June 2005. Pgs 74

Ezzati, M. and Kammen, D. (2002). "Evaluating the Health Benefits of Transitions in Household Energy Technology in Kenya." *Energy Policy* 30(10): 815-826.

FAO. (1983). *Simple Technologies for Charcoal Making*. Rome: FAO. <http://www.fao.org/docrep/X5328e/x5328e00.htm#Contents>. Accessed on 03/12/2013.

FAO, (2008). <http://www.fao.org/copyright-en.htm>. Accessed on 20/11/2013.

FAO. (2010). *What Woodfuels Can do to Mitigate Climate Change*. FAO Forestry Paper 162. Food and Agriculture Organization of the UN. Rome, Italy.

FAO (2010) *Forests and Energy: regional perspectives: opportunities and challenges for forests and forestry*. African Forestry and Wildlife Commission. Sixteenth Session. Near East Forestry Commission, Khartoum, Sudan, 18-21 February 2008.

FAO (2010). *What woodfuels can do to mitigate climate change*, FAO. Available at: www.fao.org/docrep/013/i1756e/i1756e00.htm; International Energy Agency (IEA) 2002 *Energy and poverty*. Chapter 13. In: *World Energy Outlook 2002*. Organisation for Economic Co-operation and Development (OECD) Paris, France. 530p.

FAO (2011c). *State of the World's Forests*. Rome. Retrieved from; www.fao.org/docrep/013/i2000e/i2000e00.htm(date accessed 4 march 2014).

FAO (2012). *Wood energy*. www.fao.org/forestry/energy/en/. Accessed on 20/03/2014.

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

Foddy, M., et al. (1999). *Resolving Social Dilemmas*. Philadelphia, PA: Psychology Press.

Foley, G. 1986. *Charcoal Making in Developing Countries*, Technical Report No.5. Earthscan.

Galaty J. 1980. *The Maasai group ranch: Politics and development in an African pastoral society*. In: Salzman P C and Sadala E (eds), *When Nomads Settle: Process Of Sedentarization as Adaptation And Response*. Praeger Publishers, New York, USA. pp. 157-172.

Gathaara, G. N. (1999). *Aerial Survey of the Destruction of Mt. Kenya, Imenti and Ngare Ndare Forest Reserves: February - June 1999*. Nairobi, Kenya Wildlife Service: 33.

Hardin G. 1968. The Tragedy of the Commons. *Science* 162: 1243-1248.

Hosier, R. H. (1993). "Charcoal Production and Environmental Degradation: Environmental History, Selective Harvesting, and Post-Harvest Management." *Energy Policy* 21(5): 491-509.

International Energy Agency (2002). *Energy and Poverty: World Energy Outlook 2002*. Paris, France. 530p. (<http://www.fao.org/forestry/energy/en/> (accessed on 13th November 2013)).

International Energy Agency (IEA) (2010) *World Energy Outlook*. Paris: IEA.

Jaetzold, R. and Schmidt, H. 1983. *Farm Management in Kenya*, Vol. II C East Kenya. Ministry of Agriculture, Nairobi, Kenya.

Kenya Forest Research Institute (2012). *Charcoal Production Using Improved Earth, Portable Metal, Drum and Casamance Kilns*. Print maxim. Nairobi, Kenya.

Kenya National Bureau of Statistics and Society for International Development (2013). *Exploring Kenya's Inequality: Pulling Apart or Pooling Together?* Government Printers, Nairobi.

Kituyi, E., Marufa, L., Huber, B., Wandiga, S., Jumba, I., Andreae, M., Helas, G., (2001). *Bio-fuels Consumption Rates in Kenya*. *Biomass and Bioenergy* 20:83-99.

Kumar, R. (1999). *Research Methodology: A Step-by-Step Guide for Beginners*. Thousand Oaks, CA: Sage Publications. New York.

Lambrechts, C., B., et al. (2003). *Aerial Survey of the Destruction of the Aberdare Range Forests*. Nairobi, UNEP: Division of Early Warning and Assessment: 35.

- Mangat R.,(2009). *Energy and environment*. Management journal- April issue 2009.
- Ministry of Energy (2002). *Study on Kenya's Energy Demand, Supply and Policy Strategy for Households, Small Scale Industries and Service Establishments: Final Report*. Nairobi, KAMFOR Company Limited: 158.
- Ministry of Finance and Planning (2002). *Narok District Development Plan: 2002-2008*. Government Printers. Nairobi, Government of Kenya: 80.
- Mugenda and Mugenda (1999). *Reserch Methods: Qualitative and Quantitative Approaches*. Nairobi: Act Press.
- Müller, N., Michaelowa, A., & Eschman, M. (2011). *Proposal for a New Standardized Baseline for Charcoal Projects In The Clean Development Mechanism*. Zurich. p. 86.
- Mutimba, S., and Barasa M. (2005). *National charcoal survey: Summary report. Exploring the potential for a sustainable charcoal industry in Kenya*. Nairobi: Energy for Sustainable Development Africa (ESDA).
- Mwampamba, T. H. (2007). *Has the Wood Fuel Crisis Returned? Urban Charcoal Consumption in Tanzania and its Implications to Present and Future Forest Availability*. Elsevier Energy. Policy, 35 (4), 221-234.
- Neuman, W. L. (2000). *Social Research Methods: Qualitative and Quantitative Approaches*. Boston: Allyn & Bacon.
- Newman, I., & Benz, C.R. (1998). *Qualitative-Quantitative Research Methodology: Exploring the Interactive Continuum*. Carbondale: University of Illinois Press.
- O'keefe, P.P and Bernow, S. (1984). *Energy Environment and Development in Africa: Energy Development in kenya: Opportunities and Constraints*. Stockholm. Beijer institute press.
- Orodho, J. A. (2004). *Elements of Education and Social Research Methods*. Nairobi: Masola Publishers.
- Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.

Ostrom, E., Dietz, T., Dolšak, N., Stern, P., Stonich, S. and Weber, E. (2002). *The Drama of the Commons*. Washington DC: National Academy Press. Ch. 4., 113–156.

Republic of Kenya, (2011). *Scaling-Up Renewable Energy Program (Srep): Investment Plan for Kenya*. http://www.renewableenergy.go.ke/downloads/policy-docs/Updated-SREP-Draft-Investment-Plan-May_2011.pdf

Rockström, J., Steffen, W., Noone, K., Person, A., Chapin III, F., Lambin, F., and Enton, M. (2009). *A Safe Operating Space for Humanity*. *Nature* 461 (7263): 472–5.

Sander, K., Hyseni, B., & Haider, W. (2011). *Wood-Based Biomass Energy Development for Sub-Saharan Africa*, World Bank, Washington. Issues and approaches. p. 64.

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

Smith K.R., Samet J.M., Romieu I., Bruce N. *Indoor Air Pollution in Developing Countries and Acute Lower Respiratory Infections in Children*. *Thorax*. 2000;55:518–532. [[PMC free article](#)] [[PubMed](#)]

Government of Kenya, The Poverty Eradication Commission (2009). *10 Years of Fight Against Poverty (1999 - 2009) Report*. Government printers, Nairobi. Kenya.

United Nation Development Programme (UNDP) (2010). *Human Development Report*. United Nations Development Programme (UNDP), New York. http://hdr.undp.org/en/media/HDR_2010_EN_Complete_reprint.pdf.

United Nations Environment Programme (UNEP) (2012): *Green Economy Briefing Paper, Metrics & Indicators*.

UNEP (2012). *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*. <http://www.unep.org> > [Green Economy](#) > [Green Economy Report](#). Accessed on 11/01/2014.

van Beukering, P., Kahyarara, G., Massey, E., di Prima, S., Hess, S., Makundi, V., and van der Leeuw, K. (2007). *Optimization of the Charcoal Chain in Tanzania. Poverty Reduction and Environment Management (PREM) Programme*. Institute for Environmental Studies, Amsterdam, The Netherlands.

Vanleeuwe, H., Woodley, B., Lambrechts, C., and Gachanja, M., (2003). *Change in the State of Conservation of Mt. Kenya Forests: 1999–2002*. DICE, KWS, UNEP, KFWG, Nairobi.

World Bank (2010): *World Development Report 2010, Development and Climate Change*. World Bank, Washington D.C.

World Bank's Global Monitoring Report 2012

World Agroforestry Centre ICRAF (2013). *Annual Report 2012-2013: Transforming lives and landscapes with trees*. Nairobi, Kenya:

Zulu L., Richardson R., (2012). *Charcoal, Livelihoods, and Poverty Reduction: Evidence from Sub-Saharan Africa, Energy for Sustainable Development*; <http://dx.doi.org/10.1016/j.accessed.04> march 2014.

APPENDICES

Appendix 1: HOUSEHOLD QUESTIONNAIRE

The information given here under will be used for the academic purpose and will be treated with the confidentiality it warrants.

Environmental Implications of Charcoal Enterprise in Narok-South Sub-County, Narok County

(I) HOUSEHOLD INFORMATION

1. What are your household characteristics? Please fill in the table appropriately.

Household members	Gender	Age	Educational level	Occupation	Source of income	Monthly income	Other sources of income

2. Are you involved in charcoal production? Yes [] No []

3. If yes, How long have you been in charcoal production?

(a) Below 5 years [] (b) 6-10 years [] (c) 11-15 years [] (d) 16 years and above []

(II) Sources of materials for charcoal production

5. Is charcoal burning your main economic activity? Yes [] No []

6. (i) Are all trees/wood favorable for charcoal burning? Yes [] No []

(ii) Please list the various types/species of trees used for charcoal production (Local or English name)?

(iii) If yes, list the preferred species of trees/wood to others and reasons for their preference?

7. Do consumers prefer some category of charcoal to others? Yes [] No []

(b) If yes, give reasons for their preference?

8. Where do you get the materials for charcoal production from? Tick where appropriate

(a) Government forest [] (b) Community forest [] (c) Private land []

(d) Others specify _____

9. (a) Which of the above sources is the most viable?

(b) Give reasons for its viability

_____.

10. What methods do you use for charcoal processing? Tick appropriately

(a) Traditional earth or saw dust mound procedure [] (b) Mobile metal kiln method [] (c) Pit kiln method [] (d) Others (specify)

_____.

11. Which of the above methods is the most preferred and give reasons for its preference?

_____.

(III) WELFARE ISSUES RELATING TO CHARCOAL PRODUCTION

12. (i) Do you think Charcoal burning/production contributes to your welfare? Yes [] No []

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

_____.

13. How many bags/quantity of charcoal do you usually harvest from a single production?

(a) 1-10 [] (b) 11-20 [] (c) 20 and above []

14. How much do you usually sell a bag of charcoal?

(a) Below 200 [] (b) 200-400 [] (c) 401 and above []

15. How much income do you usually generate per production? _____
_____.

16. How often do you engage in charcoal production in a month?

.
17. (i) Where do you often burn/produce the charcoal?

(a) Around the house [] (b) In the bush [] (b) Farm plots []

(ii) Could you give some reasons for the choice charcoal production location

18. Where do you usually sell the charcoal produced?

(a) Within the county [] (b) Outside the county [] (c) others specify

.

.

(IV) Local Knowledge on Sustainable Use of Resource; Tree Species

19. (i) Do you at times encounter difficulties in obtaining the materials you need for charcoal production? Yes [] No []

ii) If yes, what do you think has accounted for this?

20. i) Have you ever received training on how to improve upon your charcoal business? Yes [] No []

ii) If yes, where did u go for your training or trained by who?

.

.

21. (i) Do you usually replant trees after cutting some for charcoal production? Yes [] No []

(ii) In your opinion, do you think it's necessary to establish a tree plantation purposely for charcoal production? Yes [] No []

(iii) Give reasons for your answer _____.

_____.

22. Do you know of any wood-lots? Yes [] No []

23. If yes, list some wood-lots that are in your area?

.

_____.

24. a) Are you a member of any charcoal producers association? Yes [] No []

b) Do you think it is of any benefit for charcoal producers/burners to form themselves into associations? Yes [] No []

25. Give reasons for your answer above _____.

_____.

_____.

(V) IMPACTS OF CHARCOAL PRODUCTION ON THE ENVIRONMENT

26. i) Do you think charcoal production reduces forest cover? Yes [] No []

ii) If yes, what are some other possible reasons for deforestation? (a) Bush fires [] (b)

Logging [] (c) Settlements [] (d) Farm clearance [] others specify

.

.

27. Which do you think is the most severe cause of deforestation in your area? (a) Bush fires

[] (b) Logging [] (c) Settlements [] (d) Farm clearance [] others specify

.

.

28. What are the negative impacts as result of deforestation experienced in your area?

29. In your opinion, what do you think can be done to enhance sustainable charcoal production?

THANK YOU.

Appendix 2: OBSERVATION GUIDE

Division Name _____ . Date _____ .

Location (1) Government forest (2) community forest (3) private owned land

Land use (1) dense forest (2) woodland (3) grassland (4) cultivated land (5) others specify

Dominant species (1) _____ .

(2) _____ .

Vegetation covers Tree cover _____ .

Shrub cover _____ .

Herb cover _____ .

Kiln sites Number _____ .

Size _____ .

Tree stumps

species	Basal diameter	height	coppicing

Comment

_____ .

_____ .

_____ .

Appendix 3: Business Questionnaire

The information given here under will be used for the academic purpose and will be treated with the confidentiality it warrants.

Kindly write in the space provided where applicable and tick in the box where appropriate.

1) General information

Number of employees	Gender	Age	Educational level	Occupation	Source of income	Monthly income
1.						
2.						
3.						
4.						
5.						
6.						
7.						

2) How long have you been in charcoal business?

_____.

3) Where do you source your charcoal from?

4) Describe the management structure of the business:

i) What kind of transport do you use? _____.

ii) Who owns the means of transportation?

_____.

_____.

iii) Do you employ other people in your business? YES [] NO []

iv) if Yes, how many employees? a) 1-5 b) 6-10 c) 10 and above

5) How often do you transport charcoal?

a) Dailyb) weekly.....c) monthly.....d)
yearly.....

6) i. Do you work only in Narok-South? Yes [] No []

ii. If you also work in other areas, how do other areas compare to Narok-South Sub-County charcoal enterprise?

7)i. How much do you earn from charcoal business per month?

a) 1000-5000 [] b) 5001-10000 [] c) 10001-15000 [] d) 15001-above []

ii) Do you consider charcoal business profitable? YES [] b) NO []

iii) Give reasons for your answer in 7 (ii) above

8) What problems do you encounter in getting charcoal to the market?

9) How do you decide on the buying price from charcoal producers?

10) How do you decide on a selling price to vendors?

11) Do you require or have a permit to run the business. Yes [] No []

12) i. Are you aware of environmental impacts of charcoal burning? Yes [] No []

ii) If yes, mention some of the impacts you know

13) When do you get most returns/profit from charcoal business?

14) What support do you get from the county government in doing the business?

15) What should be done to improve the charcoal business in your opinion?

16) In what ways has the charcoal business socio-economically helped you?

THANK YOU.

Appendix 4: Institutional Questionnaire for NEMA/ Ministry of Agriculture

The information given here under will be used for the academic purpose, should be given voluntarily, and will be treated with the confidentiality it warrants.

Environmental implications of the charcoal business in Narok-South Sub-County, Narok County.

1) Are there incidences of charcoal production in your County? Yes [] No []

2) If yes, as a natural resource based establishment, could you mention County/Sub-county programmes by your institution to mitigating the effects of commercial charcoal production on the environment?

3) As an institution, what is your mandate

4) Does your organization have some specific policies for the production and use of biomass energy in the country /county? Yes [] No []

5) If yes, could you outline them and indicate the year of their formulation

6) What are the goals and objectives of the policies?

7) Could you outline the strategies for the achievement of the goals

8) Do you currently have any bio-energy related interventions? Yes [] No []

9) If yes, could you describe them

9) i. Do you have charcoal related training programmes for communities or outreach of any kind? Yes [] No []

ii. If yes, name and give a brief explanation

10) Are there structures for stakeholder participation in your organization? Yes [] No []

11) If Yes, outline the structures in place for stakeholder participation

THANK YOU.

Appendix 5: Institutional Questionnaire for KFS

The information given here under will be used for the academic purpose, should be given voluntarily, and will be treated with the confidentiality it warrants.

Environmental implications of the charcoal business in Narok-South Sub-County, Narok County.

1) Do you have incidence of charcoal production in your County? Yes[] No []

2) If yes, as a natural resource based establishment, do you have County/Sub-county programmes for mitigating the effects of commercial charcoal production

3) What are the goals and objectives of the programmes

4) Could you outline the strategies for their implementation?

5) i. Do you have any challenges in the implementation of these regulations? Yes[] No []

ii. If Yes, could you describe them

6) What measures are in place to address the challenges?

7) i. Do you have charcoal related training programmes for communities or outreach of any kind? YES [] NO []

ii. If Yes, name and give a brief explanation

8) What structures for stakeholder participation do you have in place?

THANK YOU.

Appendix 6: Work Plan and Budget

Work Plan

ACTIVITY	Sept /Oct 2013	Dec 2013	Jan/ Feb. 2014	March 2014	June 2014
Proposal writing and Presentation					
Field work and Piloting					
Correction of data collection instruments					
Data collection					
Report writing					
Presentation of final draft					

Budget

ITEM	AMOUNT
Printing	25,000
Transport & accommodation	33,500
research materials	9,500
Stationery	4,500
Miscellaneous	10,500
TOTAL in Kshs.	83,000.00