IMPACT OF FUELWOOD CONSUMPTION BY THREE TEA FACTORIES ON ENVIRONMENT AND ON-FARM TREE PRODUCTION IN KANGEMA SUB-COUNTY, MURANG'A COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or any other academic award.

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DEDICATION

This work is dedicated to my dear wife Margaret and my lovely children Melody and Peterlee whose love, encouragement and endurance has been pivotal throughout my course.

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ABBREVIATIONS AND ACRONYMS

ESD	Education for Sustainable Development
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GHG	Green House Gases
GOK	Government of the Republic of Kenya
IPCC	Intergovernmental Panel on Climate Change
KFGA	Kenya Forest Growers Association
KTDA	Kenya Tea Development Agency
MDGs	Millennium Development Goals
MoA	Ministry of Agriculture
MoE	Ministry of Energy
NGO's	Non-Governmental Organizations
NEMA	National Environment Management Authority
SPSS	Statistical Package for the Social Sciences
TRFK	Tea Research Foundation of Kenya
UN	United Nations
UNEP	United Nations Environmental Programme
UNICEF	United Nations International Children Emergency Fund
USAID	United States Agency International Development
WHO	World Health Organization

ABSTRACT

The tropical forest loss is increasing by 2,101 km^2 per year. The factors causing the increasing tropical forest loss include agro-industrial development and exploitation of fuelwood by many countries. The role of human involvement in the deforestation situation in Africa cannot be understated. Studies carried out in Kenya show that most of the Tea factories rely on fuelwood for their energy requirements. This forces them to heavily contribute to the felling down of trees in the quest of meeting energy demands. The study sought to determine the impact of fuelwood demand by three tea factories on On-farm tree production and the environment in Kangema Sub-county. The objectives that guided the study were to assess the fuelwood consumption rate by the three tea factories, to determine the effects of fuelwood consumption by the three tea factories on the environment and on-farm tree production, examine the efforts by the three tea factories to meet their fuelwood demand and to determine farmers' awareness level on the need to for on-farm tree production. The study employed a descriptive research design. The study target population was the Tea farmers in Kangema Sub-county, and the sample size was determined by simple random sampling method. The study had a sample size of two hundred and ninety farmers and six key informants. Data were collected using interview schedules, observation sheets and interview guides for key informants who included the factory section heads, area Environment Officer, the Agricultural Extension Officer and the area administrative Chief. Data were analyzed by use of descriptive and inferential statistics for the quantitative data while the qualitative data was analyzed by way of understanding the meaning of the answers brought forth by the respondents and relating it to the previous studies undertaken in the field of fuelwood demand and its impact on the tree cover requirements. The research findings indicated that the consumption rate of on-farm trees was significantly high. A correlation between the type of trees planted by the farmers and the preference to support a continuous supply of fuelwood to tea factories yielded an r = -0.459 and a *p-value* of 0.000 at a significant level of 0.05. The increased consumption of on-farm trees had serious effects on environment. A correlation test between exploitation of on-farm tree production and and the approximate portion of land with trees returned an r = 0.016 and a *p-value* of 0.792 at a significance level of 0.05. Tea factories had instituted a number of strategies and efforts to ensure continuous supply of fuelwood for their factory. This was proven by the correlation test between factories efforts to provide farmers with quality, fast growing seedlings which returned an r = 0.08 and a *p-value* of 0.901. Awareness of the need for on-farm tree production and to the environment was significantly high. The farmers' levels of awareness on the need for on-farm tree production and how they fared in attaining the 10% tree cover policy on their farms was studied by correlating the two. The result showed an r = -0.176 at a *p-value* of 0.003. The study recommended that tea factories should be regulated and forced by way of the statute to diversify their energy sources. The tea factories should equally be forced by the county governments to grow trees as a replacement measure in the harvested areas. This would positively impact on the tree replacement rates by the tea factories. Sensitization by the statutory environmental organs on the need to practice on-farm tree production to attain the requisite ten percent tree cover should be done.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The tropical forest loss is increasing by 2,101 km^2 per year. The factors contributing to the increasing tropical forest loss are agro-industrial development, development of cattle ranches in many parts of the growing economies. A classic example is Indonesia which has lost 50% of its natural forest cover in the past thirty years. The loss has been fuelled mainly by consumption of fuelwood (Moore, 2013).

The role of human involvement in the deforestation situation in Africa cannot be understated. A survey carried out in thirty-five African countries over the past eighteen years, since 1992 showed that 3.4% of the forest cover had been lost. The trees had been consumed in the production of fuelwood and through loss of forest land was converted into agricultural land. This had the effect of reducing life expectancy in the continent of Africa owing to the elimination of carbon sinks. Access to economic opportunities which are provided by the natural forests has also been lost (Jingwa & Asengu, 2012).

The deforestation trends in Kenya have been alarming. With the advent of independence, the country's tree cover stood at 10%, and it has been reduced to 5.7%. The reduction can be attributed to rapid population growth and the over-exploitation of forests for commercial activity. The invasion of forests lands by speculators seeking land for habitation has equally been a documented factor leading to the loss of forest cover. This has exposed the country to the situation of high risk about the degradation of our national heritage in which the forest cover provides (Masinde & Karanja, 2011).

The causes of forests degradation in Kenya can be partly linked to lack of political will to stem the tide of over depletion of the resource. Many politicians derive political capital from populists' agenda which encourage forest and community relationships and give rise to the misuse of the facilities at hand. It results in loss to the country due to lack of mature planning and responsible exploitation of the resource. Situations of forests excisions for human habitation are perpetuated by politicians abound. The need

to grow cash crops grown has also seen forests excisions in the Republic of Kenya. The Nyayo Tea Zones are an example of commercial agricultural activities carried out at the expense of maintaining the requisite tree cover (Transparency International, 2012).

Deforestation has been confirmed to increase global warming. This can be attributed to reduced carbon sequestration. The heat traps provided by the trees are rendered unavailable owing to the cutting down of trees and depletion of the forest cover. This exposes flora and fauna to more unstable climatic conditions owing to the imbalance perpetuated by the depletion of forest cover. It brings along with it the challenge of global warming, and puts the populations at risk (World Wide Fund, 2013).

Trees and other woody perennials are a common feature on farms and rangelands and are found in a wide range of traditional and newly introduced land use systems. Globally, trees occur on 46% of all agricultural lands and affect the lives of 30% of the rural population worldwide (Neufeldt *et al*., 2009).

In Africa, one of the key drivers of deforestation and landscape degradation is the demand for cheap energy (Neufeldt *et al.*, 2009). Wood fuel usage has increased in recent years in the developed world. Attention is now being given to finding sustainable wood fuel sources for use in the developing world (Food and Agricultural Organization, 2010).

Environmental policies and regulations are set to safeguard the environmental resources from misuse and depletion thus ensuring sustainable use. Consequently, Kenya is party to several conventions and declarations with a bearing to health and environment linkages (GOK, 2009). In the constitution of Kenya (Government of Kenya, 2010), it is well stipulated that the state shall work to achieve and maintain the global recommended tree cover of at least10% of the land area of Kenya. Such can only be achieved through active involvement and participation of the citizens by way of Awareness and participatory engagement in planting, growing trees and controlled use of the trees. Equally the industries in the country must use natural resources wisely with adherence to the set policies in order to propel the country into a middle-income economy as envisioned in the vision 2030 blueprint. Trees do account for a good proportion of the biomass energy source which provides 68% of Kenya's national energy requirements (Mugo & Gathui, 2010).

Studies carried out in Kenya show that most of the tea factories rely on fuelwood for their energy requirements. This forces them to heavily contribute to the felling down of trees in the quest of meeting energy demands. It occasions the prevailing forest cover undue negative exposure owing to the fact that the tree replacement rates cannot match the energy requirements of the tea factories. This causes most of the tea factories to overly exploit the forests around their catchment areas and expose the local communities to failure to achieve the requisite tree cover requirement (Obare, 2013).The tea factories have thus been identified as leading heavily in the deforestation and depletion of the existing natural resource regarding trees in the quest of meeting their energy requirements.

Factories consume a significant amount of the energy during the tea drying processes. At that stage, boilers are powered by burning fuelwood to produce the heat which is then used in the drying process. Factors of climate change would be blamed for the net emissions generated but then wood used in the drying process would be sustainable if the source is constantly renewed for instance a forest whose area and density is reducing (Kung'u & Langat, 2011). Because of the huge quantity of wood required to power the boilers, the continuous reliance on fuelwood purchases, factory own production and irregular harvesting places some significant financial burdens make it difficult to operate the tea agency. Most of communities surrounding each of the KTDA factories rely on fuelwood as their primary source of energy for daily cooking, thereby mounting additional pressure on the valuable natural resources. As a result of all these reasons, there exists a very strong industry case to reduce the amount of wood being used against the benefits of climate change mitigation.

The reduction in fuelwood consumption would entail engaging in alternative fuel sources such as those made from waste products like the briquettes. In order to reduce wood consumption by factories, farmers are called upon reduce their domestic consumption of wood fuel and instead install energy-saving stoves (Githiomi *et al.*, 2011). The climate change impacts due to wood consumption can also be reduced if the wood used is grown in a sustainable manner. One of the easiest ways in which to reduce the amount of fuelwood required by a tea factory is by ensuring that drying fuelwood properly before use. The essence of drying fuelwood is to reduce the moisture content in the wood in order to increase the calorific value. For optimum calorific value in the

wood, the moisture content should be less than 20%. The drying process takes between 4 and 6 months but the process is overly dependent on local conditions such as temperature, humidity, and airflow. Such undertakings require factories to have a big storage area to facilitate the drying of wood before use.

Kangema Sub-county alongside other neighboring sub Counties in Murang'a County has borne the brunt of felling down trees perpetrated by the tea factories in the area and those with a catchment area in the underlying zone. The sub-county serves tea factories in Kangema, Mathioya, and Kahuro. Most of the tea farmers in the sub-county supply the tea factories with trees for meeting their fuelwood demands.

1.2 Statement of the Problem

In the recent years, tea factories in the country have shifted to use of fuelwood mainly from tea farmers as a source of energy for processing tea with dire consequences to the environment (Kenya Forest Research Institute, 2010). In its strategic plan, Tea Research Foundation of Kenya, (2011) noted that the reliance on fuelwood for tea processing by tea factories might lead to environmental degradation. The continued dependence on fuelwood energy by tea factories thus may impact negatively on the environment exacerbating the global climate crisis. Environmental laws and policies world over are usually put in place to enhance the wise use of the resources. In so doing there will be continued use of the resources by the current generation and the future generation as advocated for by Education for Sustainable Development (ESD).

For a long period, the residents of Kangema sub-county have been relying on fuelwood as the main source of energy. This, together with other factors like timber for construction and land clearing for crop production has been gradually reducing the total area covered by trees. Davis *et al*., (2009) noted that the livelihoods of rural people heavily depend on agriculture. Moreover, Kangema sub-county is the main catchment area for fuelwood to three tea factories namely; Githambo, Kanyenya-ini, and Gatunguru. As a result, stiff competition for the wood resource from farmers' farms has led to attractive buying price per cubic meter of stack wood fuel causing farmers to sell fuelwood more and more as a source of income. This has also driven the farmers to indiscriminately cut trees for sale irrespective of indigenous or exotic species for economic gain. In so doing, the United Nations tree cover requirement is violated and

equally the new constitution of Kenya (GOK, 2010). This is a clear indicator of the high energy demand by the factories, as reflected by the country's increase in energy demand which is linked to the rising population and expanding economy; the latter which grew by 7% in 2007 (Kirai, 2009).

Unfortunately, no research has been done to determine the impact of fuelwood demand by the three tea factories on On-farm tree production and the environment in Kangema Sub-county.

1.3 Significance of the Study

The Global challenge of climate change will be tackled through strict adherence to the environmental agreements and policies. The UN requirement of 10% tree cover and on-farm tree propagation is a key pillar to ensure Carbon sequestration among other ecological, social and economic values of trees. If this is ensured, then a big step will have been taken towards achieving millennium development goal No.7 (Millennium Development Goals, 2005).

Increased awareness and knowledge on afforestation policy by individual farmers will lead to responsible use of the tree resource. This is as advocated by UNESCO Decade of Education for Sustainable Development 2005-2014. With good strategies and involvement of the tea factories, the tree cover percentage will be maintained with less environmental degradation. This study, therefore, focused on farmers' activities geared towards the achievement of 10 % tree cover by way of employment of on-farm tree cover as required by the Legal Notices NO. 166 of November 2009 on agricultural act vis-a-vis the fuelwood demand by tea factories (GoK, 2009).

1.4 Research Questions for the Study

i. What is the rate of fuelwood consumption by the three tea factories sourcing fuelwood from Kangema Sub-county?

ii. What is the effect of fuelwood consumption by the three tea factories on environment and on-farm tree production in Kangema Sub-County?

iii. Which efforts have the tea factories put forth to meet their fuelwood demand?

iv. What is the farmers' awareness level on environmental effects and on-farm tree production in Kangema Sub-County?

1.5 Objectives of the Study

The broad objective was to determine the impact of fuelwood utilization by the three Tea factories on the environment and on-farm tree plantation in Kangema Sub-county.

Specific objectives were to;

i. Determine fuelwood consumption rate by the three tea factories sourcing fuelwood in Kangema Sub-County.

ii. Assess the effects of fuelwood consumption by the three tea factories on environment and on-farm tree production in Kangema Sub-County.

iii. Examine the efforts by the three tea factories to meet their own fuelwood demand in Kangema Sub-County.

iv. Determine the farmers' awareness level on the effects of fuelwood consumption environmental and on-farm tree production in Kangema Sub-County.

1.6 Research Hypotheses

HO_1 The type of trees planted on farms is influenced by the factories demand.

HO_2 Fuelwood demand by tea factories in Kangema Sub-county has no significant impact on On-farm tree production.

HO_3 The efforts by the tea factories to meet their energy demand do not affect the attainment of the 10% tree cover

HO_4 Farmers' awareness on the impacts of fuelwood demand by tea factories and afforestation policy is not significantly high.

1.7 Justification of the Study

This study provided a case for adherence and implementation of the set policies in an effort to maintain tree cover within the required range. In so doing the widely talked

about world menace of global warming and consequently climate change can be curtailed. Moreover, the policies are tools for counterchecking environmental degradation and realization of sustainable development.

The study aimed at collecting and analyzing data to fill the gaps of knowledge on perceptions, fuelwood energy demand for industrial consumption by tea factories and its implications on afforestation and environment at large in Kangema Sub-county. This advanced knowledge led to informed decisions at the individual level, industrial level and nationally for the realization of sustainable development, mitigation to climate change through achievement of MDG No. 7.

The choice of Kiruri Tea electoral zone was based on the fact that, the area had very many trees owing to its nearness to Aberdare forests, the undulating terrain making it hardly hit by the effects of reduced tree cover if any and it was directly adjacent to two of the factories, that is Githambo and Kanyenya-ini.

1.8 Scope of the Study

The research study covered Kiruri Tea electoral area and three factories of zone III sourcing fuelwood from Kangema Sub-County. It limited itself to the fuelwood demand by tea factories, deforestation vis-a-vis afforestation policy and farmers Awareness of the impacts of the fuelwood demand.

1.9 Conceptual Framework

On-farm trees are basically for use by the farmers for biomass energy, construction and for sale to satisfy their economic needs. On the contrary, high demand for trees to satisfy these needs, combined with low environmental Awareness on policies governing tree coverage will lead to overharvesting of the resource. The rivalry between tea factories for fuelwood from farmers drives the farmers to cut down trees with low rates of replacement. All these culminate to reduced tree cover and soil exposure with dire consequences that include environmental degradation, loss of biodiversity and reduced sequestration exacerbating climate change.

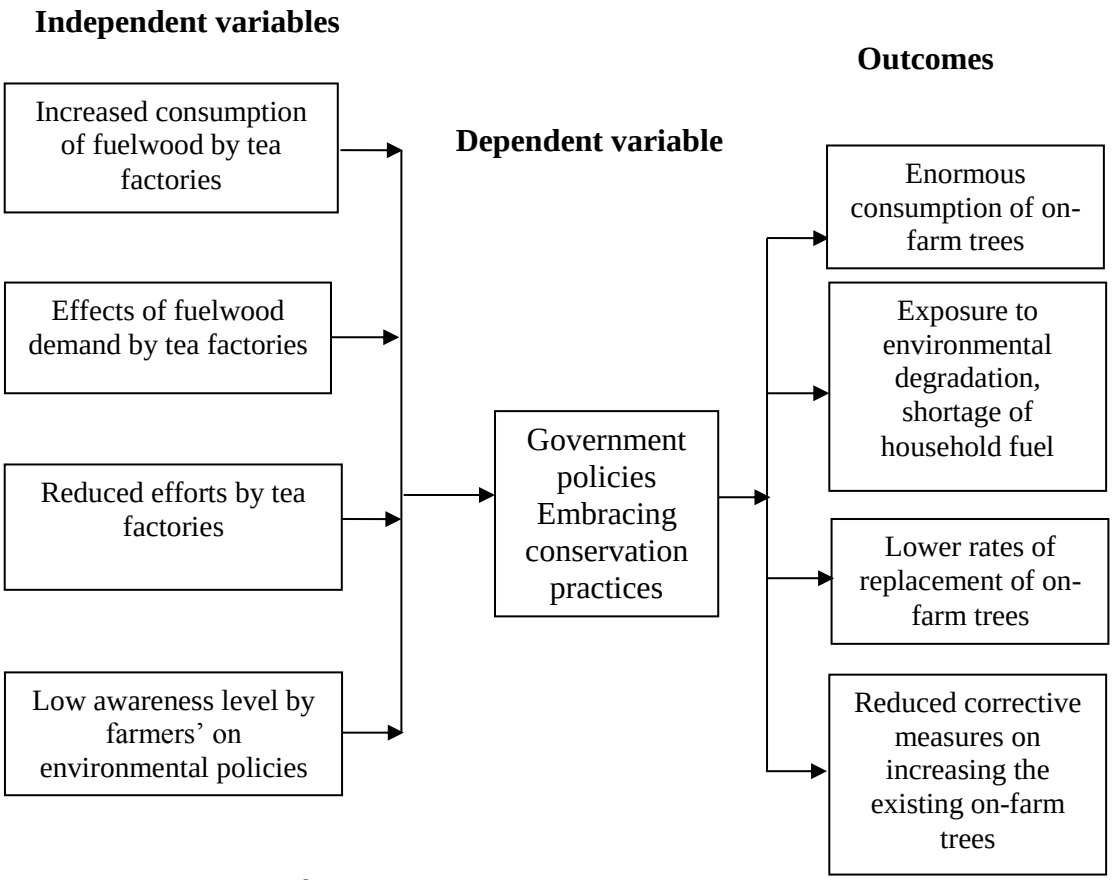

Figure 1.1 Impacts of Fuelwood Demand on Tree Cover and Environment (Source: Adapted from the National Land Use Policy, 2011)

1.10 Definitions of Operational Terms

Degradation - Loss of economic, ecological and aesthetic values of an area as a result of human interference.

Deforestation- Removal of the trees from an area for economic use.

Biomass- Renewable energy derived from animal and plant organic matter.

Sequestration- Removal of carbon dioxide from the atmosphere and storing it in wood material.

Vision 2030- Government of Kenya development plan (blueprint) for 2013

Electoral area- An area under the jurisdiction of one tea factory director

CHAPTER TWO

LITERATURE REVIEW

2.1 Preview

The role of forestry in the environmental amelioration and local people's life assumed global significance after the 1992 Rio Summit. The saga of deforestation in the developing countries on account of rising population and consequent poverty has attracted the global attention of scientists, resource managers and lawmakers (Anjaneyulu, 2006). According to United Nations [UN] (1992) in the Agenda 21, Awareness should be increased at all levels concerning the needs to optimize the sustainable use of resources through efficient resource management taking into account the development needs of the populations of developing countries.

Development in Kenya is best served by harnessing a comprehensive response to climate change focused on building resilience through adaptation measures, one that invests in and achieves due rewards from reduced deforestation and forest degradation (GoK, 2013). Due to the country's rising population trend and consequently increasing resource needs, the pressure on land has been increasing considerably with a high rate of deforestation. The forest cover in Kenya reduced from 12 percent in the 1960s to 6 percent today (GoK, 2013). It is in this spirit of sustainable development that in the Constitution of Kenya (2010), the state should ensure a 10 % tree cover. This is also captured in the vision 2030 blueprint aimed at transforming the Kenyan economy to a middle-income economy. Such can only be achieved with proper management of the closed canopy (forest), state plantations, woodlands, private plantation forests together with the coastal mangroves (Ministry of Forestry & Wildlife, 2012).

The Kenya Forest Growers Association which is an association for small scale has embarked on the commercial approach towards the tree growing industry. The association has invested heavily in the propagation of private forests on individual member farms. This is with the aim of realizing commercial benefits accruing from the propagation of the trees (KFGA, 2014). The association has played a pivotal role in giving the members a platform to engage the government and allied statutory bodies in the commercial ventures which entail tree cover enhancement and growth of the forest percentage.

The consumption of fuel derived from trees has been a factor which has challenged and exposed the forestry and conservation sector to enormous risk. This is attributed to the rapid degradation of the forest cover occasioned by the felling of trees for charcoal and firewood (Njoroge, 2013). A study carried out in Kitui County established that massive tree cutting had led to the continuous degradation of the environment owing to depletion of the forest cover. The study identified felling of trees for charcoal consumption as a factor which greatly accelerated the depletion of the forest cover. tea factories were equally identified as large consumers of trees in the forested areas owing to the fact that they relied on fuelwood for Tea processing. This was a significant factor which greatly accelerated the deprivation of the national tree cover percentage (Njoroge, 2013).

According to a study by National Environmental Management Authority (NEMA) on fuelwood production in Kenya, 84% of the total fuelwoods is sourced from small-scalefarmlands (NEMA, 2010). Presently, the country's forest cover stands at 3.467 million ha equivalent to 5.9% of the total land mass (Kenya Forest Service Strategic Plan, 2013). The KFS strategic plan (2011) showed that the area under indigenous tree cover stands at 1.417 million ha which includes the closed canopy forests, mangroves and man-made plantations. Both internal and external influences are demonstrated as major threats to closed canopy forests in Kenya.

In a separate study, overharvesting of forest cover is highlighted as an ill driven idea that will plunge the country into a serious environmental crisis and dwellers exposed to serious consequences which include environmental degradation, loss of biodiversity as well as acute shortages of basic household requirements such as fuelwood and timber among others (Nellie & Githiomi, 2009). The Kenya Forest Service strategic plan (2009), noted that wood stocking with regards to the size of farmlands with tree cover is abnormally high as compared to other countries in sub-Saharan Africa standing at about 9.7 m^3/ha. Stern measures were recommended by the Kenya Forest Service Strategic Plan (2009) to safeguard the forest resources where a moratorium on tree harvesting from public forests was imposed in 1999 followed by a complete ban in 2002. The ban precipitated an acute shortage of wood products and sawn timber in the country's markets forcing the users to seek alternatives.

Although the ban was perceived negatively by the users as it led to increased timber prices as well as other products, it encouraged more farmers to plant more trees. To

enhance sustainability in the sector, integration of trees in formal and informal agriculture systems is inevitable (Schuren & Snelder, 2008). Through research, various on-farm forestry systems, integration of trees has been made possible, easier, diverse, and efficient (Adensinu & Chianu, 2002). According to reports by the Republic of Kenya (2007), the government has been on the forefront in the campaigns to promote tree planting on the farms with the aim of increasing tree cover from the current 5.9% to 10% by the year 2030. Tree planting programs in the rural areas of Kenya led by the forest extension officers and various non-governmental organizations have registered remarkable success (Githiomi *et al.*, 2012).

According to Kenya Forest Service reports (2011; 2012), fuelwood plantations interventions were treated as matters of national priority alongside timber production. Fast growing tree species are most suitable for such plantations because they match the specified environmental and ecological conditions for maximum output. The locally viable land which can be used for fuelwood plantations can be leased through the county governments, trust lands, rangelands and community land as appropriate. The approach seeks to strengthen the integration of timber and wood fuel into local farming systems because the sector plays a key role in supplementing fuelwood**.** Fuelwood and other tree products can as well be produced through commercialized farm activities. Through policies such as the 10% tree cover and the legal notice no. 166 of November 2009, the government plans to increase the national forest cover to recommended standard for all agricultural land holdings in the country. Moreover, the intervention is need driven as it aims to increase fuelwood supply from the farmers owned lands.

Adopting a strategic management approach to ensure effectiveness in the use of land resources through enriching the planting and regulating the charcoal production activities can reduce by a big margin the depletion of forest resource United Nations Environmental Programme [UNEP], (2013). The UNEP study (2013) acknowledged that resources mostly in rural areas are utilized unsustainably a situation that can be reversed through the application of strict regulatory policies on tree harvesting and fuel exploitation. The study recommended proper management plans of woodlands and rangelands for sustainable wood fuel resources (KFMP, 2004). The strategy was aimed at developing the capacity for the individual district to become self-sufficient on fuel need and supply.

2.2 Fuelwood Sources for Household Biomass Energy

In Kenya, wood fuel commands the largest proportion of consumable biomass energy accounting for up to 70% of the total national energy demand. According to studies by Theuri (2010) and MoE (2010), approximately 90% of Kenyan population residing in the rural areas uses fuelwood either as firewood or charcoal. The study noted that over 93% of rural household energy needs are met through application of fuelwood as opposed to the urban households where charcoal is the dominant fuel (Theuri, 2010; Kituyi, 2008). Although fuelwood is considered an important source of fuel to most households in Kenya, it also doubles up as a source of energy to small-scale rural industries where alternatives are absent (Githiomi, 2010). Despite the growing need for information on the country's energy needs which is required to guide the country's economic development programs, data on fuelwood supply and demand is scarce or characterized by a high degree of inaccuracy that makes it difficult to be assimilated into reliable decision making, planning and formulation of the industrial policies.

Fuelwood is perhaps the most common household energy due to its availability and ease of reach. It is however acknowledged as the cheapest source of energy for urban household cooking. In comparison to other forms of energy, fuelwood demands consume on average Kenyan shillings 12,000 for every household per year in the urban setting as compared to shillings 31,760 and 59,200 for liquid petroleum gas (LPG) and electricity respectively. Fuelwood is available for purchase in relatively affordable and manageable quantities of as little as 1.5 kg which cost as little as shillings 30-50. This makes the energy source the most affordable to most low income earning households (Pisces, 2011).

Kalua (2011) decried that the 9,500 secondary schools in Kenya rely heavily on fuelwood for their energy needs, which precipitates for a massive loss of forest cover. On average, the Kenyan secondary schools consume about 5.3 medium-sized trees daily, which translates to a significant loss of 18.3 million trees per annum. The Republic of Kenya (2011) estimated that 20,000 institutions are consuming an average of 270 tonnes of firewood per annum, which translates to an absolute loss of 5.4 million trees per annum because the institutions rarely re-plant trees.

Industrial consumption of fuelwood in Kenya has remained high, despite the knowledge. In Brazil industrial consumption of fuelwood to fire its steel industry is at 32% (co-firing with coal at 68%). Agricultural sector industrialists such as KTDA and edible oils manufacturers continue to depend heavily on firewood, with the 65 KTDA-managed tea factories consuming a peak average of 20 tonnes of firewood daily (over 260,000 tonnes annually) and the three major edible oils manufacturers in Thika, Nakuru,and Mombasa combining to consume more than 200 tonnes daily. Firewood has less than 50% of the calorific values and transport costs posted by fuelwood, but due to the bulk density of fuelwood and inconsistent, highly volatile supply, it does not even remotely come up as an energy option to these industrialists (GoK, 2012).

Among the available sources of energy for domestic use such as electricity, kerosene, and gas, fuelwood forms the best alternative among these in most of the households in developing world, especially in Africa. Fuelwood has relatively cheaper cost and does not need complicated devices to use it. Besides this, it has special unique properties suitable for cooking which make many individuals prefer it in the presence of other viable alternative sources of household energy (Mugo & Ong, 2006). Fuelwood is widely used as energy source by urban households. For instance, in Zambia, 85% of the urban households use fuelwood as their source of energy while in Ethiopia about 70% of fuelwood production is used in urban towns by households. Similarly, in Tanzania, 80% of the fuelwood made is utilized by urban households. In Kenya, 80% of the urban households used fuelwood as a source of energy for cooking (Mugo & Ong, 2006). It is estimated that in every year about two million tonnes of fuelwood is used in Kenya (ESDA, 2005).

In some Sub-Saharan African (SSA) countries, the proportion of people with access to electricity is actually declining (Venro, 2009). Access to electricity is not expected to replace wood-based fuel use for cooking because the cost of cooking using electricity or other alternatives such as liquefied petroleum gas (LPG) is often prohibitive. Hovorka *et al.,* (2008) established that in SSA countries, urban households use modern energy sources in addition to, instead of solid fuels. For example, half the total firewood demand in Harare is from households with access to electricity (Chambwera & Folmer, 2007), while in Kampala, 83% of urban dweller suse wood biomass as their primary source of fuel (Bacon and Berkes., 2010).

A World Bank survey on Energy Sector Management Assistance Programme (ESMAP) in 45 cities in 12 countries between 1984 and 1993 Price (2000) demonstrated that a decrease in the use of wood fuel triggered shifts in the consumption of petroleum products which has an effect in the users economic status. In a later study, the World Bank (2011) found that switching from wood-based energy in SSA will not necessarily be a matter of improving the economic situation of the users but that of the environment. It noted that most households got few choices to switch to when alternative fuels continue to rise and supply remains erratic.

Given the often erratic and unreliable income streams in most SSA urban households, it is more rational to purchase household fuel which is available in relatively smaller quantities as opposed to alternative fuel which are never available in small packages. The World Bank (2011) further established that a doubling of typical urban household incomes would only reduce the number of biomass consumers by 16%. Kenya predicts that by 2030 energy derived from wood in Africa will still account for estimated three-quarters of total residential energy consumption serving about one billion people accounting for about 10% of the global energy supply (IEA 2006 and 2008).

2.3 Fuel Energy Use in Developing Countries like Kenya

Adoption of current best practices is a critical factor in the sustained growth of a country's energy sector. This is occasioned by the fact that in the event of capacity to assure a jurisdiction of sustainable energy provision it may forestall the need to have the exploitation of natural resources like forests for fuel provision (Kumardasa 1997). In Sri Lanka, the country has managed to exploit by-products from an industrial production for instance bagasse in sugar production has been used to generate electric power for industrial activities. Similarly the agricultural by-products have been carbonized for generation of briquettes. These efforts have effectively safeguarded the country against the ravages of increased deforestation and the subsequent risk of desertification (Kumardasa 1997).

State of the art in utilization of crop residues in India has been a key selling point to the ability of the country to harness its environmental resources. The use of residues from rice production in optimizing Tea processing in the industrial setting has provided the country existing forest cover sound protection against the risk of depletion in the

industrial processing activities. This has been a factor which has assured the country sustainable industrial processing capacity despite the high energy demands without negative implications on the forest cover (Piyasekara, 1993).

The use of renewable energy sources in the Republic of Malaysia has seen sustained growth of the country's Gross Domestic Product GDP (Ferradon, 2008). The growth can be credibly reflected the savings accruing to the exchequer associated with reduced demand for foreign exchange geared towards fuel importation (Ferradon, 2008). Industries exploit renewable sources of energy like solar and wind for their production purposes. It has had a sustained impact on the country's economic growth in line with the spirit of natural resources conservation and assurance of stability of programmes (Ferradon 2008).

The level and intensity of commercial energy use is a key indicator of economic growth in a country. In Tanzania, 88 percent of the total energy consumption is estimated to be fuelwood and 4 percent charcoal, leaving only 7 percent for petroleum and just one percent for electricity from hydropower. Major fuelwood consumers are domestic household purposes, and small-scale industries related to agriculture such as tobacco and Tea curing, brick burning and fish smoking (Malimbwi and Zahabu, 2008).

It is estimated that nearly half of population globally continues to depend on woodfuel biomass energy particularly in the form offuelwood for cooking. In Sub-Saharan Africa, about 81% of the households also depend on fuelwood for cooking (AFREA, 2011). It is projected that even though biomass fuels are likely to increase in developing countries such as India and China among others. In Sub-Saharan Africa, the use of fuelwood has remained high and is projectedto continue in the same trend. The World Energy Outlook approximates that by 2030 individuals using biomass energy from fuelwood will likely reach to about one billion in Sub-Saharan Africa (IEA, 2010).

According to the status report by the Ministry of Energy (2002) the energy sector in Kenya is dominated by biomass-based fuel; fuel-wood and charcoal are the primary cooking fuel for the people living in the extreme edge of the economy, accounting for over 68% of national consumption. Petroleum-based fuels used in transport and industrial sector account for another 22%, while electricity contributes 9%. The balance is shared between renewable such as wind power, solar amongst others (Yuko, 2004).

Kenya has had initiatives inclined towards assuring the sustainable country development of its energy sector and increasing fuel demands. Investment in geothermal energy exploration has been a focal point for the Republic of Kenya (Ngunjiri, 2013). Seeking out alternatives, for instance, the solar energy and wind fuel for industrial and allied purposes has equally helped spur innovation and creativity in the energy sector. This may portend good tidings to the country's economy especially so to the realms of environmental conservation and management.

Households are the most basic units in fuelwood energy consumption with an estimated consumption of 6.5 tonnes per household annually (Mugo, 2001). The second highest consumer of wood fuel is the cottage industries that incorporate the brick making, jaggaries, tobacco industries, and bakers. Others users include restaurants/hotels and learning institutions where cooking is done by use of fuelwood. On average, most of the cottage industries energy consumption account for 20-30% of the total operating costs and which is mainly from wood (MoE, 2002).

2.4 Energy Demand by Tea Factories and Environmental Degradation

Kenya Tea Development Agency (KTDA among other players command tea processing industries in most parts of rural areas in Kenya and have control of over 50 small-scale tea factories spread out across most districts making them the chief consumers of fuelwood. Curing of tea in more than 70% of these factories is done through use both furnace oil and firewood inside a huge boiler. In order to reduce the cost of tea production, the tea factories use wood-fired steam boilers to generate heat. Comparatively, the cost of processing tea using furnace oil is significantly higher than using the wood energy which helps to save up to 60% in the cost of fuel.

In Kenya, 80% of the population is dependent on firewood and fuelwood for cooking and other energy needs (The Republic of Kenya, 2008). KIPPRA (2010) suggested that renewable technology is the way forward to Kenya's energy security, but the energy production from renewable sources has been limited to small-scale consumption and household cooking in the country. An analysis of fuel types in Kenya by KIPPRA (2010) observed that the most common household fuel in terms of usage is kerosene at 80% while charcoal follows closely at 60% and fuelwood stands at 55%.

In the wake of industrialization, anthropogenic greenhouse gases emissions have been increasing immensely, and a broad consensus has emerged that human activity will be affected by earth's climate change. The industrial combustion of coal and fossil is used to generate energy for heavy industrial works. The economic and environmental impacts ofsuch emissions require a world-wide solution. According to IPPC (2007), carbon dioxide is the most important anthropogenic greenhouse gas, and the global atmospheric concentration of carbon has since increased from a pre-industrial value of about 280 ppm^3 to 379ppm^3 in 2005 and which exceeds the natural range of between 180-to-300 ppm^3 in the last 650,000 years.

The tea processing factories consume both thermal and electric energy in the process. Thermal energy used in the withering and drying processes is produced by burning coal, firewood or fuel oil in heaters. A study by Asian Institute of Technology (2002) indicated that tea industry is one of the energy-intensive food processing sectors consuming both electrical and thermal energy. Most of the thermal energy requirement is derived from firewood, lignite, coal and fuel oil and ultimately they contribute to direct emission of carbon dioxide (CO_2) in Asia (India, Vietnam and Sri Lanka). The report also rates that the extensive damage of deforestation created by the use of fuelwood is also to be reckoned with.

Tea factories in Kenya majorly consume fuelwood in the tea processing activity. The consumption of fuelwood has had profound effects with regard to environmental degradation owing to the massive tree felling occasioned by the tea factories. This has had far-reaching ramifications on the expected tree cover requirement. It has had negative implications on the overall forestry industry attributed to the massive consumption of trees in the fuel generation (MoA 2012). The need to have the tea factories adopt more robust and efficient sources of energy cannot be underscored. It may have positive implications on the overall performance of the agricultural sector driven by the reduction of climate change effects (MoA 2012).

The most effective way in which to dry fuelwood is first to split the wood and then stack it in piles. It is important to ensure that the wood is stacked in a way that leaves space for airflow and natural ventilation so that the wood can dry. It is also important to ensure that the fuelwood does not get wet or damp whilst it is being stored. If the wood gets wet, it will most likely cause rotting, evident through the growth of mould

(Theuri, 2010). Dump and poor quality lower the calorific value of the wood and the rotting process is a source of methane, one of the greenhouse gases is responsible for climate change. In order to prevent the wood from getting wet, placing them above the ground, stacked under a cover and have effective drainage.

The quantity of fuelwood required by a tea factory can be reduced to improve the efficiency of the boiler. First, ensuring that there are no leakages within the system to allow moisture. The boiler and all its associated piping should be fastened and checked for compliance routinely. Secondly is toensure that the system is tightly insulated (Akinga, 2006). Insulating the system preventsit from losingheat and thereby reducing the amount of fuelwood consumed. Thirdly is to ensure that all boiler operators acquire regular training which ensures that their skills level and understanding of boilers operation remains constant.

The energy requirements in most tea factories in Kenya is met by use of wood fuel which powers the factories boilers. The low carbon emission quality in woodfuel makes it stand out amongst many other available choices locally. The Inter-governmental Panel on Climate Change (2012) when discussing emissions mitigation from forests a sustainable forest management strategyand planseeks to maintain and increase the forest's carbon stock, while producing annual sustained energy from the forest, will generate the largest mitigation benefit. A key emissions mitigation strategy for tea factories dependent on fuelwood is thus to ensure that the wood used to run their boilers is being supplied in a sustainable manner (Barnes *et al.,* 2004). The simplest way through which tea factories can achieve reliance and sustainability is to increase the size of fuelwood plantations so that they can fully supply themselves with fuelwood.

Increasing forest cover in area and density by way of afforestation, reaforestation and restoring of extinct forests increases the absorption of carbon dioxide from the atmosphere, provided care is taken to avoid the cutting down of native forest in favor of managed wood plantations. Establishing wood plantations in areas that cannot sustain a forest is preferred (Barnes *et al.,* 2004). However, it is most uncertain that a given factory can sustain its fuelwood requirements internally. Therefore, effort should be put in place to support local small-scale farmers to put up woodlots in a sustainable manner and which encourages them to sell fuelwood to the nearby factories. The move will ensure that tea factories have a secure fuelwood supply which provides the local

farmers with an additional income.

Observing the necessary steps during the developing of sustainable fuelwood plantations is an instrumental attribute that ensures efficient and large-scale tree nurseries and planting tree seedlings. Managing the plantation for optimal tree density and harvesting the wood for use in a sustainable manner. The Kenyan Forestry Service recommends the use of Eucalyptus as a source of fuelwood (GoK, 2013). However, it should be recognized that *Eucalyptus species* of trees are exotic trees and concerns have been raised over and over again about their relationship with water supply. The procedure requires that when setting up a woodlot at the factory or on an individual farm *Eucalyptus species* be planted away from the water courses and more precisely they should not be planted along riparian strips.

The importance of trees with regard to environmental conservation is immense. The situation of having the trees felled and alienated to generate fuel for industrial activity overriding the essence of conservation has been a worrying trend nationally. Instances of industrial concerns failing to take the initiative and exploit alternatives in the quest to generate energy have been the undoing of the Kenyan industrial sector (Olubiri, 2013). Despite the incentives that exist in the private and public sectors as regards rewards with carbon credits and allied provisions, the energy sector in Kenya is still heavily dependent on wood fuel. This has had a massive drawback to the country's economic mainstay in the field of energy generation. It has negatively impacted on the economic performance on the frontiers of the energy sector (Olubiri, 2013).

In Kenya, most of the tea factories have switched from the traditional furnace oil source of thermal energy to fuelwood energy. In Meru, all the seven factories have been able to switch partially to fuelwood,but the lack of fuelwood is cited as the main limiting factor for a complete fuel switch (Osawa and Muchunku, 2006).

2.5 Farmers' Awareness on Afforestation

Ashley *et al.,* (2005) carried out a study on the outcome of small-scale farmers' Awareness level in Etelä-Pohjanmaa, Mikkeli and Kuopio, all in rural business districts in Finland with regards to forests, forestry and afforestation and found that 54% of the farmers who practiced either agro-forestry or afforestation on their farms were influenced by the Awareness agents either on-site or through proxies. The study noted

that farmers and Awareness agents held differing views on the role of forests and afforestation in their localities. Elum *et al.,* 2016 concluded that farmers' Awareness complemented the efforts to achieve world recommended tree cover in three provinces in South Africa. The study noted that the Awareness campaigns that were aimed at sensitizing farmers on the need to adopt alternative sources of fuel so as to achieve the recommended status had an 18% success.

The World Meteorological Organization [WMO] (2014) cited reduced vegetative cover due to fuel charcoal in the Sahel zone of Africa as the major cause of adverse climatic effect in the region. The study observed that while there were some levels of uncertainty about the macro-climatic effects of deforestation and desertification, the micro-climatic effects appeared less, ambiguous. The study recommended reevaluation of policies and their implication while embracing farmers' Awareness as the center of the maintenance of an adequate plant cover (Anderson & Fishwick, 2010); World Meteorological Organization, 2014).

2.6 Woodlot Development in Farmlands and 10% Tree Cover

Zomer *et al*., (2009), conducted a global assessment of tree cover on agriculture land and found that 48% of all agricultural land had at least 10% tree cover. Although Africa has a smaller percentage of tree cover against its land mass, there is a widespread farming system of agroforestry than all the other continents of the world referred to as Parkland/ Scattered trees in cropland (Boffa, 1999).

The FAO Forest Resources Assessment Report (FAO, 2011) has integrated since year 2000 the assessment of trees outside forests. More countries are now measuring and reporting trees outside of forests, and country provided data indicate that such areas are significant. For example, such area is greater than forest area in countries like Kenya, Tunisia and Niger.

Lack of formal regularization for the wood energy resource and the irregular trading that does not pass through a clearly defined monetary economy altogether make the wood energy data scanty and uncertainty unlike others in the case of liquefied petroleum gas, kerosene,and electricity whose data is available. The national energy convention charged with the mandate of planning for consumable energy concentrates much of its energies on conventional fuels while forestry service and wildlife services

focus more on the supply of wood for commercial purposes and the conservation of protected areas (The Republic of Kenya, 2010). These two key sectors deny biomass energy the consideration it deserves due to the role it plays in supply of energy resources and environmental degradation as supported by past studies by Akinga (2006) and Ministry of Energy (2012), which despite being half a decade apart showed a widening gap between supply and demand in fuelwood. The deficit in fuelwood was caused by massive tree cutting that exceeded replacement. Strategies call for measures to ensure sustainability ofthe energy resource. A comprehensive biomass study conducted in Kenya in the year 2000 revealed that the principal sources of fuelwood are the farmlands with an average production of 84% of the total wood fuel requirement (NEMA, 2004).

Integrating wood fuel into local farming systems in the agricultural sector has a key role to play in supplementing wood fuel through wood production (Githiomi and Oduor, 2012). This initiative is supported by both the government and the legal notice NO. 166 of November 2009 on agricultural act which aims at raising the current tree cover to 10% by 2030 and requires the farmers to maintain 10% of tree cover in agricultural holdings respectively.

2.7 Role of Trees in Mitigating Climate Change

The Inter-governmental Panel on Climate Change concluded that the impacts of climate change could be reduced, delayed or avoided if proper mitigation is put in place and that efforts and investments in the next 20 to 30 years will have a large impact. If action is delayed, it increases the risk of more severe climate change (IPCC, 2007).

Forest removes CO_2 from the atmosphere through photosynthesis and globally could provide abatement equivalent to 25% of current CO_2 emissions from fossil fuels by 2030 through a combination of reduced deforestation, forest management, and afforestation (Read *et al*., 2009). The report further states that trees have an important role in helping the society to adapt to climate change, through providing eco-friendly shelters, cooling, shade and runoff control.

Carbon sequestered by trees and stored in above-ground biomass and soil contribute to reducing greenhouse gas concentrations in the atmosphere. The estimated carbon sequestration potential by agroforestry systems vary greatly, from under 100 $MtCO_2e$

per year by 2030 to over 2000 $MtCO_2e$ per year over a 30 year period. Regardless of the volume, agroforestry systems have a propensity to sequester much greater quantities of carbon than agricultural systems without trees (Neufeldt *et al*., 2009).

2.8 Social-Economic and Ecological Importance of Trees

Forestry has become more people-centered, and society's perceptions of forests have undergone significant changes with increasing emphasis on the environmental, social and cultural values of forests. In addition, the critical roles that forests and trees outside forests play in climate change mitigation and adaptation and as a source of bio-energy are increasingly recognized, requiring careful consideration in national and international decision-making.The benefits from trees, forests,and forestry are increasing, widely recognized and appreciated. Their contributions to society are increased, including the role of forests in livelihoods, poverty alleviation, food security and sustainable supply of raw materials and energy. Investments in forestry are increased, and forestry is accorded a growing priority in wider development strategies (FAO, 2010).

2.9 Research Gaps to be Filled by the Study

The integration of assessment of trees outside forests by FAO since the year 2000 is a clear indication of the importance of maintaining the required tree cover as per UN global requirement. The Government of Kenya has put in place policies to help achieve 10% tree cover, but the implementation level could be low. A study by Nyandike (2008), found that the underlying causes of environmental problems in the Tea industry in Kenya are mainly overutilization of primary resource base such as forest products and water, inadequate use of appropriate technologies, weak enforcement of environmental laws and insufficient support towards technology change. The study scrutinized the impacts of fuelwood consumption by the tea factories on on-farm tree production.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Area of the Study

The study was carried out in Kangema Sub-County, Murang'a County. It is located approximately 147 kilometers by road north of Nairobi.It lies between latitudes 00°34' S and 10°07' S and longitudes 36° E and 37°27' E (Kabubo-mariara *et al*., 2006). Kangema Sub-County borders Mathioya sub-county to the west and Kahuro sub-county to the east. To the north is Aberdare forests. Tea is the dominant cash crop in the Sub-County while coffee takes the second position. The Sub-County is a catchment area for fuelwood to three tea factories, Kanyenya-ini, Githambo,and Gatunguru.

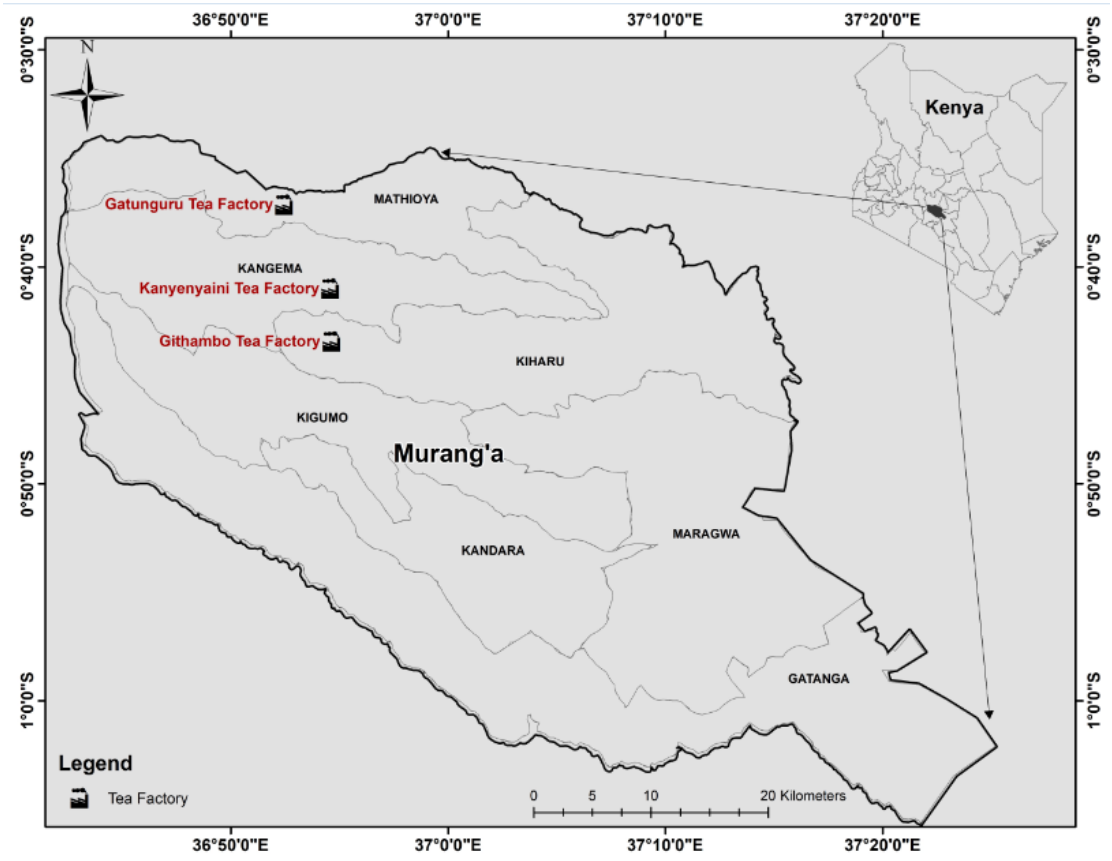

Figure 3.1 Map of Murang'a County Showing the Study Area and the Three Tea Factories. Source: Survey of Kenya

3.2 Study Design

The study assumes both qualitative and quantitative research designs. Qualitative design was used to gain an understanding of the underlying reasons for fuelwood use by the tea factories, the perceptions held by the farmers on the national target of 10% tree cover vis a vis the on-farm tree production and on the fuelwood energy use by the tea factories, also the level of environmental degradation resulting from fuelwood consumption by the factories. Quantitative research was used to quantify data and generalize results from sample data to population data (Burns, 2000).

3.3 Target Population

An experimentally accessible population was considered for the purpose of the study in accordance to Mugenda & Mugenda (2003). All the 1200 registered small-scale tea growers of Kiruri Tea electoral zone constituted the target population. The study considers that tea farmers in the region had their own targets for fuelwood even before the factories extended their hand to the farmers. The unit of analysis was the household while the unit of observation was the household head. The study also had 6 key Informants who were; area Chief, Agricultural Extension Officer, area Environment Officer and Section Heads for the three tea factories.

3.4 Respondents Size Determination

The study employed random sampling method as the most appropriate method for identifying registered tea farmers in the four villages within the study area. The four villages were; Kamakwa, Kiruri, Karurumo, and Kianjuru. Through it, each registered farmer was assigned a unique number for participating in the study prior to distribution of the questionnaires. Sampling was done per village till the sample size was achieved.

The sample size was determined based on the Research Masters Table adopted from Krejcie & Morgan table (2006). The table used to determine sample sizes of finite populations. The target population considered by the study was 1200 registered tea farmers in the electoral zone. According to the sample size determination table at a confidence level of 95%, the study sample size was 291 respondents.

Table 3.1 Sample Size Table

Villages	Respondents	Percentage
Kamakwa	70	24
Kiruri	75	26
Karurumo	75	26
Kianjuru	70	24
Total	290	100

The respondents' distribution in all the four villages was fairly balanced thus minimizing incidences of bias in the sample selection. The study employed purposive sampling to sample key informants who included area Chief, Agricultural Extension Officer, tea factory section heads for the three factories specifically the person in charge of fuelwood acquisition and consumption and the District Environment Officer. These key informants provided relevant information required for this study. The study thus had a total sample size of 296 respondents inclusive of the key informants.

3.5 Instruments of the Study

This study utilized semi-structured questionnaires, interview schedule and personal observations as the leading instruments. An observation record sheet was used for quick recording. In its structure, it contained the household number and observations made such as; the presence of remnants of logging, stacked wood for sale, bare ground as a result of tree harvesting and visible eroded ground.

The interview schedule involved pre-coded questions in producing quantitative data. It was pre-tested in one of the villages outside the four that were studied and the necessary amendments made. The interviewer engaged a face-to-face contact; explained the purpose of the study and the information needed. This created a congenial atmosphere for the purpose of data collection.

The study instruments reliability was confirmed by use of the test and retest method in the pilot study. This assured the researcher the ability of the respondents to understand the language used in the tools, and it was also a measure of confirming the adequacy of the tools as regards the coverage of the thrust of the study.

3.6 Data Collection Procedure

Interviews were conducted with individual farmers in the sample and the key informants. Three section heads from the three factories were interviewed to evaluate their knowledge on the 10% tree cover policy as a measure of encouraging On-farm tree production, the role of tea factories in afforestation, the rate of fuelwood consumption and possible impacts of the continued harvesting of trees for fuelwood. A five-year fuelwood consumption data (2009-2013) by the three tea factories were analyzed to verify the tree harvesting trend from farms. The area administrative Chief, Agricultural Extension Officer, and District Environment Officer were interviewed on their perception on the fuelwood use by the factories and the tree harvesting trend in Kiruri area Vis-a-Vis the 10% national tree cover requirement.

3.7 Data Analysis

Descriptive statistics based on the questionnaire structure were used to provide insights into the perceptions offuelwood consumption trends by the tea factories. Farmers' Awareness of the impacts of fuelwood use on the environment, fuelwood consumption rate and tree replacement rate were also assessed.

The data collected were categorized for the purpose of generating themes and coded to facilitate data analysis by use of inferential statistics. Coding is the conversion of qualitative data into numerical codes (Mugenda & Mugenda, 2003). Graphical presentation and tabulations were made of analyzed data and conclusions made from statistically significant tests thus making recommendations.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Characteristics of the Respondents

The study sought views from 290 respondents who were household heads and 6 key informants who were three factory section heads, the Sub-County environment officer, the agricultural extension officer, and the area administrative chief. The respondents had a wide range of demographic characteristics. These characteristics were summarized and are presented in this section.

4.1.1 Origin Location of Respondents

The responses regarding whether the respondents were originally from the villages of their residence were as captured in fig 4.1.

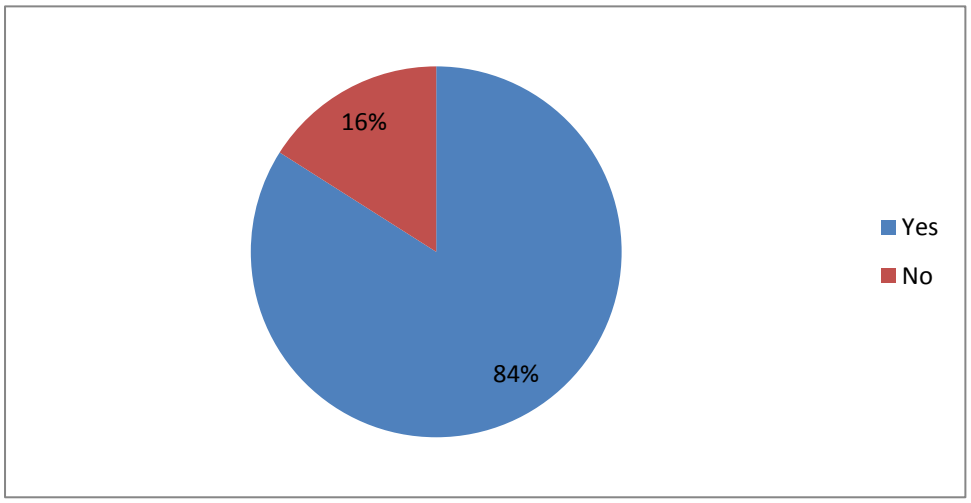

Figure 4.1 Responses on Villages of Origin

Majority of the respondents who participated in the study 84% (n=244) had been born grew up in villages within the study area. The responses were reflective of a situation whereby most of the respondents were originally from the villages that they resided in. This implied that they had a good history and institutional memory as regards the evolving trends on the consumption of fuelwood by tea factories which were set up in the 70s and 80s.

The findings were similar to those of Masinde & Karanja (2011) who opinioned that local residents had a good historical knowledge of the deforestation trends in Kenya.

At independence, Kenya's tree cover stood at 10%, but has now reduced to 5.7%. This reduction in tree cover may be attributed to the rapid population growth and over-exploitation of forests for commercial purposes. The situation in the study area aptly captures the thrust of the findings owing to the fact that the original population in the villages had increased over the years with a similar rise in demand for fuelwood for energy purposes (Masinde & Karanja, 2011).

4.1.2 Respondents' Awareness of the 10% Tree Cover Policy by Ages

The respondents who were aware of the 10% tree cover policy were as shown in figure 4.2.

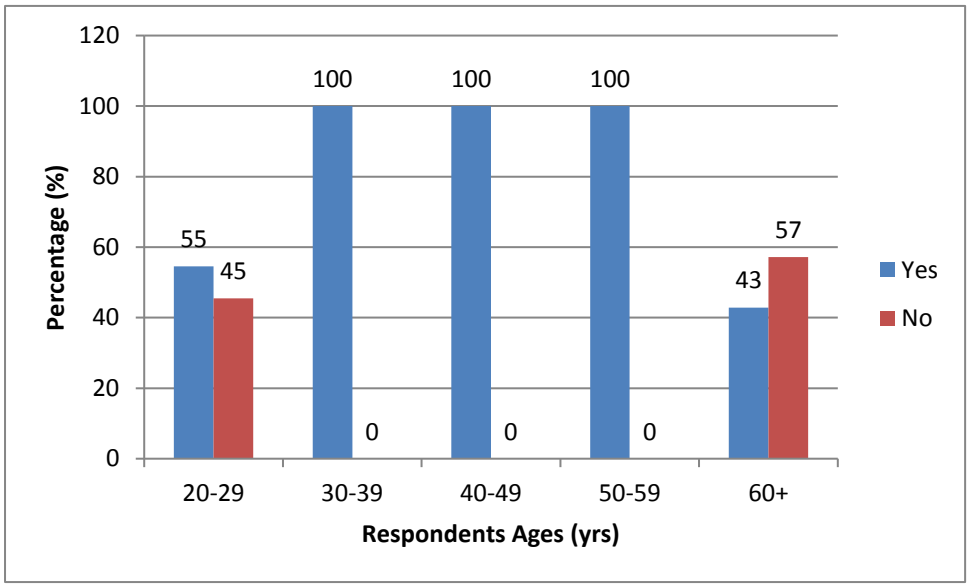

Figure 4.2 Respondents' Ages and 10% Tree Cover Policy Awareness

Majority of the respondents fell in the age bracket of 40-49 years representing 24% (n=70) of the total respondents. There was a significant representation of those aged 30-39 years 21% (n=60) which denotes a change in the socio-demographic patterns taking into account of the relatively young age of the household heads. The study observed that all the respondents aged between 30-59 years were aware of the 10% tree cover policy requirement. This brought to the fore a situation whereby most of the young respondents and those that were relatively advanced in age were not aware of the 10% tree cover policy.

4.1.3 Respondents' Gender and 10% Tree Covers Policy Awareness

Fig 4.3 shows the relationship between the respondents' gender in relation to the 10% tree cover policy Awareness level.

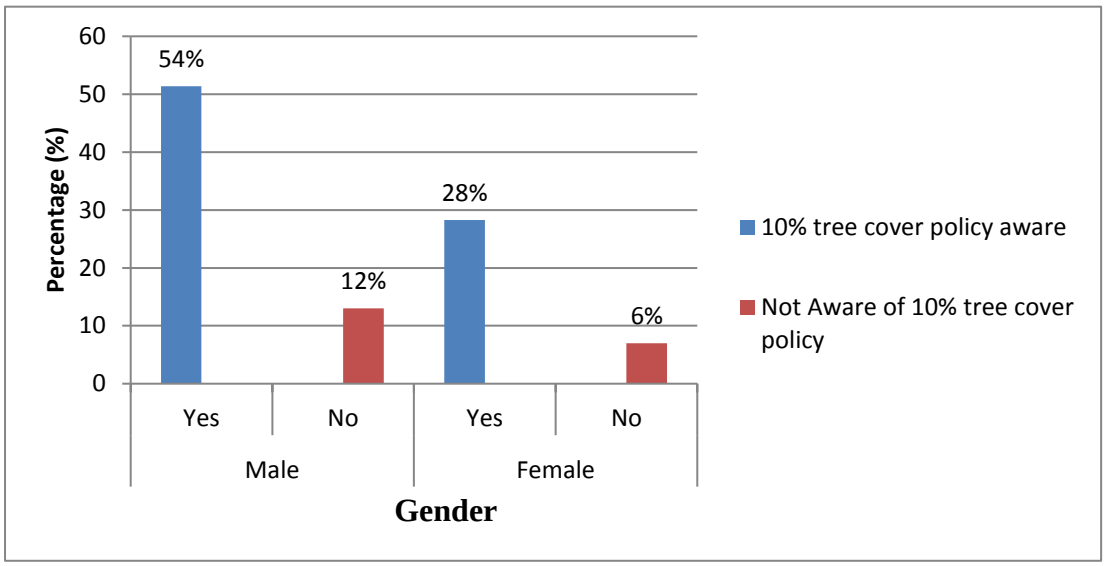

Figure 4.3 Respondents' Gender and 10% Tree Cover Policy Awareness Level

Gender orientation had a significant influence on the awareness of the 10% tree cover policy; more males 54% (n= 159) were aware of the 10% tree cover policy than females 28% (n=35). This can be attributed to the socialization and exposure of the male and female gender in the rural areas. Many members of the male gender are exposed and are keen on following up current affairs and policy issues as disseminated by government. On the other hand, members of the female gender seldom seek current affairs owing to their socialization patterns which at times confine them to their households. This limits interaction with their peers at the village level only. They are therefore shut out from many issues regarding government policy and current affairs.

4.1.4 Respondents' Education Levels and Their Occupations

Fig. 4.4 shows the relationship between the respondents' education levels and their occupations

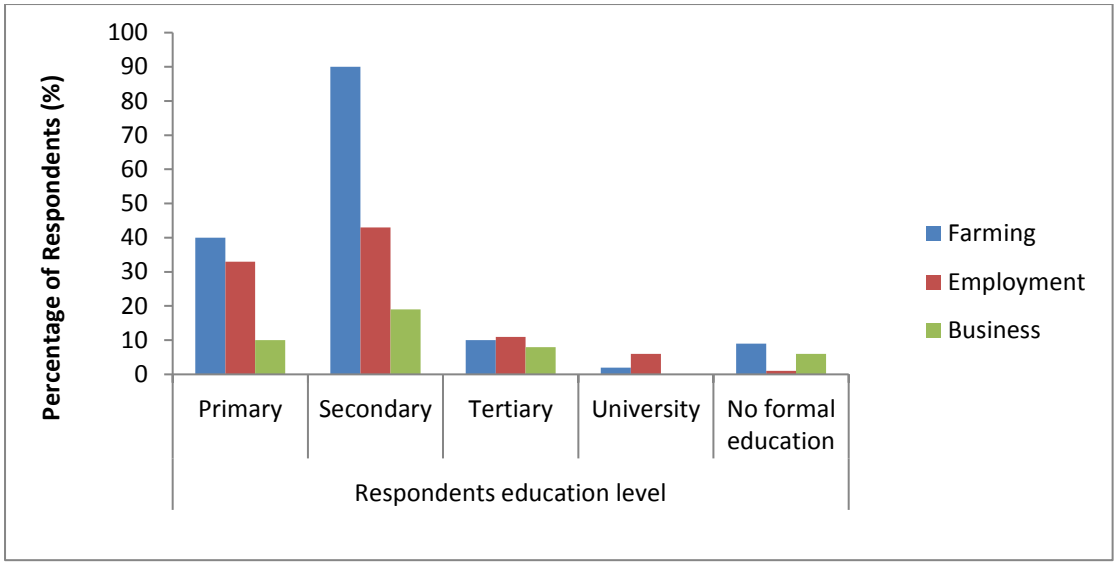

Figure 4.4 Respondents' Education Levels and their Occupations

The study established that most of the respondents 44% (n=128) with primary and secondary school education certificate holders accounting for the majority in the farming industry.

4.1.5 Respondents' Household Sizes

The study inquired into the respondent household sizes. Their responses were as captured in Table 4.1.

Table 4.1 Household Sizes

Response	Frequency	Percentage (%)
1-5 members	96	33
6-10 members	178	61
11 -15 members	16	6
Total	**290**	**100**

Varied responses were put forth on household sizes. On average, many households came out as having 6-10 members 61% (n=178) who resided in the homesteads on a daily basis. This shows that the socio-demographic patterns of the area denote relatively large households. This can be attributed to the situation of dependence on agricultural economic activities which holds labor in the rural areas.

4.1.6 Total Land Holding in Acres

The respondents were asked to indicate the total land holding in acres in their possession. Their responses were as captured in Table 4.2.

Table 4.2 Total Land Holding in Acres

Response	Frequency	Percentage (%)
Less than one acre	26	9
1 - 5 acres	243	84
6- 10 acres	12	4
11-20 acres	9	3
Total	**290**	**100**

Most of the respondents owned between one and five acres of land 84% (n=243). Only 4% had bigger parcels which ranged from six to ten acres, and partly 3% of the respondents had parcels of land more than ten acres. The holding in terms of acreage was a pointer to the situation of sustained land fragmentation which can be attributed to rapid population growth. The area can thus be identified with smallholder farming going by the relatively small portions that the farmers in the area possess. The prevailing situation has a negative bearing on the 10% tree cover policy owing to the inclination towards food production as opposed to tree planting.

4.1.7 Decision Making in Land Management

The respondents were asked to identify the person upon whom land management decisions were bestowed. The responses captured were as in Table 4.3.

Table 4.3 Decision Making in Land Management

Response	Frequency	Percentage (%)
Head of household	253	87
Any household member	37	13
Total	**290**	**100**

The respondents confirmed that in many instances 87% (n=253), decision making in the land management was the responsibility of the household head who also held the rights of land ownership. This denoted a community with patriarchal cultural ties and with leaning towards the traditional hierarchy whereby critical decisions which had a

heavy bearing on the future outlook of the household like land management were exclusive to the head of the household which is partly unfair to the women who are mainly actively involved in the daily agricultural activities.

4.1.8 Respondents' Source of Income

The various sources of income of the respondents were captured as shown in table 4.4.

Table 4.4 Main Source of Income

Response	Frequency	Percentage (%)
Farming	197	68
Employment	58	20
Business	35	12
Total	**290**	**100**

The respondents indicated that their main source of income was farming 68% (n=197). The study found out that the major farming activities which were undertaken by the respondents were Tea farming, dairy farming, and subsistence farming. This brings forth the impression that majority of the respondents were heavily reliant on farming activities to earn their daily income. It thus denotes the essence of adherence to the 10% tree cover policy by way of On-farm tree production by the members of the local community as a measure to ensure safeguards against accelerated climate change on agriculture. The study established that household sources of income compared with the trends in fuel consumption which depict fuelwood as the preferred household energy source due to its affordability.

4.1.9 Respondents' Income and Exploitation of On-Farm Trees for Fuelwood

Respondents' monthly incomes and exploitation of trees for fuelwood were as shown in fig 4.5.

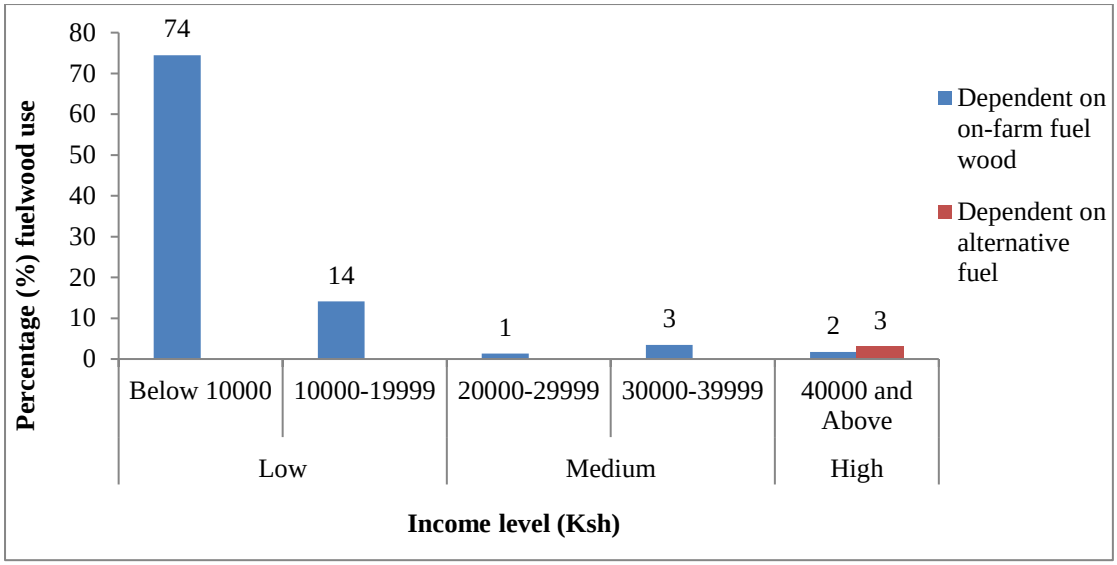

Figure 4.5 Monthly Income and use of fuelwood

The respondents' predisposition to exploitation of trees on their farms due to fuelwood demand was related to their monthly incomes. The study found out that those respondents with low-income levels tended to engage more in the exploitation of trees on their farms for use as fuel and for sales to the tea factories. The increase in income levels was aptly correlated with a reduction in the practice of exploitation of trees for fuelwood irrespective of demand. Low income households highly depending on the trees as a source of income thus the practice of depleting the forest cover on the farms for sales to earn a living. It can also be attributed to lack of purchasing power.

4.1.9 Household Fuel in relation to Farmers' Ability to Practice Agro-Forestry

Sources of household fuel were examined in relation to the capacity of individual farmers to practice agro-forestry as shown in fig 4.6.

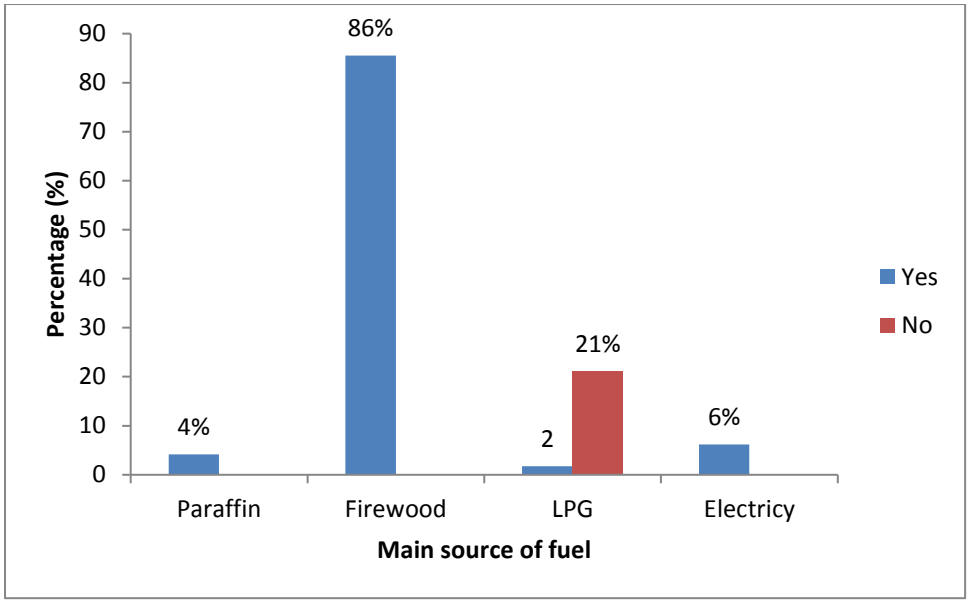

Figure 4.6 Types of Household Fuel in Relation to Farmers' Capacity to Practice Agro-Forestry

Sources of household fuel were examined in relation to the capacity of individual farmers to practice agro-forestry as shown in fig 4.6. The predominant source of fuel energy was fuelwood as confirmed by 86% (n=248) of the respondents. Electricity was also a source of fuel energy which was used by 6% (n=18) of the respondents. This was a confirmation of the rural electrification programme gaining root in the area. The practice of fuelwood consumption was sustainable. This is because all the respondents who engaged in fuelwood consumption confirmed that they engaged in agro-forestry practices. This was a pointer to their capacity to continuously replenish the used stocks from their farmlands. The small percentage of respondents using biogas shows the slow adoption of renewable energy technology by the residents of the area. It was also the testimony of their ability to maximize the available resources by way of making greater use of their livestock production units.

The agricultural extension officer equally confirmed that the most prevalent source of fuel energy for the residents of the area was firewood. Similar sentiments were shared by the chief and the sub-county environment officer. The trend of consumption of on-farm trees is similar to Njoroge, (2013), who argued that consumption of fuel derived from trees has been a factor which has challenged and exposed the forest conservation sector to enormous risk. This is attributed to the rapid degradation of the forest cover occasioned by the cutting down of trees for charcoal and firewood. The study carried

out in Kitui County established that massive tree cutting had led to the continuous degradation of the environment owing to depletion of the forest cover. The study identified felling of trees for charcoal burning as a factor which greatly accelerated the depletion of the forest cover. Tea factories were equally identified as large consumers of trees in the forested areas owing to the fact that they relied on fuelwood for drying Tea leaves. This was a significant factor which greatly hindered the achievement of the national tree cover target.

The findings equally mirrored a report by the government of Kenya which stipulated that the Kenya Forest Service should develop plantations for wood fuel and timber production as a national priority. The firewood plantations should comprise of fast-growing tree species that can cope well with the areas' environmental and ecological conditions for maximum productivity. Fuelwood plantations can be leased by the government through relevant authorities. Such lands include the trust lands, rangelands and community lands. This strategy considers integrating fuelwood into local farming systems as the agricultural sector has a key role to play in supplementing fuelwood through wood production**.** Through the development of commercial farms, fuelwood plantations can be commercialized an intervention that is supported by government policy and whose intentions are meant to increase forest cover to 10% by 2030 (The Republic of Kenya, 2007). It is also supported by legal notice no. 166 of November 2009 on an agricultural act which requires the farmers to maintain 10% of tree covers in agricultural zones. The intervention strategy however is supply oriented as the overall objective is to increase wood fuel supply from farmlands.

4.2 Fuelwood Consumption Trends

The following section captured the fuelwood consumption trends by the three tea factories**.** This was with a bias to determining the volumes of fuelwood consumed over a span of five years and how that affected the environment and on-farm tree production.

4.2.1 Fuelwood Consumption Patterns for Githambo Tea Factory

Figure 4.7 shows the trends of fuelwood consumption on an annual basis for Githambo tea factory for the period of the year 2009 – 2013. The amount of fuelwood consumed is measured in M^3.

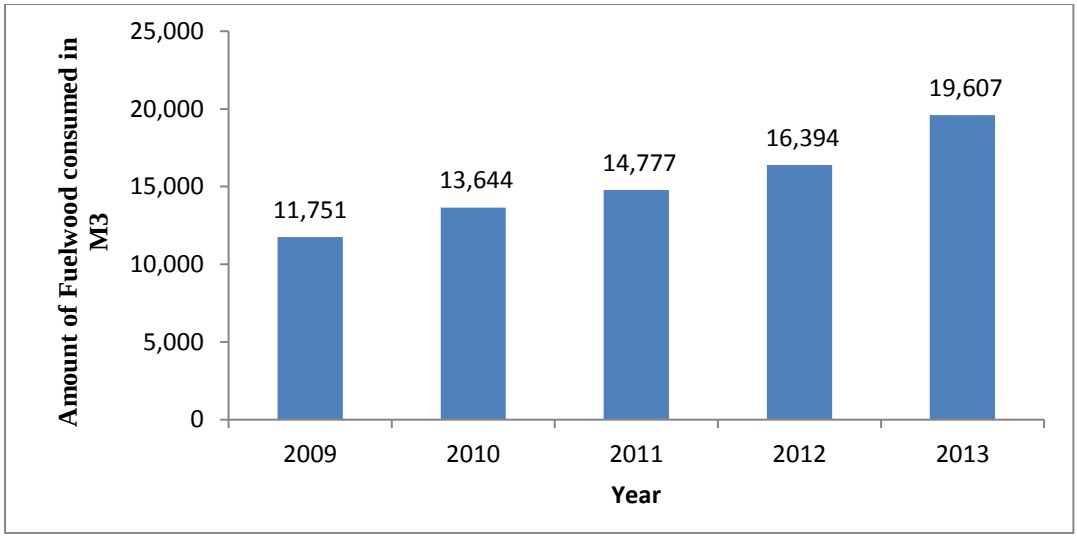

Figure 4.7 Fuelwood Consumption by Githambo Tea Factory in Five Years

The figure 4.7 shows a pattern of increased consumption between the periods of the year 2009 to 2013. In the year 2009, Githambo tea factory consumed 13,664m^3, compared to 19,607m^3 in 2013. The consumption is a reflection of an upward trend which has seen the factory consumes higher volumes of fuelwood by the year. The total consumption for the five year period is 76,173m^3. This is an enormous volume of fuelwood and reflection of many trees having been felled for the supply to be realized. The consumption trends show a variation in the monthly consumption patterns. This can be identified with the production patterns of the affected tea factories going by the monthly production trends. This was large amount of fuel and at a huge cost to the tree cover depletion rate in the catchment area serving the fuelwood requirements of the factory. Kangema sub-county was thus directly affected in terms of its tree cover percentage.

The section head confirmed that Githambo tea factory started consuming fuelwood from the year 2006. The main suppliers of the fuelwood were contracted farmers from Kiharu, Kangema and Mathioya sub-counties in Murang'a County. The factory also sourced fuelwood from Mbeere area, Embu County. The profound source of wood by the factory for fuel was the exotic type. The section head for the factory confirmed that it had storage space for purchased fuelwood and the stored fuel at the time of data collection was 900m^3. The section head confirmed that the factory had the challenge of

sourcing fuelwood in terms of seeking transport, competition by other factories, failure to have a permanent source of fuelwood.

Plate 4.1 A Lorry from Githambo Tea Factory Ferrying Fuelwood (Source: Author **May 2014)**

Plate 4.1 shows a caption of a lorry ferrying fuelwood to the factory. This was a vivid confirmation of the entrenched practice of fuelwood consumption by the aforementioned factory.

4.2.2 Fuelwood Consumption Patterns for Gatunguru Tea Factory

Figure 4.8 shows the trends of fuelwood consumption on an annual basis for Gatunguru tea factory for the period of the year 2009 – 2013. The amount of fuelwood consumed is measured in M^3.

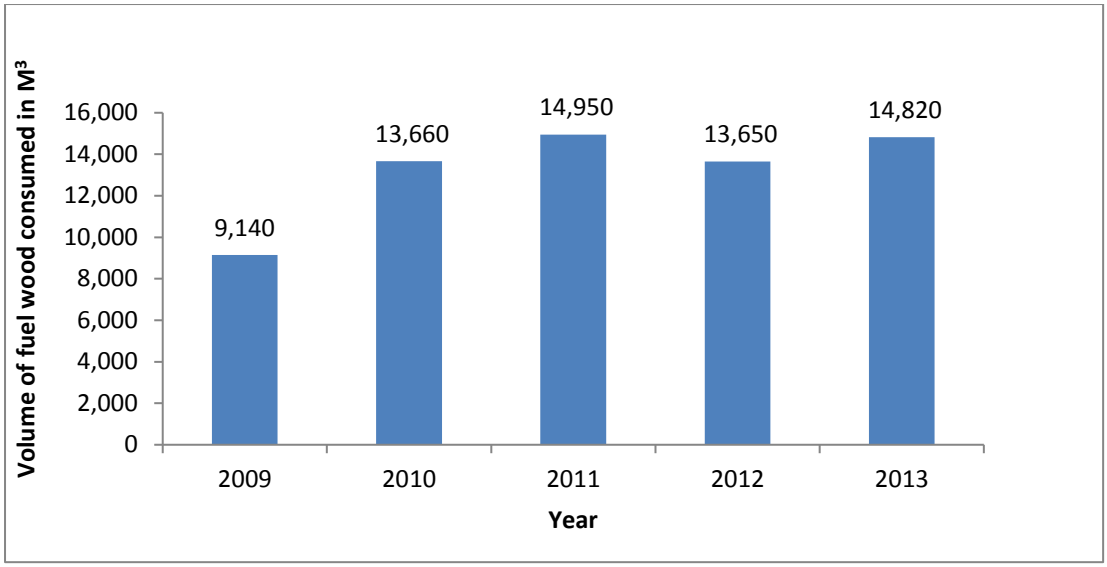

Figure 4.8 Fuelwood Consumption by Gatunguru Tea Factory in Five Years

The factory section head confirmed that the tea factory started consuming fuelwood in the year 2003. The main suppliers of the fuelwood were the farmers in the adjoining areas served by the tea factory. These were Kangema and Mathioya sub-counties in Murang'a County. The preferred choice of fuelwood was from the exotic trees. The section head confirmed the presence of a storage facility for fuelwood and during the data collection exercise the amount of stored fuelwood was 5200m^3. He was of the opinion that the challenges that the tea factory faced in the acquisition of fuelwood was competition from other tea factories attributed to high demand. The high cost of purchase and a poor road network thus increased costs of operations.

The consumption trends form the year 2009 to 2013 showed that the tea factory has been having a steady increase in the consumed wood fuel. This can be closely linked to the Tea production levels. In the year 2012, the factory had a slight decline in the consumption attributed to the low Tea production levels. In the year 2009, the factory consumed 9140m^3, 13660m^3 in the year 2010, 14,950m^3 in 2011, 13,650m^3 in 2012 and 14,820m^3 in 2013. The five year period had a total consumption of 66220m^3 of wood fuel. The drop in consumption during the year 2012 can be attributed to the drastic weather change whereby the area experienced frost leading to reduced Tea production and occasioning the farmer's losses and lesser fuelwood consumption by the tea factory.

The total fuelwood consumed by the tea factories is at 51,285M^3. Kangema sub-county is a critical area in terms of providing supply to the tea factory with its fuelwood requirements. This was thus reflective of a situation whereby the forest cover of the sub-county has been greatly affected. This may have had negative effects on the attainment of the requisite ten percent tree cover requirement for the sub-county.

Plate 4.2 A Lorry from Gatunguru Tea Factory Ferrying Fuelwood (Source: Author May 2014)

Plate 4.2 shows a caption of a lorry belonging to Gatunguru tea factory ferrying fuelwood which was confirmation of the consumption of fuelwood by the tea factory. This was an explicit pointer to the prevailing situation of fuelwood consumption by the aforementioned tea factory which has its catchment area for fuelwood supplies as Kangema sub-county.

4.2.3 Fuelwood Consumption Pattern for Kanyenya-ini Tea Factory

The trends of fuelwood consumption on an annual basis for Kanyenya-ini tea factory covering the period of the year 2009 – 2013 are as shown in figure 4.9. The amount of fuelwood consumed is measured in M^3.

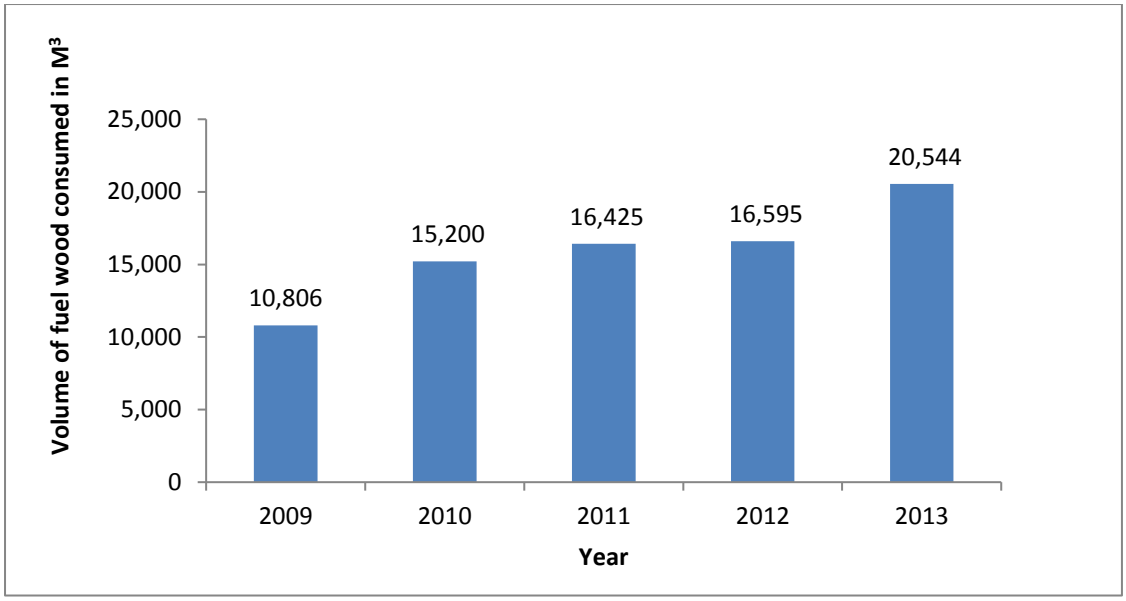

Figure 4.9 Fuelwood Consumption by Kanyenya-ini Tea Factory in Five Years

The section head of Kanyenya-ini tea factory confirmed that the institution had consumed fuelwood from the year 2006 to date for the purpose of Tea processing. The factory sourced fuelwood from Kangema, Mathioya, Kahuro and Kiharu sub-counties in Murang'a County. The highly preferred trees for the fuelwood purposes were the exotic types.

Presence of a storage facility for fuelwood was confirmed in the factory. The researcher confirmed that at the time of collecting the data the factory had 3000m^3 of stored wood fuel. The factory had the challenge of a poor road network which were impassable during the rainy seasons and which the factory relied upon for the transport of fuelwood. Demands for immediate payment on delivery by suppliers were equally a huge drawback to the factory. Shortage of trees for fuelwood exploitation equally made the source unreliable for optimum efficiency.

The study findings were in tandem with the position of KTDA (2013) which affirmed that tea factories were some of the highest fuelwood consumers known in most rural areas in the country. The study noted that there were over 50 small-scale tea factories spread across the country all of which are ran by the Kenya Tea Development Agency. According to the report 70 percent of those factories have multifunctional boilers capable of using either the furnace oil or fuelwood in curing tea leaves. Despite the multifunctionality most of the tea factories prefer using woodfuel in order to reduce

cost of tea production and raise their profits. The average cost of processing tea using furnace oil is significantly higher as compared to using the wood energy which saves up to 60% of the total cost.

The consumption trends from 2009 to 2013 reflect an upward trend. It showed that there had been an accelerated and steady increase of the volumes consumed. In the year 2009, the factory consumed 10,805.9m^3, 15,200m^3 in 2010, 16,425m^3 in 2011, 16,595m^3 in 2012 and 20,454m^3 in 2013. The total consumption by the factory for the five year period was 79,570m^3. This reflects a large consumption of trees in the wake of realizing the high demand for fuelwood. It has thus a net negative effect on the tree cover percentage of Kangema sub-county.

Plate 4.3 A Lorry from Kanyenya-ini Tea Factory Collecting Fuelwood (Source: Author May 2014)

Plate 4.3 shows a caption of a Kanyenya-ini tea factory lorry loading fuelwood to deliver to the factory for tea processing.

4.2.4 Total Consumption between 2009-2013 by the Three Tea Factories

Table 4.5 shows the total consumption of fuelwood by the three tea factories with a catchment area of Kangema sub-county for a period of five years.

Table 4.5 Total Consumption by the Three Tea Factories

Factory	Total consumption (M^3)	Percentage (%)
Githambo	76,173	37
Gatunguru	51,285	25
Kanyenya-ini	79,570	38
Total	**207,028**	**100**

The total fuelwood consumption by the three tea factories in the period of 2009-2013 was enormous with a total of 207,028 M^3 consumed. This portends a big risk to the wiping out of the forest cover and non-achievement of the required 10% tree cover. This is attributed to the fact that with increased tea production and failure to diversify the energy sources, the tea factories may totally deplete the available tree cover and expose the area to high risks of environmental degradation.

The situation in the tea factories confirms previous findings that fuelwood was relatively cheaper in terms of cost and does not need complicated devices to use it Mugo & Ong (2006). Fuelwood is widely used as energy source by urban households. For instance, in Zambia, 85% of the urban households use fuelwood as their source of energy while in Ethiopia about 70% of fuelwood production is used in urban towns by households. Similarly, in Tanzania, 80% of the fuelwood made is utilized by urban households. In Kenya, 80% of the urban households used fuelwood as a source of energy for cooking (Mugo & Ong, 2006). It is estimated that in every year about two million tonnes of fuelwood is used in Kenya (ESDA, 2005).

4.2.5 Rate of Consumption for the Three Tea Factories per Year

$$\text{Rate of consumption} = \frac{\text{Vol of fuelwood consumed } (M^3)}{\text{Time (Years)}}$$

$$\text{Rate of consumption} = \frac{207{,}028\ (M^3)}{5\ \text{years}} = 41{,}405\ M^3/\text{Year}$$

4.2.6 Study Hypothesis Testing

A correlation between the type of trees planted on farms and the preference to support continous supply of fuelwood to the tea factories was conducted and the results showed a r = -0.459 and a *p-value* of 0.000. This implies that there was a significant correlation

between the two variables and therefore most of on-farm trees has been influenced by the demand for fuelwood by tea factories among other needs. The hypothesis that the type of trees planted on farms is influenced by the factories demand was thus accepted as true as most of the farmers conformed to the factories most prefered type of fuelwood.

4.3 Effects of Fuelwood Consumption by the Tea Factories

The study sought to establish effects of fuelwood consumption by the three tea factories on the environment and on-farm tree production.

4.3.1 Effects of Cutting Down Trees on Farms

Responses on the impact of cutting down all trees in the farms were as captured in table 4.6.

Table 4.6 Impact of Cutting Down all Trees in Farms

Response	Frequency	Percentage (%)
Soil degradation	108	37
Lack of fuelwood	136	47
Accelerated desertification	46	16
Total	**290**	**100**

The respondents had varying views on the impact of cutting down all trees on their farms. They were of the view that it would lead to exposure to environmental degradation 37% (n=108) whereby the land would be left bare leading to massive soil erosion owing to the fact that the soil would not have tree roots to hold it together. They were also of the view that very strong winds would affect the area leading to wind erosion and losses in the event of destruction by wind. This is because the trees act as very good safeguards against astrong wind.

The respondents were of the view that cutting down all trees would expose them to the challenge of accessing fuel in a sustainable manner 47% (n=136). This was motivated by the fact that they rely on trees to provide them with firewood for fuel purposes and in the absence of trees to harvest firewood they would suffer immensely. This denotes

the importance that they are attached to the trees as a source of fuel. The cutting down of trees would also impoverish the respondents due to the fact that they rely on the trees as a source of income. Failure to access income from timber and fuelwood would certainly ruin the respondents economically.

Higher incidences of accelerated desertification 16% (n=46) were also brought forth by the respondents as the perceived challenges that would be occasioned by the cutting down of all trees. They were of the view that there would be reduced rainfall exposing the area to lower precipitation thus inhibiting capacity to sustain vegetation. Increased cases of frost and alternate high and cold temperatures were also some of the perceived outcomes that could come along with the cutting down of all trees. The respondents equally confirmed having had experienced the pain of frost in the year 2012 which can be related to the cutting down of trees. The frost came along with enormous losses in the Tea plantations and other agricultural activities.

The responses were reflective of the ability of the respondents to identify trees as important and effective in assuring them their economic and environmental needs. This equally brings to the fore the capacity of the respondents to attach a high premium to trees in their daily livelihoods. It was thus proof of having them informed on the importance of trees in terms of making the world a better living place.

4.3.2 Reduction of Fuelwood for Domestic Use

The responses were captured for the respondents who experienced fuelwood shortage as a result of the increased demand by tea factories as shown in table 4.7.

Table 4.7 Fuelwood Shortage

Fuelwood shortage	Frequency	Percentage (%)
Yes	170	59
No	120	41
Total	**290**	**100**

Table 4.7 shows that 59% (n=170) of the respondents experienced firewood shortage. The firewood shortage was attributed to the long periods that the trees took to mature, thus bringing about deficits in the firewood supply owing to the disparity between consumption and the maturity rates. The respondents equally attributed firewood

shortage to the prevailing weather condition in the study area. They were of the opinion that the area was predominantly wet leading to high moisture content and longer drying periods for the firewood lots. This occasions them the challenge of going for intermittent periods without firewood as they waited for it to dry.

The respondents were also of the opinion that the temptation to sell firewood to the tea factories was a handicap which exposed them to the shortage. The situation of deriving the benefits accruing from the sales and having the farmers left without firewood for use was a common scenario in the study area. The respondents admitted to having had occasion to sell and deplete all their stocks leading to a shortage in their households. This was a confirmation that the ready markets provided by the tea factories for fuelwood posed a risk of exposing the local community to firewood shortage.

Plate 4.4 Stacked Fuelwood for Use by Gatunguru Tea factory (Source: Author May, 2014)

Plate 4.4 shows stacked fuelwood ready for consumption at Gatunguru tea factory. The massive stack of fuelwood is evidence of the many trees had been felled to realize such a massive storage. The stack confirmed the environmental impact occasioned by the factory's fuelwood demand and its stark reflection of the capacity to totally dissipate the available forest cover in the wake of continued fuelwood consumption**.**

Drying of fuelwood (as shown in plate 4.4) identifies with research carried out by (Theuri, 2010) who argued that the most effective and quicker way to dry fuelwood is

achieved through spliting the wood into smaller pieces and then stacking them in piles while ensuring that air passes through them. It is also essential to ensure that the fuelwood does not get wet or damp whilst it is being stored because if it does most likely the wood will begin to rot. In order to prevent the wood from getting wet, it is important that they be stacked on a surface above the ground, under a roof while ensuring proper drainage of water. In case wood gets wet during the storage, re-drying is important before it is used in the boiler.

4.3.3 Over-Exploitation of Trees Attributed to Increased Fuelwood Demand

The responses on whether the respondent had sold fuelwood to tea factories were as shown in table 4.8.

Table 4.8 Over-Exploitation of Trees Attributed to High Fuelwood Demand

Over-exploitation of trees due to high Fuelwood demand	Frequency	Percentage (%)
Yes	188	65
No	102	35
Total	**290**	**100**

Table 4.8 shows that a significant percentage of respondents who confirmed that they had occasionally over-harvested their farm trees as a result of economic pressure which was complemented by high fuelwood demand by tea factories. They also confirmed that similar situation had applied to their neighbors. The situation of harvesting immature trees was also confirmed. This was a pointer to the situation of high demand for fuelwood by the tea factories which was not being effectively met by the local community.

This was confirmed by the chief of the study area who was of the opinion that the local farmers had not put in place effective measures to ensure that the tea factories had sustainable provision of wood fuel. He alluded this to be a factor which led to the over depletion of the available trees. The sub-county environment officer was equally of the opinion that the measures put in place by the farmers to ensure sustainable provision of fuelwood to the factories were below average. He was of the opinion that they would not effectively guarantee the tea factories access to fuelwood in a regular and sustainable manner. Similar sentiments were shared by the agricultural extension

officer about the underlying factors which led to over-exploitation of trees by the farmers selling fuelwood to the tea factories.

The practices carried out by tea factories in Kangema mirrored previous works by Barnes *et al.,* (2004) whose finding revealed that most of the energy requirements by most tea factories in the country are actually met by use of wood fuel which are a necessary source of power to the boilers. Through carbon cycle forests have a huge potential to lower carbon emissions by fuel wood but this is subject to proper management of forest. The Intergovernmental Panel on Climate Change concluded that ‘a sustainable forest management strategy is responsible forproviding guidelines for maintaining and increasing forest carbon stock.In the same spirit it is expected to balancethe sustained annual yield for timberas well as energy from the forest. This will perhaps generate the biggest sustained mitigation benefit to the country. The emissions mitigation strategy for which tea factories depends on require that the wood used to run factory boilers be supplied in a sustainable manner (Barnes *et al.,* 2004). The easiest way by which such sustainable supplies can be achieved is by tea factories increasing the size of fuelwood plantations so that they can fully supply themselves with wood requirements and equally manage those plantations in a sustainable manner.

Plate 4.5 Environmental degradation as a result of over-exploitation of on-farm Trees in Kiruri Village (Source: Author May 2014)

Plate 4.5 is reflective of the massive degradation occasioned by the over-exploited area. The cutting down of trees has devoured the formerly scenic environment and eroded its appeal and luster. It denotes the importance of maintaining the requisite tree cover

requirement as a medium of safeguarding against continued environmental degradation which may ultimately expose the community to enormous collateral damage.

The tea factory managers from the sampled factories alluded to not having an explicit programme to ensure sustainable provision of fuelwood by the local communities. They were of the opinion that the tea factories engaged the farmers on commercial agreements driven by the premise of a willing buyer and willing seller devoid of the situation in the individual farmer's portions of land. This brought to the fore the precarious situation that the farmers were put in by the tea factories with regards to having the financial motivation overriding and superseding environmental concerns at the advent of tree harvesting from the farms.

The Kenya Tea Development Agency issued out a circular to the factory unit managers on 28th April 2014 discouraging them from the use of indigenous trees for fuelwood in line with the company's policy as regards the conservation of indigenous trees. On the other hand, though, the circular brought out information about the practice of exploitation of indigenous trees for fuelwood, the practice was still prevalent. A joint audit carried out by RA-Cert and Africert established that the practice was still ongoing in many KTDA factories in contravention of the national ideals of the natural ecosystem conservation and the KTDA's own environmental policy. The circular gave out a strong warning to all the managers against the practice regardless of the fact that supplies of fuelwood to the factories were the function of contracted suppliers.

The researcher had the occasion of visiting fuelwood storage lots for the sampled tea factories. He had the opportunity of coming across fuelwood from indigenous trees. In the course of data collection, he also came across cut trees stumps of indigenous trees in farms harvested by suppliers contracted by the tea factories. This was evidence of the event of harvesting indigenous trees by the tea factories.

Plate 4.6 Evidence of Stored Fuelwood Harvested from Indigenous Species (Source: Author May 2014)

Plate 4.6 shows evidence of harvested fuelwood from *Macaranga kilimandscharica* (Kikuyu name-*Mukuhakuha*) which is an indigenous tree. This is an explicit pointer to over depletion of the existing exotic trees to a level whereby the suppliers contracted by the tea factories have no choice but to harvest the indigenous trees for fuel purposes. This is in total contravention of the policy guiding fuelwood use by the tea factories despite the regulations put in place by the Kenya Tea Development Agency.

The study findings concur with (AFREA, 2011) which found out that in Sub-Saharan Africa, about 81% of the households also depend on fuelwood for cooking .It is projected that even though biomass fuels are likely to increase in developing countries such as India and China among others, in Sub-Saharan Africa use of fuelwood is relatively higher and is expected to increase further in future.

In Kenya, 80% of the population is dependent on firewood and fuelwood for cooking and other energy needs (The Republic of Kenya, 2008). KIPPRA (2010) suggested that renewable technology is the way forward to Kenya's energy security but the energy production from renewable sources has been limited to small-scale consumption and household cooking in the country. An analysis of fuel types in Kenya by KIPPRA (2010) observed that the most popular household fuel in terms of useage presently is kerosene at 80 percent, followed by charcoal which stands at 60 percent,

fuelwood at 55 percent, electricity and LPG at thirty-one and twenty-one percent respectively.

4.3.4 Perceived Effect of Fuelwood Demand on the Environment

Responses on the impact of fuelwood demand on the environment are as shown in table 4.9.

Table 4.9 Perceived Impact of Fuelwood Demand on Environment

Impact of fuelwood demand on the environment	Frequency	Percentage (%)
Yes	244	84
No	46	16
Total	290	100

Table 4.9 shows that 84% (n=244) of the respondents appreciated the fact that fuelwood demand impacted on the environment. This depicted an enhanced level of Awareness of the impact of the vagaries associated with cutting down trees for the purpose of fuelwood on the environment. It was a pointer to the situation of the respondents having had experienced firsthand of the challenges brought forth by fuelwood demand on the environment. It also showed that the respondents had experienced the pain of watching the depletion of natural ecosystems occasioned by increased fuelwood demand.

The respondents went further to enumerate some of the effects of increased fuelwood demand on the environment which they cited as the situation of increased frost. They attributed it to the felling down of trees occasioning reduced forest cover exposing the environment to lower temperatures and chilly weather from the mountainous ranges unlike before when the trees acted as safeguards from the frost. They held the view that the felling down of trees exposed the local community to the pain of aggravated losses occasioned by strong winds undeterred by lack of windbreaks.

The respondents were of the opinion that felling of trees for fuelwood had impacted negatively on the water catchment areas. This had occasioned the lowering down of water volumes in the rivers, streams wells and springs. They were of the opinion that the situation had heavily compromised the availability of water to the local populations.

It had impacted negatively on the persons living downstream in terms of their capacities to access to natural water sources in abundance like before.

Deforestation of the formerly heavily forested areas had equally exposed the residents to incidences of increased soil erosion. The respondents attested to having had incidences of soil being washed downhill owing to impaired holding by the roots from the cut-down trees. They were of the view that the prevailing situation heavily impaired and compromised the capacity of available farmlands to be productive owing to the event of having the rich top soils eroded. This heavily reduced the productivity of the farms occasioning the community diminished returns from their production.

The cases of smoke pollution owing to the use of fuelwood for Tea processing also came out from the respondents. They were of the view that increased fuelwood use caused accelerated smoke pollution leading to the depletion of the ozone layer and increased carbon deposits in the air. This was a factor which contributed to profound global warming occasioning the larger communities the risk of suffering from the resulting ramifications. The consequences of the climate change have had an immense negative toll on the populations like the incidences of reduced rainfall, increased temperatures and similar changes in weather patterns.

The respondents' position mirrored previous works by (Barnes *et al*., 2004) who argued that increasing forest cover by area and density through afforestation, reforestation and forest restoration will increase the absorption of carbon dioxide from the atmosphere thereby increasing the carbon stock. Establishing wood plantations in areas that do not fall under forest fields is ideal. However, it is unlikely that every tea factory will become self-sufficient in terms of fuelwood needs thus effort should be put in place in order to support the local small farm holders to develop woodlots in a sustainable manner and encourage them to sell wood to their local factory.

Plate 4.7 Evidence of accelerated deforestation in Kamakwa Village (Source: Author May 2014)

The fuelwood demand by tea factories has been confirmed to accelerate the rate of deforestation thus causing a negative impact on on-farm tree growing and consequently affecting the attainment of the 10% tree cover. Plate 7 reveals the underlying risks that continued use of fuelwood by tea factories expose the local community to. Plate 4.7 clearly shows bare land exposed by virtue of the heavily depleted tree cover. It has inadvertently exposed the area to a high risk of soil erosion and allied vagaries associated with the depletion of forest cover.

4.3.5 Study Hypothesis Testing

Exploitation of on-farm trees was correlated against the approximate portion of land held by the farmers to assertain the extent of the effects of fuelwood consumption by the tea factories. A Pearson's correlation index of $r = 0.016$ and a *p-value* of 0.792 were obtained thereby meaning that the increased demand for on-farm trees by factories to facilitate tea processing had a positive correlation with the reduced tree cover on the portions of land held.

4.4 Efforts by the Tea Factories to Meet Fuelwood Demand

The study sought to find out the efforts made by the tea factories and the stakeholders in seeking strategies to meet the fuelwood demand and its effects on on-farm tree harvesting.

4.4.1 Tea Factories Efforts towards Continuous Fuelwood Supply

The section heads from the three tea factories sampled in the study were unanimous on the opinion that the demand for fuelwood for tea processing was increasing. They noted that the factories were facing serious deficits in fuelwood supply. They attested to the factories having acquired tracts of land away from the tea growing zones for tree growing to assure them of consistent fuelwood supply. The Githambo tea factory section head confirmed that the factory had purchased five hundred and twenty acres of land in Mbere, Embu County and an equal acreage in Laikipia County for tree production as a measure to ensure sustainable fuelwood provision.

The section head Kanyenya-ini tea factory confirmed that the factory had also purchased six hundred acres of land in Maragua within Murang'a county and Mbere in Embu county for tree propagation. Gatunguru tea factory had also purchased one hundred and eighty acres in Mweiga in Nyeri county and seventy acres in Mbeere for woodlots development. On the other hand though, despite purchasing land for tree propagation, the researcher found out that the approximate land size planted was below 20%.The researcher observed that the woodlots had been established far away from the Tea growing and processing zones. This equally posed the challenge of increased carbon prints accruing from the transportation of fuelwood and allied dynamics in the Tea processing exercise. They may negate the importance of the conservation measures accruing from the resulting pollution.

The tea factories have also made some feeble measures towards putting in place tree nurseries for sale to the farmers. This demotivating factor which curtailed on-farm tree production and lowered the tree replacement rates enormously owing to the element of costs shouldered by the farmers.

Plate 4.8 A tree nursery at Kanyenya-ini tea factory for providing farmers with tree seedlings (Source: Author May 2014)

The tea factories have attempted to put in place systems to assure continued afforestation programmes. Kanyenya-ini tea factory has a mundane tree nursery to provide farmers with an avenue to purchase trees seedlings for planting. The nursery has barely met the demands. The caption (plate 4.8) shows a tree nursery for Kanyenya-ini tea factory.

4.4.2 Influencing Tree Planting across Seasons

The responses on tree planting season were as captured in figure 4.10.

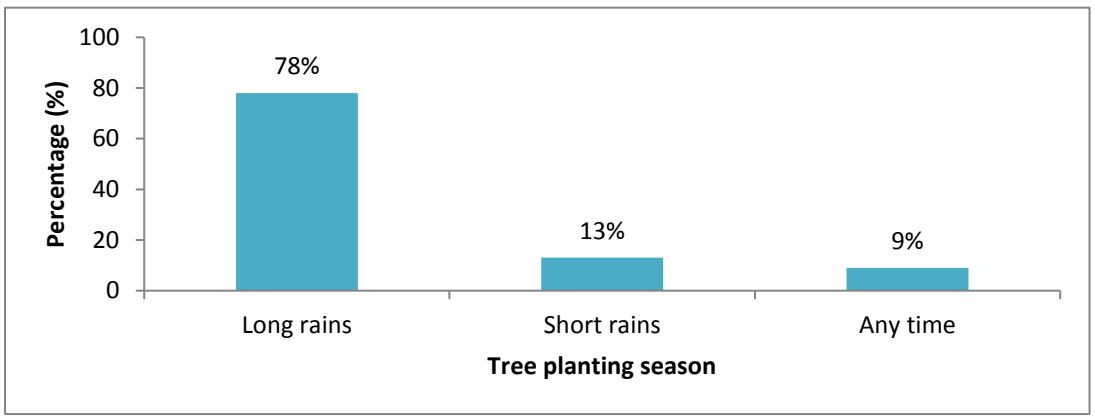

Figure 4.10 Periods for Tree Planting in Relation to Experience of Firewood Shortage

Most of the respondents claimed that they planted trees annually during the wet seasons 73% (n=212). Rainfall was, therefore, a major determinant for the sustainable propagation of tree seedlings. Farmers mainly depended on the rainfall for their tree planting activity as no irrigation was done as an agroforestry practice. Most of the respondents confirmed transplanted seedlings that germinated naturally from mature trees. Some respondents also confirmed to having had to access the tree nurseries run and managed by individuals and community-based organizations (CBOs), from where they bought tree seedlings for planting. A few farmers obtained seedlings from tree nurseries managed by the tea factories.

The study findings were similar to those of KFMP (2004) which took a position that a strategy on efficient management of rangelands and woodlands through enrichment planting and controlled harvesting of trees for charcoal, would greatly regulate the supply. The study noted that resources in areas where charcoal was produced caused depletion of tree cover and were thus unsustainable. However this can be improved through the implementation of the recently introduced charcoal regulations which ensures that both tree harvesting and charcoal production are done sustainably. Sustainable resource utilization can as well be achieved through proper management of woodlands and rangelands. Fuelwood production strategy should challenge each district to become household energy self-sufficient.

Delocalized area based wood energy planning is the most suitable in Kenya as wood energy situation and problems are site-specific and vary from one region to the other. Therefore, the implementation strategies in the decentralized wood energy plan should be site specific depending on the prevailing problems. The wood energy plans should be integrated with other decentralized planning activities at the devolved governance levels. There is a need for clear charcoal policy guidelines which would encourage investments in improved charcoal processing technologies. Charcoal production like all other farm activities should be taxed and reflected as a potential revenue earner for the government. The 2009 charcoal regulations rules which are meant to establish sustainable charcoal production, transportation and marketing need to be put into operation.

4.4.3 Introduction of Fast Maturing Tree Species

The study sought to understand the types of trees farmers planted and the reasons which motivated them to plant the particular types. The responses were captured in table 4.10.

Table 4.10 Types of Trees Planted and Reasons for Preference

Response	Frequency	Percentage (%)
The maturity period of trees	185	64
Capacity to provide fuelwood	58	20
Provision of fruits	47	16
Total	290	100

The major reason provided by most of the farmers for the choices on particular types of trees that they planted was the maturity period 64% (n=185). This made them settle on the exotic trees which they considered fast maturing in terms of the maturity periods. The motivation for fast maturing trees helped farmers to gain from sales and fuelwood.

The farmers also planted fruit trees which were providing them with fruits for nutritional value and sustenance in terms of drawing economic benefits from the sales of fruits in the local markets. This brought to the fore the essence of the economic gains derived from the types of trees planted as the motivating factor to the decision on the type of tree to plant. Few of the respondents plant indigenous trees. However, they acknowledged that the indigenous trees helped in the environmental conservation by guarding the land against soil erosion and allied challenges occasioned by environmental degradation.

The choice of trees was chiefly motivated by the maturity periods, the particular economic gains derived from the actual trees and the capacity of the trees to provide the farmers with safeguards against environmental challenges. This is in tandem with the position taken by the Kenya Forest Growers Association which has embarked on the commercial approach towards the tree growing industry (KFGA, 2014). The association has invested heavily in the propagation of private forests on individual farms. This is with the aim of realizing commercial benefits accruing from the propagation of the trees. The association has since played a pivotal role in giving the members a platform to engage the government and allied statutory bodies in the

commercial ventures which entail tree cover enhancement and an increase of tree cover. Commercial motivation was the most captivating factor for the farmers propagating trees in Kangema Sub-county.

4.4.4 Provision of Ready Fuelwood Market for the Farmers

The responses were captured for respondent had sold fuelwood to tea factories as shown in table 4.11.

Table 4.11 Selling Fuelwood to Tea Factories

Fuelwood sales to Tea factories	Frequency	Percentage (%)
Yes	196	68
No	94	32
Total	290	100

Table 4.11 shows that 68% (n=196) of the respondents had sold fuelwood to either of the three tea factories. This can be attributed to the fact that the study area has acknowledged fuelwood sales to the tea factories as a medium of revenue and this practice has been embraced by many residents of the area. This has led to the practice of massive tree harvesting for sales to the three tea factories for fuelwood.

The respondents who sold the trees had the major motivating factor influencing the sales as the need to earn an income from the fuelwood consumed by the tea factories. Some equally had the need to replace aging fields with overly too mature trees as the motivating factor for the sales made. This was a confirmation of their capacity to duly engage in the requisite standards as regards conservation of trees to their optimum maturity. The need to open up the farms for more commercial agricultural activities and replacement with young seedlings also came out from the respondents. This was a pointer to a community cognizant of the need to engage in sustainable environmental conservation activities.

The area chief confirmed that the three tea factories regularly bought fuelwood from the study area. He confirmed that the three tea factories, Kanyenya-ini, Githambo and Gatunguru bought fuelwood from the area. This was an explicit pointer to the presence of a ready market for fuelwood consumed by the tea factories. It was also reflective of a practice which had gained credence and acceptance by the community resident in the

study area. The agricultural extension officer and the sub-county environment officer shared similar sentiments. They were of the opinion that the three tea factories engaged in the purchase of fuelwood from the local farmers on the terms of mutual engagements with regards to business agreements motivated by the elements of supply and demand.

The tea factories managers of Kanyenya-ini, Gatunguru, and Githambo confirmed that their factories used fuelwood to processing tea. They also confirmed that part of their catchment area for fuelwood purchase was Kangema Sub-county. This was a confirmation of the information provided by the other respondents as regards the market for the fuelwood in the study area.

The Ministry of Agriculture (MoA, 2012), stated that tea factories in Kenya majorly used fuelwood in the tea processing activity. The consumption of fuelwood has had profound effects with regard to environmental degradation owing to the massive tree felling occasioned by the tea factories. This has had far-reaching ramifications on the expected tree cover requirement. It has had negative implications on the overall forestry industry attributed to the massive consumption of trees in the fuel generation. The need to have the tea factories adopt more robust and efficient sources of energy cannot be underscored. It may have positive implications on the overall performance of the agricultural sector driven by the reduction of climate change effects. The situation prevails in Kangema sub-county whereby the consumption of fuelwood by the tea factories is the norm.

Kenya Tea Development Agency (KTDA among other players command tea processing industries in most parts of rural areas in Kenya and have control of over 50 small-scale tea factories spread out across most districts making them the chief consumers of fuelwood. Curing of tea in more than 70% of these factories is done through use both furnace oil and firewood inside a huge boiler. In order to reduce the cost of tea production, the tea factories use wood-fired steam boilers to generate heat. Comparatively, the cost of processing tea using furnace oil is significantly higher than using the wood energy which helpsto save up to 60% in the cost of fuel (Theuri, 2010).

4.4.5 Farmers Perceptions towards Measures taken by Tea Factories

The responses on the perception of farmers about measures taken by the tea factories to ensure sustainable and continuous supply of fuelwood were as captured in table 4.12.

Table 4.12 Farmers' perceptions on the measures towards a continuous supply of fuelwood

Perceptions on measures to ensure continuous fuelwood supply by the Tea factories	Frequency	Percentage (%)
Agree strongly	21	7.2
Agree	46	15.9
Not sure	104	35.9
Disagree	84	29.0
Strongly disagree	35	12.1
Total	**290**	**100**

Table 4.12 shows that 23.1% (n=67) of respondents perceived the measures taken by tea factories as satisfactory to ensure sustainable and continuity of fuelwood supply. At the same time a significant size of the respondents 41% (n=119) perceived the measures as not satisfactory to ensure sustainability and continuity of supply. This was a pointer of failure on the part of the factory to place measures that inspire farmer's confidence in the safeguard their on-farms resources. This interpreted that the respondents were ill-equipped in terms of knowledge and awareness on the essence of undertaking personal initiatives aimed at afforestation and increasing of the tree cover percentage. It can also be linked to the situation of apathy and presence of a lackluster attitude towards environmental conservation matters by the respondents.

The respondents who confirmed to have engaged in individual activities aimed at assuring the tea factories continuous use of fuelwood attested to have partaken in tree planting activities on their farms. This was out of own volition and the activities were carried out with the aim of replacing the harvested trees from their farms. This was a safeguard against over-exploitation of the tree resource. It also ensured sustainable fuelwood consumption by virtue of guaranteeing the additional industry trees for the future.

The essence of enhanced tree cover maintenance and achievement of the required standards also came out as an activity practiced partaken by the respondents through peer mobilization. Some respondents confirmed that they actively sensitized and mobilized their fellow farmers from an individual perspective. This was a confirmation

of their passion and dedication to the cause of environmental conservation and achievement of the ten percent tree cover requirement.

Some respondents confirmed to having had invested in their own tree nurseries. Investment in tree nurseries by individuals was a reflection of the dedication and the personal resolve to ensure that afforestation is realized to the optimum. It also shows that the respondents had appreciated and embraced tree farming as an economic venture. This aptly captured the importance and value attached to tree growing and gives credence to the need for involvement of communities and individuals in the realization of the ten percent tree cover requirement by the statutory bodies charged with the responsibility.

Planting of exotic fast maturing trees came out as an activity, which some of the respondents had engaged in to assure the tea factories of sustainable acquisition of fuelwood. This was a confirmation of the capacity of the respondents to not only replace the planted trees but also get to approach fuelwood utilization and consumption from a commercial angle. This was by way of propagating specific trees which took shorter times to mature in the quest for guaranteeing tea factories access to fuelwood.

Avoidance of fuelwood consumption in the individual households also came out as a practice geared towards assuring tea factories access to wood fuel. Some respondents confirmed of having had the opportunity to use alternative sources of fuel like biogas and sold the trees to tea factories owing to the surplus generated by aging trees which would have been used as fuel. These were vivid cases of ingenuity and pro-activeness on the part of the respondents in the face of the need to make money from the trees and get access to alternative energy in their households.

The Agricultural Extension Officer confirmed that farmers had been sensitized by his office on the need to carry out individual afforestation activities geared towards ensuring enhancement of the tree cover requirement. A similar position was taken by the sub-county environment officer who was of the view that his office went out of its way to even facilitate the provision to farmers with free planting seedlings in the wake of assuring greater individual farmer participation in afforestation programmes. The area chief equally confirmed that efforts had been made to enlist farmer participation in the afforestation programmes in a big way.

The factory section heads confirmed that they had put programmes in place to enlist farmer participation by way of providing extension services to them. This was a measure employed to ensure they acquired the knowledge and skills requisite for the fruition of the ideal afforestation and tree cover requirements standards. They also confirmed that the factories had established tree nurseries which provided the local farmers with an option of where to procure seedlings from.

The tea factories section heads were also of the opinion that the acquisition of better and revamped machinery had facilitated them to be more efficient in their consumption and processing of wood fuel. The putting in place of a new boiler in Gatunguru tea factory had turned around the fortunes of the factory owing to the enhanced efficiency associated with the upgrade. This reflected the gravity of the underlying fuelwood consumption phenomena and the varying measures adopted by the tea factories to ensure efficient consumption of fuelwood.

The researcher observed that the tea factories had invested in tree nurseries for the purpose of availing the farmers with an avenue to procure seedlings for planting. On the other hand, though, they had not made efforts to have a sense of responsibility in the wake of providing farmers with free seedlings or even making follow up with the farmers who had acquired seedlings to plant in their farms on the progress of the growing trees. This was a drawback on the part of the tea factories and a factor which greatly inhibited the achievement of On-farm tree production.

The fuelwood consumption situation in Kangema is a stark contrast to that in Sri-Lanka whereby the adoption of current best practices is a critical factor in the sustained growth of a country's energy sector as cited by Kumardasa (1997). This is occasioned by the fact that in the event of capacity to assure a jurisdiction of sustainable energy provision it may forestall the need to have the exploitation of natural resources like forests for fuel provision. The country has managed to exploit by-products from an industrial production for instance; bagasse in sugar production is used providecomplementary energy for industrial activities. The use of agricultural by-products which are carbonized for generation of briquettes has also been employed. This has effectively safeguarded the country from the ravages of increased deforestation and the risk of desertification.

The situation in Kangema was equally not in line with the envisaged position of the Kenyan forests (GoK, 2013). It outlined a number of steps under which a sustainable fuelwood plantation can be developed. It requires for an establishment of reliable tree nurseries for planting tree seedlings, management of the plantation for optimal tree density and harvesting of the wood for use in a sustainable manner. According to Kenya Forestry Service, *Eucalyptus* species are recommended as a perfect source of fuelwood while it prohibits the others. However, much emphasis has since been placed on the use of *Eucalyptus* as they are not indigenous to Kenya. The regulations require that when setting up a woodlot either at the factory or at the farm level, *Eucalyptus* species are to be planted away from watercourses and more precisely they should not be planted along riparian strips.

4.4.6 Sensitizing Farmers on Tree Planting in Comparison to Harvesting

The respondents were asked to bring out their comparison to the harvesting in their respective villages. The responseswere reported in table 4.13.

Table 4.13 Rates of Tree Planting in Comparison to Harvesting

Response	Frequency	Percentage (%)
Extremely high tree harvesting rate	163	56
Number harvested not commensurate with replacement	127	44
Total	**290**	**100**

Varying responses were provided, but most of the respodents 56% (n=163) viewed the tree harvesting rates as extremely high in comparison to the planting. This was a confirmation of the fact that the harvesting and replacement rates were varied with the scales tipping in favor of harvesting. It showed that most of the respondents had seen evidence of tree harvesting going out of proportion and not in sync with the envisaged replacement levels. It was a pointer to the risk of losing out on a large percentage of tree cover and failing in the afforestation programmes. This may ultimately expose the local community to the non-realization of the requisite ten percent tree cover requirement.

The respondents were equally of the view that the numbers of trees cut were not commensurate with the numbers replaced. This exposed the community to accelerated deforestation. A significant size of the population held the view that the levels of maturity in terms of the time spans taken was not comparable to the level of cutting down trees for exploitation in varying uses. This aptly captured the thrust of the fact that the tree replacement levels were not comparable to the cutting rates. It also brought to the fore the salient risk of failure to achieve the requisite ten percent tree cover replacement owing to the low tree replacement rate in comparison to the harvesting.

This identified with sentiments shared by the sub-county environment officer, the agricultural extension officer and the area chief who were all of the opinion that the tree replacement rates were not comparable to the harvesting rates. This was a confirmation of the high risk that the consumption of trees for fuelwood and allied requirements posed to the realization of the tree cover requirement. It also showed the high risk that the wiping out of our national heritage in terms of the forest cover stood. This is a challenge which needs to be surmounted at all costs.

4.4.7 Study Hypothesis Testing

In order to test the hypothesis for the study that the efforts of the tea factories to ensure continous supply of fuelwood does not affect the attainment of the 10% tree cover policy. A correlation between the factories effort to provide farmers with quality tree seedlings and the attainment of the 10% tree cover on the farms was coducted and the result showed a r = -0.063. This implies that the factories effort have not adequately addressed the deficit as most farmers still don't have a 10% tree cover on their farms. Similarly, a correlation between the percieved increased demand for fuelwood and the attainment of the 10% tree cover on the farms was coducted and the result showed a r = 0.008. Therfore implying that the increased demand for fuelwood by the factories has effects on on-farm tree production. The hypothesis was thus rejected as being true.

4.5 Farmers awareness on environmental effects and on-farm tree production

The respondent's perceptions on the role of tea factories in the realization of afforestation policy were compared to their education levels.

The study sought to find out the respondents opinions on how the tea factories facilitated the realization of the afforestation policy in a Likert scale of five points attributes on afforestation policy were compared to the respondents' levels of education. The scales denoted the respondent's capacity to strongly agree, somehow agree, don't know, somehow disagree and strongly disagree in order from the strongest point to the weakest point.

The study findings show that all the respondents strongly agreed that the tea factories used fuelwood for processing tea leaves. This was regardless of their levels of education. This was a pointer to the fact that regardless of the academic position all the respondents acknowledged and were fully aware of the situation of fuelwood exploitation by tea factories for the processing of tea leaves in the production process. It was also an indicator of the fact that fuelwood consumption by tea factories was an event which had gained acclaim and recognition in the study area. This can be attributed to the proceeds generated by the sales from trees and allied economic factors.

The respondents with an even dispersion across their academic levels equally agreed to the fact that the tea factories purchased trees mainly from tea farmers. Most 90.3% (n=262) of the respondents took the position while a significant percentage was not aware and the others dissented. The responses could aptly be attributed to the fact that the area is predominantly a tea growing zone and the residents may have had a perception that the factories source the supplies from the area only. This may have been a great contributing factor to the response. It was also a contradiction to the prevailing position taking into account that the factories sourced trees from even outside the sub-county confines, the county and other regions which are not conducive for the growth of tea.

The study found out that most 87.2% (n=253) of the respondents took issue with the position that the three tea factories purchased trees from the farmers with many trees only. This was a reflection of high levels of incisiveness and knowledge on the part of the farmers. They must have noticed the situation of factories purchasing trees from farms which do not have many trees thus their response. The academic levels of the respondents were not an influencing factor in deducing the practices and procedures that the tea factories used in purchasing of wood from the farmers. The respondents' position was in tandem with that of the factory section heads. They were of the position

that the purchasing of trees from the farmers was based on the willing seller and willing buyer premise. This was regardless of the capacity of the farmer to have many trees on the farm or not. This was in essence, a practice which may negate the importance of the afforestation programmes by virtue of the fact that trees may be wiped out from farms at the event of haphazard harvesting and compromise the ten percent tree cover requirement on On-farm tree production.

Most of the respondents 93.8% (n=272) were of the position that fuelwood used by tea factories had reduced the tree cover in their villages. This was a reflection of the dire straits that the exploitation of fuelwood by the three tea factories had exposed the local communities. It was a reflection of them having had noticed the vivid effects of deforestation in the name of tree cover reduction in their villages. It was a pointer to the over-exploitation of trees for fuelwood and failure to undertake replacement in a timely manner. This identified with the position taken by the sub-county environment officer who held the position that use of fuelwood for Tea processing by the factories posed a real threat to the environment and could stand a risk of wiping out entire forest covers and the tree populations.

Most of the respondents 95.2% (n=276) affirmed that the reduced tree cover had had real negative effects on the environment. This was a pointer to the reality of climate change effects having had ravaged the populations. It was a reflection of the respondents having had acquired information as regards the risks posed by the reduction of tree cover and allied challenges. It was a reflection of respondents' intuition and ability to seize the moment as regards the negative effects occasioned to the environment denotes of tree cover reduction rates.

The respondents 97.9% (n=284) were of the opinion that the tea factories did not provide them with free seedlings for planting. This was a pointer to the situation of the respondents having had to purchase the seedlings as opposed to receiving free seedlings form the tea factories. This identified with the position taken by the factory section heads who confirmed that the factories had tree nurseries for selling to willing farmers. Factories should influence more farmers to agroforestry and tree seedlings commercialythereby impactinggreatly on factorscontributing to the low tree replacement rates as motivated by the cost of purchase.

Most of the respondents 77.9% (n=218) confirmed that the farmers purchased the tree seedlings from the factory at will. This was a pointer to their appreciation of the fact that tree seedlings were sold to the farmers by the tea factories. This was a confirmation that the farmers had accepted the situation of the purchasing of tree seedlings for their agro-forestry needs a significant percentage of the respondents were not aware of the purchasing procedures. This was a pointer to failure by the factories to sensitize farmers and create Awareness on the available tree nurseries for the provision of tree seedlings for the farmers.

Most of the respondents 74.1% (n=215) affirmed that the tea factories advised farmers on the afforestation policy. This was an indicator of the tea factories engaging in activities geared towards satisfying the requirements of the farmers with regard to agroforestry and tree management practices. This was a confirmation of the position taken by the factory section heads who attested to their factories having extension services for farmers geared towards enhancing the agro-forestry practices. This was a reflection of the capacity of the factories to invest in extension services with a focus on aiding the farmers and bettering their lots on the realms of tree management and agroforestry practices.

Most of the respondents 95.9% (n=278) were of the opinion that farmers should be enlightened on the afforestation policy. This was a strong reflection of the respondents' position and capacity to identify with the need to sensitize and enlighten the farmers on the afforestation policy. This shows that many respondents affirmed that farmers ought to be sensitized and trained on the afforestation policy. This was an indicator of the respondents affirming and identifying with the need to sensitize and enlighten the farmers on the afforestation policy.

The findings tally with the position taken by Olubiri (2013), who stated that the importance of trees with regard to environmental conservation is immense. The situation of having the trees felled and alienated to generate fuel for industrial activity overriding the essence of conservation has been a worrying trend nationally. Instances of industrial concerns failing to take the initiative and exploit alternatives in the quest to generate energy have been the undoing of the Kenyan industrial sector. Despite the incentives that exist in the private and public sectors as regards rewards with carbon credits and allied provisions, the energy sector in Kenya is still heavily dependent on

wood fuel. This has had a massive drawback to the country's economic mainstay in the field of energy generation. It has negatively impacted on the economic performance on the frontiers of the energy sector.

4.5.1 Approximate portion of land with trees and on-farm tree production

The study learned that most of the respondents 63% (n=201) had a total land possession less than five acres. This attributed to heavy land fragmentation occasioned by the rapid population growth. This can be attributed to the heavy land fragmentation occasioned by the rapid population growth. This led to most of the respondents to heavily exploit the available parcels to a situation whereby they had very little space left to put under trees owing to the fact that they depended on them for their mixed farming exercises which supported livestock, subsistence and cash crop farming. The study area is a tea growing zone and the parcels have tea bushes on virtually every available space thus heavily limiting the respondents in terms of having the capacity to allocate portions for tree planting.

The study equally deduced that many of the smallholders had tried to achieve the 10% tree cover requirement for their farms but most of the respondents with large parcels of land had not achieved the same. A significant number of respondents held the opinion that they had failed to undertake on-farm tree production due to lack of tree seedlings for planting on their farms. This denotes the fact that availability of tree seedlings for planting can heavily compromise the farmers' capacity to carry out on-farm tree production.

The area chief was of the opinion that most of the residents in the location did not undertake on-farm tree production. He attributed low rates of tree planting to laxity on the part of the residents and over-exploitation of trees for fuelwood and allied timber products. The agricultural extension officer was of the opinion that the farmer's replacement rate of the harvested trees was very low leading to failure to achieve the 10% tree cover requirement. She held the view that the maturity period of the planted trees could not be compared to the harvesting rate. This lead to failure in attaining the requisite tree covers in the area. The sub-county environment officer was of the view that his office had strived to sensitize the farmers on the need to maintain the requisite tree cover requirement on the individual holdings. This had affected the farmer's abilities to achieve the requisite tree cover.

Regardless of the position taken by the sub-county environment officer, the researcher found out that the respondents' capacity and the membership of the local community to carry out on-farm tree production was seriously wanting. This calls for active sensitization on the part of the agricultural extension officers and the environment officers to assure the community capacity to achieve the requisite tree cover.

4.5.2 Responsibility for Decision on When to Harvest Trees

Responses on the persons responsible for the decision on when to harvest trees were captured in table 4.14.

Table 4.14 Decision on When to Harvest Trees

Response	Frequency	Percentage (%)
Household head	261	90
Eldest child	29	10
Total	**290**	**100**

Most of the respondents 90% (n=261) were of the opinion that the decision on when to harvest trees was made by the head of the household. In some cases though, the respondents affirmed that the decisions were made by persons with a position of responsibility in the household, for example, the eldest child in the absence of the head. The respondents went further to state the reasons which motivated the decision to harvest trees. They were of the opinion that demand for fuelwood was a chief factor in the households which led to tree harvesting.They also considered the need for drawing an income from the fuelwood sales as a factor which motivated tree harvesting. They were of the opinion that in the event of harvesting periods by tea factories they found themselves felling trees not to miss out on the income generated by scale to the factories. The maturity of the trees also determined the need for harvesting so as to create room for planting new trees. The inclination towards having the heads of the households and persons holding positions of responsibility in the households deciding on when to harvest trees denotes the premium attached to the trees on the respondents' farms. The relatively valid reasons which equally went along with the tree harvesting equally was evidence of monetary value that the households attached to the trees. This was a positive element as regards to the local communities identifying with the afforestation policy and the need to maintain the 10% tree cover.

4.5.3 Responsibility for Planting Trees

Respondents were asked to identify the household member responsible for planting trees in the farm. The responses were as shown in table 4.15.

Table 4.15 Responsibility for Tree Planting

Response	Frequency	Percentage (%)
Household head	232	80
Any member of the family	30	11
Employees	28	9
Total	**290**	**100**

The respondents were asked to state the person who was responsible for planting trees on their farms. Most of the respondents 80% (n=232) were of the opinion that the household heads who were also the landowners had the responsibility of planting trees on their farm holdings. This can be interpreted to mean that the tree planting exercise was a task which was very close to the hearts of the landowners and they were charged with the responsibility of deciding where and when to plant particular trees and probably even their future use. This may be good with regard to decision making and management of the farms. On the other hand, it may be disadvantageous to the practice of tree planting on farmlands in the area. This is occasioned by the fact that the household members and the employees engaged by the landowners did not have explicit capacity and authority to engage in tree planting out of their own volition. This may be a factor inhibiting the forest cover increase, and it may greatly limit the On-farm tree production.

4.5.4 Importance of On-Farms Trees

Responses on theimportance of trees in farms were as captured in table 4.16.

Table 4.16 Importance of Trees on the Farms

Response	Frequency	Percentage (%)
Fuelwood, timber& Aesthetics	241	83
Fencing and demarcation	30	10
Landslide control	19	7
Total	**290**	**100**

The respondents had varying views on the importance of the trees that they planted on their farms. Most of them 83% (n=241), were of the opinion that they relied on the trees to provide them with firewood for their households' fuel needs. This denotes the importance and the attachment it is they have for the trees with regard to having them assured of fuelwood provision. The respondents equally had high regard for the trees as a source of income in the event of exploiting timber and fuelwood for sales to the tea factories. This brought to the fore the importance of trees in the local community with regard to income generation and daily sustenance assurance. The need to provide aesthetic value to their homesteads and farms also came out as a factor which made the local community view trees with high regard. The respondents attested to having the trees beautifying their farms and homesteads and providing them with shade during sunny periods.

The provision for fencing and demarcation of plots of land also came out as an attribute which many of the local respondents identified the trees with. This was attributed to the fact that they had trees planted on the boundaries of their farms and they provided a live fence which acted as a clear demarcation between the different parcels. Many respondents equally identified the importance of the trees with regard to safeguarding the environment.

They identified the trees as having the capacity to check and control landslides taking into account that the study area is very hilly and prone to the challenge of landslides during rainy periods. The capacity of the trees to assure the residents of safeguards from frosts is also one of the factors that came out during data collection exercise. This was a pointer to them identifying and meriting the trees with the ability to assure them greater comfort in their day to day lives regardless of the vagaries of environmental and climate change.

The respondent's position identified with that of the Intergovernmental Panel on Climate Change which states that climate change impacts can be reduced, delayed or avoided through mitigation while upholding recommendations that long term investment in the 20 to 30 years will have a large impact. The delayedaction, however, increases the risk of more severe climate change IPCC (2007). Chiefly among the mitigation measures is ensuring that trees are conserved and effectively planted to act as carbon sinks and check the effects of accelerated climate change.

Households are the most basic units in fuelwood energy consumption with an estimated consumption of 6.5 tonnes per household annually (Mugo, 2001). The second highest consumer of wood fuel is the cottage industries that incorporate the brick making, jaggaries, tobacco industries, and bakers. Others users include restaurants/hotels and learning institutions where cooking is done by use of fuelwood. On average, most of the cottage industries energy consumption account for 20-30% of the total operating costs and which is mainly from wood (MoE, 2002).

4.5.5 Availability of Extension Services

The responses on the availability of extension services are as captured in table 4.17.

Table 4.17 Point of Access to Extension Services

Point of Access	Frequency	Percentage (%)
Farm	23	8
Seminar	38	13
Field day	74	26
Media	155	53
Total	290	100

Table 4.17 shows that 53% (n=155) of the respondents interacted with agricultural extension services on tree growing and management through the media. This was reflective of the agricultural extension service providers and the marketers of agricultural products seizing the opportunity and identifying the media as a good forum for the dissemination of information on agricultural extension programmes. This can be deduced from the large number of respondents 53% (n=155) who affirmed of having benefitted from the media programmes. Conducting field days to provide agricultural extension services was equally confirmed by 26% (n=74) and came out as a forum which was exploited by the extension service providers. This showed that the farmers identified and appreciated for an interaction facilitated for experiential and demonstration purposes. This may be a factor which greatly endeared them to the field days for agricultural extension services.

Seminars were also a medium which was appreciated by 13% (n=38) of the respondents. This is going by the responses which showed that they dedicated and made

time to attend the training forums away from their abodes. This was a pointer to their capacity to identify with the information which was disseminated to them in the seminars. The practice of extension officers visiting the respondents on the individual farms was limited. Only 8% of the respondents had taken the initiative to visits agricultural extension officers in the area. It was thus a pointer for the need to scale up the agricultural on-farm extension visits to farmers in the wake of realizing better production.

4.5.6 Utilization of Extension Services on Tree Growing and Management

Responses on Access to extension services on tree growing and management in relation to agroforestry practices by respondents were as shown in figure 4.11.

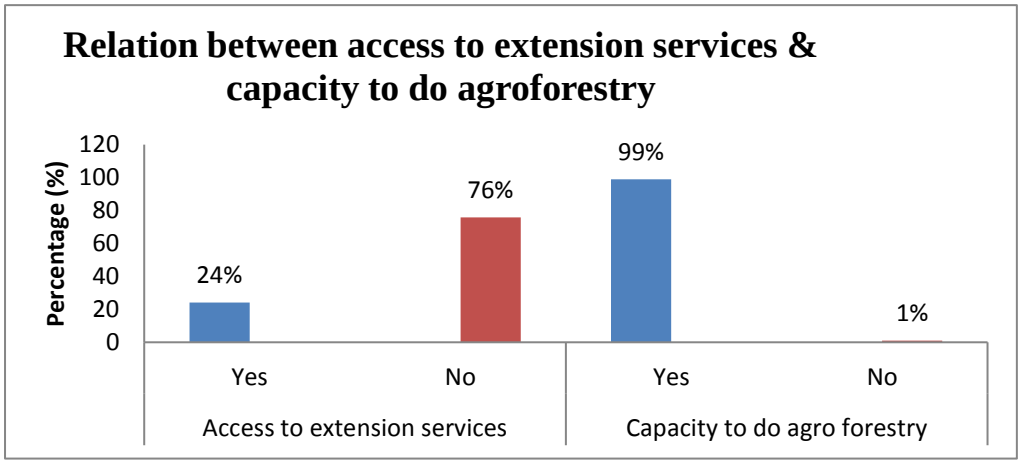

Figure 4.11 Access to Extension Services in Relation to Agro-Forestry Practices

Figure 4.11 shows that most of the respondents 76% (n=220) could not access extension services on tree growing and management. This denotes the low capacity by the offices charged with the mandate of providing extension services to the farmers in the communities. On the other hand though, despite the challenge of failure to access extension services on tree growing and management, the respondents were able to practice agro-forestry. This was a pointer to the passion and dedication that the local community had towards tree growing and management in the parcels that they undertook crop and animal husbandry. It also showed that the respondents were aware of the advantages of atree growing. Thus they did not have to wait for the government officers to push them into doing it. It also shows that the local community had a high tree growing ability which was not exploited in the area of agro-forestry. This is going

by the fact that even without access to extension services, the practice was still profound. It thus shows that in the event of realization of the expected standards with regard to offering extension services by the government officers, the prevailing levels of agroforestry practicing would be exceeded by far.

On the other hand, the agricultural extension officer was of the view that his office did its best in reaching out to farmers and offering extension services. She was of the view that the farmers were educated and imparted with the requisite skills to grow trees on farmlands. The sub-county environment officer shared a similar opinion with the agricultural extension officer. The researcher deduced a disparity on the positions taken by the agricultural extension officer and the sub-county environment officer going by the overwhelming response by the respondents who were of the opinion that they were not reached in the provision of extension services on tree growing and management. This calls for more effective supervision and regulation of the field officers charged with the responsibility of providing farmers with training so as to ensure that they don't abdicate their responsibilities.

4.5.7 Respondents' Understanding of the Fuelwood Situation

The respondents were asked to give their recommendations with reference to fuelwood demand by tea factories. Varying recommendations were made by the respondents. They included the provision of seedlings at a subsidized price by the tea factories to ensure that tree growing and production is at the optimum. This would encourage farmers to grow more trees and assure the tea factories of the enhanced provision of fuelwood from the harvested trees without compromising on the requisite tree cover requirement.

The respondents equally proposed that the tea factories should provide farmers with fast maturing tree varieties for planting. This is with a view of having the trees maturing fast and getting to compensate for those cut down to provide wood fuel. The respondents believed that this would serve as a solution and provide a cushion in the event of the risk of heavy harvesting of the trees for wood fuel.

Some of the 78.4% (n=227) respondents were however totally against the use of fuelwood for energy requirements. They were of the opinion that the factories should seek to find out sound cheaper energy alternatives which do not pose a risk to the

erosion of the requisite tree cover requirement. They believed that this would act as a good measure to ensure that all the energy requirements for Tea processing are met without compromising on the afforestation requirements. They were of the opinion that the seeking out of energy alternatives would guarantee the trees on farmer's portions of land safety as demand for fuelwood would naturally go down leading to the event of greater conservation. This would in turn positively impact on the ten percent tree cover requirement and guarantee the community a rich heritage in terms of the available forested areas and translate into good tidings in terms of the positive environmental effects.

The sub-county environment officer shared similar sentiments; he was of the opinion that continued use of fuelwood would translate into negative effects for the environment. He was of the view that alternatives should be sought in the wake of processing tea by the factories to check the tide of environmental degradation and protect the trees. He proposed that tea factories should cut down on the fuelwood and use hydroelectric power and maybe revert back to furnace oil as a source of energy for the Tea processing. He argued that this would ensure that the energy requirements were met without exposing the forests to any risks of loss and the potential for decreased tree cover would be effectively mitigated against.

This identified with the position taken by Ngunjiri (2013) who argued that Kenya has had initiatives inclined towards assuring the sustainable country development of its energy sector and increasing fuel demands. Investment in geothermal energy exploration has been a focal point for the Republic of Kenya. Seeking out alternatives like the solar energy and wind fuel for industrial and allied purposes has equally helped spur innovation and creativity in the energy sector. This may portend good tidings to the country's economy especially so to the realms of environmental conservation and management.

The area chiefs believed that the solution lay in the regulation of tree cutting. They were of the view that the tea factories should not buy trees from farmers who did not have a surplus on their farms. They too held a view that the practice would ensure sustained interaction between the farmers and the factories and see to it that the tree cover requirements are met. They argued that constant monitoring of the tree growth rates and levels would assure the factories ability to gauge when the harvesting is going

overboard and bring along the need to regulate and stem the tide. This would positively impact on the ten percent tree cover requirement owing to enhanced capacity to regulate individual farmers.

The agricultural extension officers were of the view that factories should diversify their energy sources and put in place mechanisms for increasing their replacement rates. They also proposed that factories should buy land and plant their trees to ensure sustainability of fuelwood provision and if possible the land be within the locality. The factory section heads equally had varying recommendations on the alternatives which can be used to process tea leaves as a measure geared to safeguard trees from extinction. The Kanyenya-ini tea factory section head was of the view that the factory should innovate and put in place the measures to use coal or hydro-power for tea processing. This would greatly check the practice of using firewood for tea processing and assure the attainment of the requisite ten percent tree cover requirement.

The section head of Gatunguru tea factory was of the view that the tea factories should ensure no more use of the eucalyptus trees as a source of fuelwood. He was also of the view that factories should purchase large tracts of land to plant trees for their own consumption as a measure to ensure adequate fuelwood supply.

The Githambo tea factory section head equally had ingenious propositions. He was of the view that the factory should seek to access alternative energy sources like briquettes and hydropower. He was also of the view that the factory should change the boilers to configure them to accommodate solar energy. He expressed concerns that technological revolution would greatly impact positively on the capacity to have the Tea processed with clean and renewable energy. The change would equally forestall the practices of fuelwood consumption, bringing along a decrease in demand and ensure that the ten percent tree cover requirement is achieved.

This is unlike India where the use of residues from rice production to ensure optimum tea processing in the industrial setting has been key to assuring the country sound protection of the existing forest cover Piyasekara (1993). It has seen to it that the cover is safeguarded and not exposed to the risk of depletion in the industrial processing activities. The varying opinions and recommendations brought forth by the respondents were a reflection of their capacity to understand the gravity of the situation of fuelwood

consumption in the tree cover requirement. It was also a pointer to informed respondents who had varying opinions of how best to handle the prevailing situation and the risks posed by the continued exploitation of trees as a source of fuel.

4.5.8 Study Hypothesis Testing

The farmers' levels of awareness on the need for on-farm tree production by the farmers and how they fared in attaining the 10% tree cover policy on their farms was studied by correlating the two. The result showed an $r = -0.176$ at a *p-value* of 0.003. The situation interpreted that farmer's awareness on the need for on-farm tree production was significantly high and therefore the null hypothesis was rejected as true.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

The fuelwood consumption for Githambo tea factory for the period of between years 2009 to 2013 reflected a total consumption of 76,173m^3. The same period of the year 2009 to 2013 saw Gatunguru tea factory have a total consumption of 66,220m^3 of wood fuel. Kanyenyaini tea factory equally had a total consumption by the factory for the five year period was 79,570m^3. The study found that for the five year period under review, there was a continuous increase in volumes of fuelwood consumed cutting across all the three tea factories. All the factories consumed enormous volumes of fuelwood. This reflects a large consumption of trees in the wake of realizing the high demand for fuelwood.

Cutting down on-farm trees for sale to tea factories is a common practice in Kangema and has accelerated environmental degradation, exposed farms to adverse climatic effects. Farmers continue to suffer shortage of fuelwood resources due to increased demand for fuelwood by the tea factories in the area.

The study found out that the farmers appreciated the fact that tea factories consumed fuelwood for their energy requirements. The study established that only 23% of the farmers had taken individual measures to ensure continued fuelwood consumption by tea factories by way of sustained tree replacement by on-farm cultivation. The researcher found out that all the tea factories had made an attempt for woodlots establishment but in areas which were far away from the factories. The woodlots had not matured as yet.

The study found out that the farmers were aware of the need to conserve trees and the significance of on-farm tree production. To the contrary majority were not even aware of the policy regulating tree cover. The study found out that 84% of the respondents viewed the harvesting of fuelwood for tea factory energy needs as having had negative implications on the environment. The responses also showed that 52% of the respondents did not support fuelwood consumption by tea factories as a

medium for energy provision. Most of the respondents called for the need to engage in continuous afforestation programmes for sustainable fuelwood provision.

5.2 Conclusions of the Study

The study drew the following conclusions:-

The volume of fuelwood consumed by the tea factories were equally enormous and portends a large risk to the realization of the requisite ten percent tree cover requirement. The study concluded that the fuelwood consumption rates by the three tea factories sourcing fuelwood from Kangema Sub-county and other neighboring sub-counties was high at 41000m^3 per annum which would cause negative implications on the environment in the long run. The fuelwood consumption trends by the three tea factories suggest a negative effect on the realization of the 10% percent tree cover requirement by the individual farmers. This casts the factories in a bad light with regard to their contribution in the non-realization of the requisite tree cover requirements.

Cutting down on-farm trees for sale to tea factories in the area has resulted to accelerated environmental degradation, increased climatic effects like desertification and reduced consumption of CO_2 in the air. The increased demand for fuelwood from local farmers by the tea factories has seen the farmers run short of fuelwood resources across the region.

The three tea factories sourcing fuelwood resources in the area were identified with a number of strategies and efforts aimed at maintaining a sustainable supply of fuelwood amid many challenges. The study had noted that a small fraction of farmers had benefited from the factories seedlings which were aimed at boosting fuelwood supply to the factory. Few farmers had benefited from free agricultural awareness regarding afforestation and the need for the best quality and early maturing on-farm trees. The study thus concluded that the efforts made by the tea factories and other stakeholders had not realized the envisaged results.

Although most farmers were highly aware of the importance of on-farm trees and the significance of the of on-farm tree production, farmers were not compliant of the government requirement for the 10% tree cover. However, the ever decreasing size of household land holding and the need to diversify to cope up with the dynamic

economics of on-farm needs is a serious challenge to the realization of the 10% tree cover on the farms. Most of the farmers were also fairly aware that fuelwood demand by tea factories had a negative effect on the environment. The study thus concluded that the farmers perceived the fuelwood demand by tea factories as having negatively impacted on the environment.

5.3 Recommendations of the Study

The study had the following recommendations:-

1) The tea factories should be regulated and forced by way of the statute to diversify on their energy sources. This will force them to move away from the consumption of fuelwood and have them get alternatives which will assure the trees reduced alienation and falling for energy requirements. This may impact positively on the increase of the tree cover and impact positively on the environment. Statutory provisions should also be made to ensure use of solar energy by the tea factories as a source of fuel to safeguard the forests and reduce the operational costs. Sensitization on use of the byproducts accruing from the Tea processing should be done as a measure of costs reduction by tea factories. They should seek to have the fluff carbonized and manufacture briquettes for fuel needs of the factories.

2) Tea factories should constitute measures to diversify their sources of energy for them to ease the accelerated environmental effects such as worsening climatic conditions, environmental effects such as soil erosion and desertification that reduce the areas viability. Tea factories should also focus on enlightening locals on possible ways of diversifying the domestic options for sources of energy besides fuelwood so as to increase the tree cover.

3) The tea factories should equally be forced by the county governments to plant trees as a replacement measure in the harvested areas. This will ensure that they have an obligation to restock the harvested areas. This would positively impact on the tree replacement measures by both the factories and individuals. The factories should equally partake in greater afforestation programmes by way of freely giving out tree seedlings to farmers. This may positively impact on the afforestation levels and encourage the increasing of the tree cover to optimum levels. Initiatives geared towards training farmers on agroforestry and tree management practices should

equally be undertaken with a focus on ensuring the need for tree planting, replacement of cut trees and conservation of available trees. This may positively impact on the realization of the ten percent tree cover requirement and lead to greater environmental benefits to the community at large.

4) Sensitization by the statutory environmental organs on the need for on-farm tree productions that are aimed at attaining the requisite ten percent tree cover. This may require farmers to plant more trees and conserve those in their individual farms with greater zeal and passion. It may highly and positively impact on the realization of the ten percent tree cover requirement on individual holdings.

5.4 Suggestion for further study

1. A similar study with a bigger scope should be carried out in Murang'a County. This is with a view of finding out if the circumstances in Kangema sub-county apply to Mathioya, Gatanga, Kigumo,and parts of Kiharu sub-county in Murang'a County where Tea growing and processing is the main economic activity.

2. A study should be carried out on the role of the National Environment Management Agency on the achievement of the ten percent tree cover requirement.

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APPENDICES

Appendix I: Introduction Letter

Samson Githinji Kahare
P. O. Box 294- 10202
Kangema

Dear Respondents

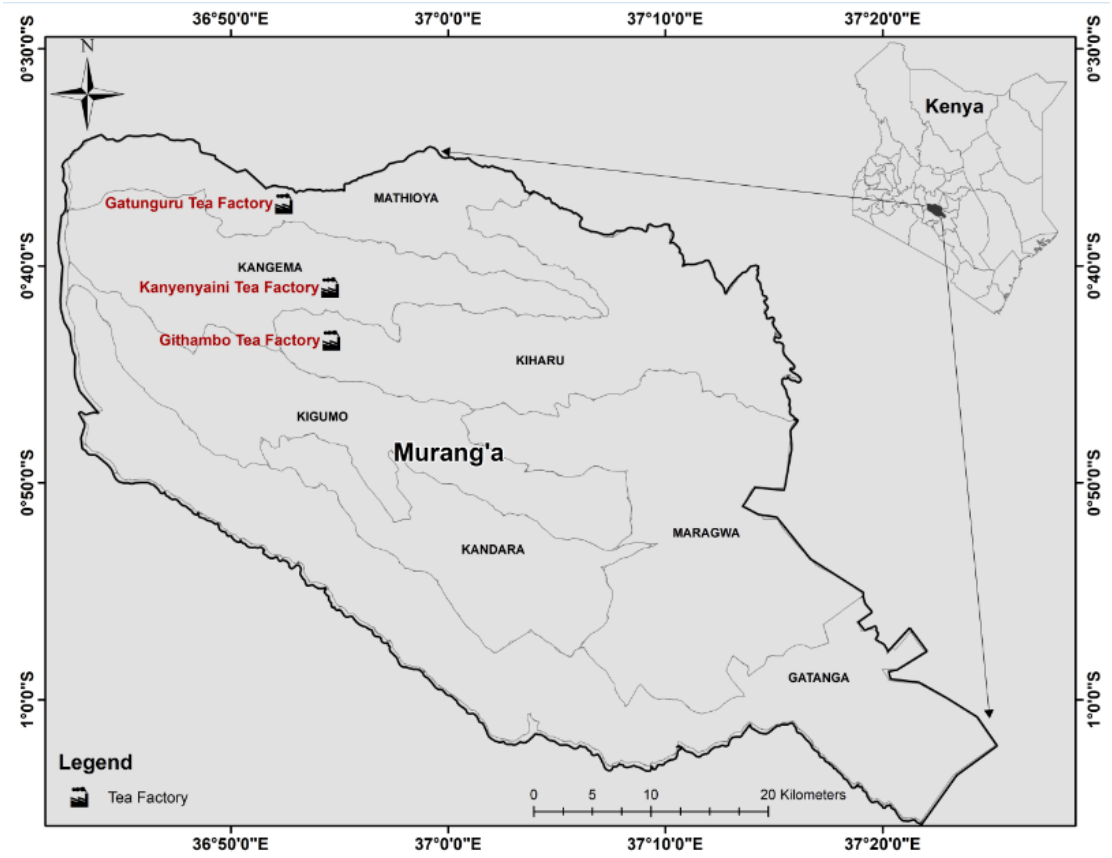
I am a post graduate student at Kenyatta University, School of Environmental Studies. I am undertaking a research on Impact of Fuelwood Demand by Three Tea Factories on On-farm tree Production in Murang'a County Kenya. Kindly assist by filling in questionnaires to the best of your ability. Your cooperation will be highly appreciated and your identity will be treated with utmost confidentiality.

Thanking you in advance

Yours faithfully,

Samson Githinji Kahare

Appendix II: Study Area Map in Murang'a County



Appendix III: Interview Schedule for Household Head

This interview schedule is intended to collect information on impacts of fuelwood demand on on-farm tree production and environment in Kangema Sub-county for academic purposes only.

Kindly give sincere responses

Section A: Background Information

1) What is the name of your village?
2) Are you originally from this village? Yes ☐ No ☐
3) What is your age (Years) 20-29 [ ] 30-39 [ ] 4049 [ ] 50-59 [ ] 60 and Above [ ]
4) House Hold gender Male [ ] Female [ ]
5) What is your Education Level? (a) Primary [ ] (b) Secondary [ ](c) Tertiary [ ] (d) University [ ] (e) None [ ]
6) What is your household size? ……
7) What is your total land holding? ……
8) Who makes decision on the land management? …….
9) What is your principal occupation? ……
10) What is your main source of fuel? (a) Paraffin [ ] (b) Firewood [ ] (c) Liquid petroleum gas (LPG) [ ] (d) Electricity [ ] (e) Others [ ]

Section B: Fuelwood Demand

11) Do you practice Agro-forestry in your farm? (a) Yes [ ] (b) No [ ] If yes, which tree species? ……
12) For what purpose did you plant the trees? (a) Fuel [ ] (b) Fodder [ ] (c) Windbreak [ ] (d) fruits [ ] (e) Commercial [ ] (f) Others [ ] (Specify) ……
13) Do you experience firewood shortage? Yes [ ] No [ ] If yes, give reasons

    ……

    ……

14) Have you ever sold fuelwood to any tea factory? Yes [ ] No [ ] If yes, what was the reason? (a) Commercial [ ] (b) Thinning [ ] (c) Government policy [ ] (d) Others [ ] (Specify)…….

15) Has the fuelwood consumption by tea factories led to over harvesting of trees in your farm?

Yes [ ] No [ ]

16) Do you think the fuelwood demand has impacts on the environment? Yes [ ] No [ ] If yes, give examples of the impacts……

……

17) Do you support the continued use of fuelwood by Tea factories? Yes [ ] No [ ] If No, Why?.....

18) What is your feeling towards the fuelwood use by Tea factories?.....

……

19) What would you comment on the rate of harvesting trees for fuelwood and the rate of planting trees?……

Section B: Role of Tea Factories In 10% Tree Cover Policy

Kindly use the options below to respond to the following statements according to your level of agreement or disagreement.

A - Strongly Agree B - Somehow Agree C - Don't Know

D - Somehow Disagree E - Strongly Disagree.

20) Tea factories have been using fuelwood in processing Tea leaves……..

21) Tea factories purchase fuelwood from farmers.....

22) Tea factories purchase fuelwood from those farms with many trees only….....

23) Farmers are given free tree seedlings by the Tea factories to plant.....

24) Farmers purchase tree seedlings from Tea factories at will….....

25) Tea factories advise farmers on maintaining 10% tree cover in their farms….....

26) Tea factories enlighten farmers on the 10% tree cover ……...

……

Section D: Awareness Level

27) Who plant trees in your farm?.....

28) What time of the year do you plant trees? (a) Dry season [ ] (b) short rains [ ]
(c) Long rains [ ] (d) Any time [ ]

29) Who decides when to harvest trees in your farm? ……

30) Give the importance of trees in your farms

a) Ecological [ ]
b) Economical [ ]
c) Cultural [ ]
d) Religious [ ]
e) Others [ ] (Specify)……

31) Approximately what portion of your land has trees?.....

32) Have you ever heard about 10% tree cover policy? Yes [ ] No [ ].
If Yes, have you achieved the 10% tree cover in your farm? Yes [ ] No [ ]

If No, why?.....

33) What do you think would happen if all the farmers cut down all trees in their farms?……
…….....

34) Do you enjoy the services of an extension officer on tree growing and management?
Yes [ ] No [ ] If Yes, Where? (a) Farm [ ] (b) Seminar [ ]

(c) Field day [ ] (d) Media [ ] (e) others [ ]

Appendix IV: Observation Record Sheet

Activity	**Remarks**
Stacked wood for sale	
Remnants of tree harvesting i.e. stumps	
Visible eroded land as a result of tree harvesting	
Bare ground as a result of tree harvesting	
Any other relevant information	

Appendix V: Key Respondents Interview Schedule

Background information
1. What is your i) age? ..... ii) gender? .....

2. What is your job designation? .....

3. How long have you served in your current position? .....

a) Chief/ Agricultural Extension Officer

1) Which is the most prevalent source of fuel energy for residents in this area?
2) Do Tea factories purchase fuelwood from farmers of this area? Yes [ ] No [ ] If yes, which factories? (i) (ii) (iii)
3) Are there negative impacts as a result of the fuelwood use by the Tea factories in this area? Yes [ ] No [ ] If yes, which ones? ……
   ……
4) Is the government's 10% tree cover policy being adhered to in this area?.....
5) What is your feeling on fuelwood demand by tree factories and achievement of 10% tree cover policy?.....
   ……

b) District Environment Officer

1) Is your office aware of fuelwood consumption by Tea factories?.....
2) What is the replacement rate of trees cut by farmers in the district?.....
3) Is the government's 10% tree cover policy being adhered to in this district?.....
4) How does your office promote the implementation of the 10% tree cover policy in the district?.....
   ……..
5) What is your feeling on fuelwood demand by the Tea factories and achievements of 10% tree cover policy?.....
   ……

c) Section Head in tea factory

1) For how long has the factory been using fuelwood?.....
2) Which type of trees do you prefer most? (a) Indigenous [ ] (b) Exotic [ ] (c) Any [ ]
3) Who is your main supplier of the fuelwood?.....
4) What is the consumption rate of fuelwood for the last five years in tonnes?

   2009 -

   2010 -

   2011 -

   2012 -

   2013 -

5) In which districts do you source your fuelwood?

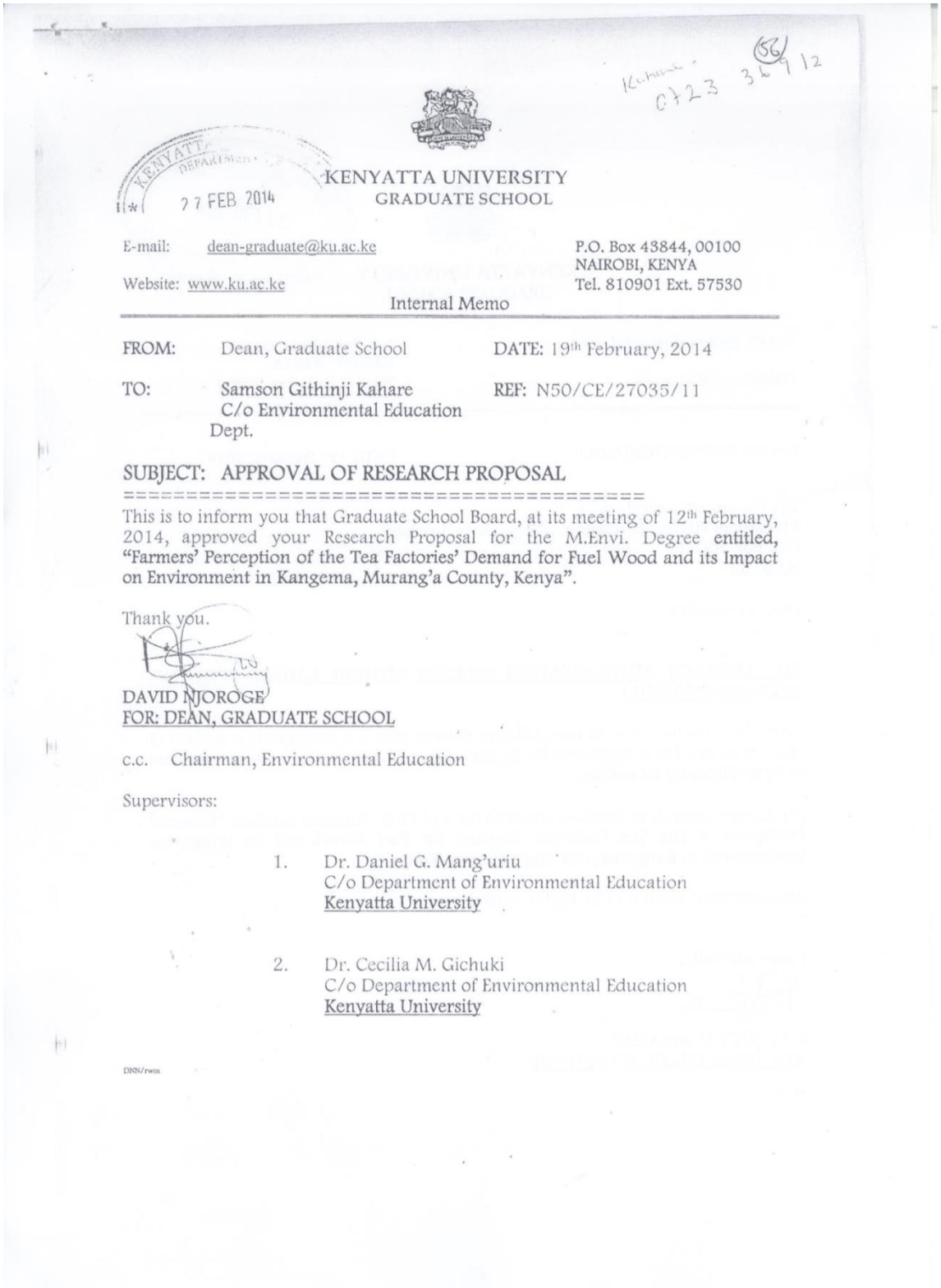
   ……..

6) How does the factory advocate for the achievement of 10% tree cover policy by the farmers?.....
7) Does the factory have any policy or guideline on tree cover before purchase of fuelwood from the farmers? Yes [ ] No [ ]
8) What is your feeling on fuelwood demand by tea factory and achievement of 10% tree cover policy?.....

   ……

Thank you your participation

Appendix VI: Approval of Research Proposal



KENYATTA UNIVERSITY
GRADUATE SCHOOL

27 FEB 2014

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School
DATE: 19th February, 2014

TO: Samson Githinji Kahare
C/o Environmental Education Dept.
REF: N50/CE/27035/11

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board, at its meeting of 12th February, 2014, approved your Research Proposal for the M.Envi. Degree entitled, "Farmers' Perception of the Tea Factories' Demand for Fuel Wood and its Impact on Environment in Kangema, Murang'a County, Kenya".

Thank you.

DAVID NJOROGE
FOR: DEAN, GRADUATE SCHOOL

c.c. Chairman, Environmental Education

Supervisors:

1. Dr. Daniel G. Mang'uriu
C/o Department of Environmental Education
Kenyatta University

2. Dr. Cecilia M. Gichuki
C/o Department of Environmental Education
Kenyatta University

DNN/rwm

Appendix VII: Research Authorization

KENYATTA UNIVERSITY
GRADUATE SCHOOL

KENYATTA UNIVERSITY DEPARTMENT OF ENVIRONMENTAL EDUCATION 27 FEB 2014 P.O. Box 43844 - 00100 NAIROBI

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: N50/CE/27035/2011

DATE: 19th February, 2014

The Permanent Secretary,
Ministry of Higher Education, Science & Technology,
P.O. Box 30040,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION SAMSON GITHINJI KAHARE– REG. NO. N50/CE/27035/2011

I write to introduce Mr. Samson Githinji Kahare who is a Postgraduate Student of this University. He is registered for M.Envi. degree programme in the Department of Environmental Education.

Mr. Kahare intends to conduct research for a M.Envi. Proposal entitled, "Farmers' Perception of the Tea Factories' Demand for Fuel Wood and its Impact on Environment in Kangema, Murang'a County, Kenya."

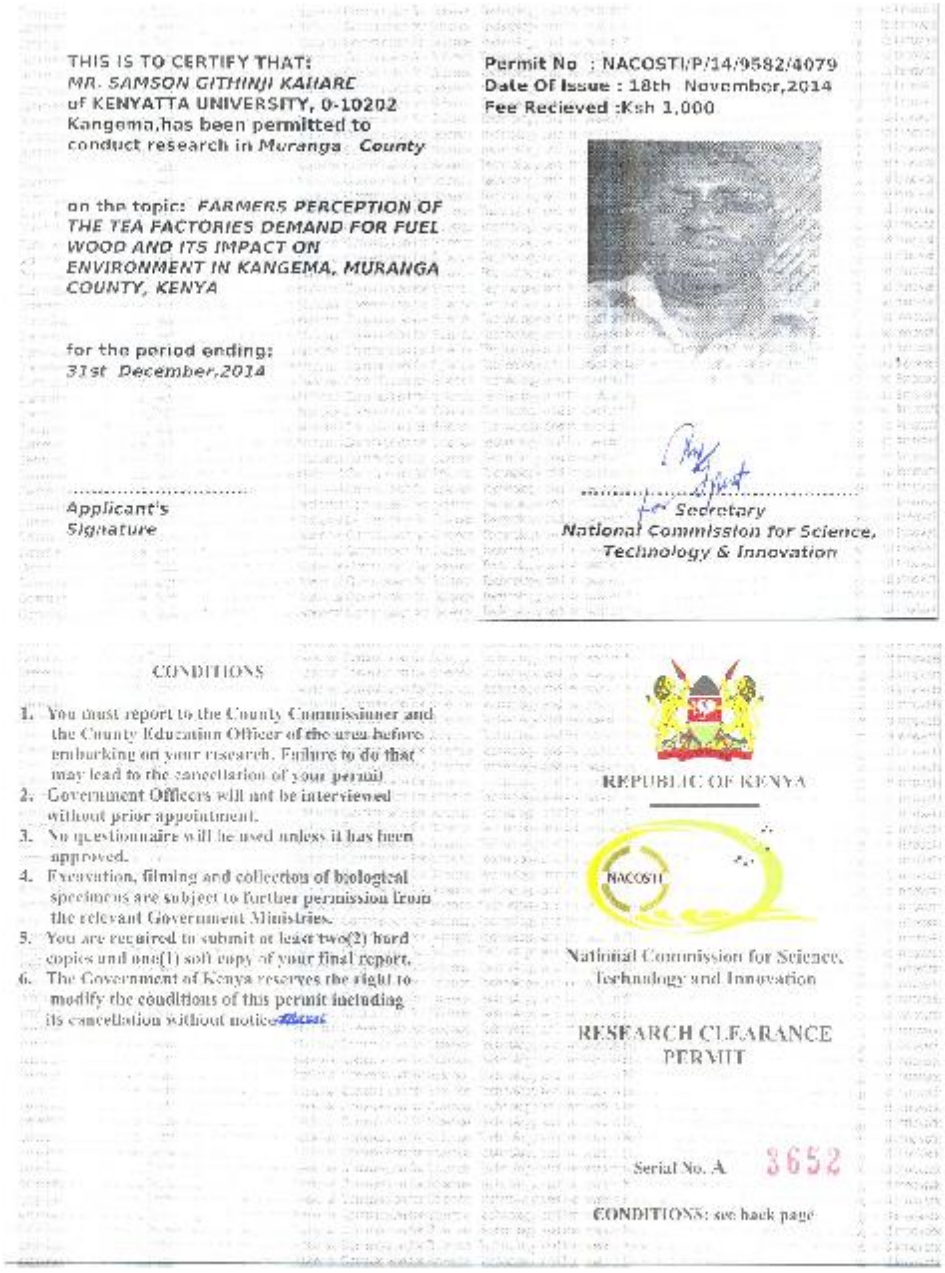
Any assistance given will be highly appreciated.

Yours faithfully,

MRS. LUCY N. MBAABU
FOR: DEAN, GRADUATE SCHOOL

DNN/rwm

Appendix VIII: Research Permit



THIS IS TO CERTIFY THAT:
MR. SAMSON GITHINJI KAHARE
of KENYATTA UNIVERSITY, 0-10202
Kangema,has been permitted to
conduct research in *Muranga County*

on the topic: *FARMERS PERCEPTION OF THE TEA FACTORIES DEMAND FOR FUEL WOOD AND ITS IMPACT ON ENVIRONMENT IN KANGEMA, MURANGA COUNTY, KENYA*

for the period ending:
31st December,2014

.....
Applicant's Signature

Permit No : NACOSTI/P/14/9582/4079
Date Of Issue : 18th November,2014
Fee Recieved :Ksh 1,000

.....
for Secretary
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

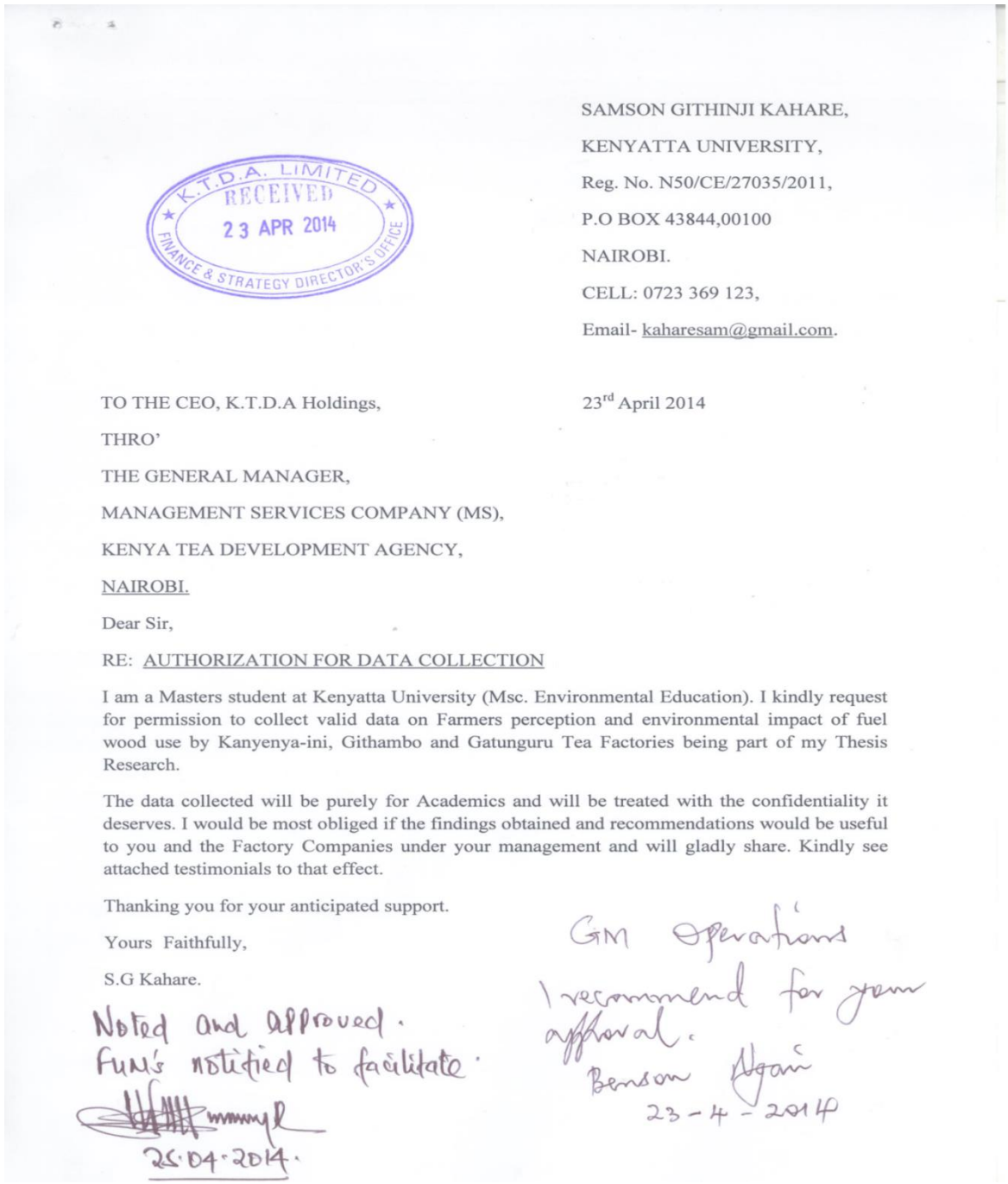
National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 3652

CONDITIONS: see back page

Appendix IX: Authorization to Collect Data from KTDA



K.T.D.A. LIMITED
RECEIVED
23 APR 2014
FINANCE & STRATEGY DIRECTOR'S OFFICE

SAMSON GITHINJI KAHARE,
KENYATTA UNIVERSITY,
Reg. No. N50/CE/27035/2011,
P.O BOX 43844,00100
NAIROBI.
CELL: 0723 369 123,
Email- kaharesam@gmail.com.

TO THE CEO, K.T.D.A Holdings,

THRO'

THE GENERAL MANAGER,

MANAGEMENT SERVICES COMPANY (MS),

KENYA TEA DEVELOPMENT AGENCY,

NAIROBI.

23rd April 2014

Dear Sir,

RE: AUTHORIZATION FOR DATA COLLECTION

I am a Masters student at Kenyatta University (Msc. Environmental Education). I kindly request for permission to collect valid data on Farmers perception and environmental impact of fuel wood use by Kanyenya-ini, Githambo and Gatunguru Tea Factories being part of my Thesis Research.

The data collected will be purely for Academics and will be treated with the confidentiality it deserves. I would be most obliged if the findings obtained and recommendations would be useful to you and the Factory Companies under your management and will gladly share. Kindly see attached testimonials to that effect.

Thanking you for your anticipated support.

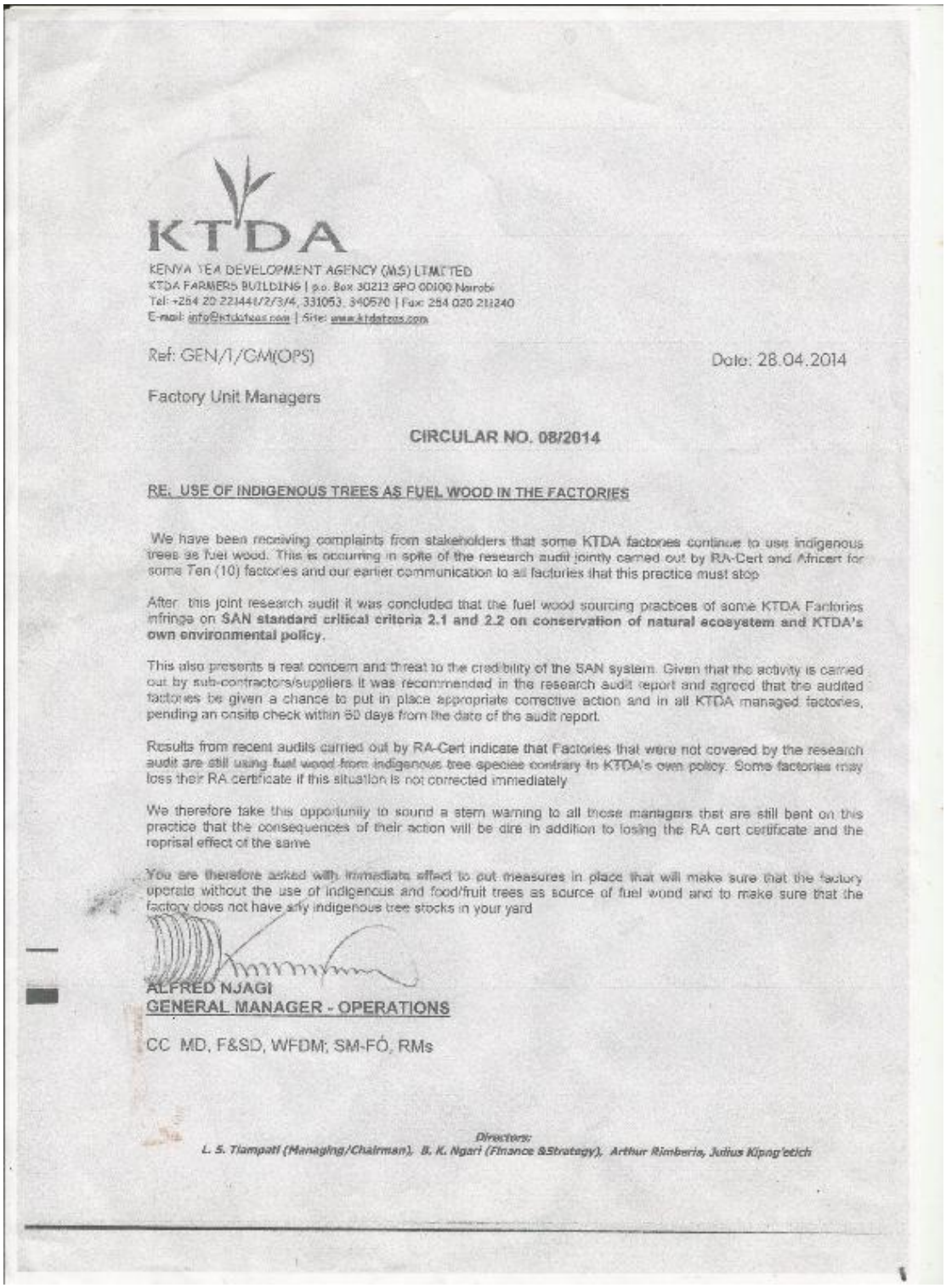
Yours Faithfully,

S.G Kahare.

GM Operations
I recommend for your approval.
Benson Ngari
23-4-2014

Noted and Approved.
FUM's notified to facilitate.
25.04.2014.

Appendix X: Circular on Indigenous Trees Used by KTDA



KTDA

KENYA TEA DEVELOPMENT AGENCY (MS) LIMITED
KTDA FARMERS BUILDING | p.o. Box 30213 GPO 00100 Nairobi
Tel: +254 20 22144/2/3/4, 331053, 340570 | Fax: 254 020 211240
E-mail: info@ktdateas.com | Site: www.ktdateas.com

Ref: GEN/1/GM(OPS)

Date: 28.04.2014

Factory Unit Managers

CIRCULAR NO. 08/2014

RE: USE OF INDIGENOUS TREES AS FUEL WOOD IN THE FACTORIES

We have been receiving complaints from stakeholders that some KTDA factories continue to use indigenous trees as fuel wood. This is occurring in spite of the research audit jointly carried out by RA-Cert and Africert for some Ten (10) factories and our earlier communication to all factories that this practice must stop

After this joint research audit it was concluded that the fuel wood sourcing practices of some KTDA Factories infringe on **SAN standard critical criteria 2.1 and 2.2 on conservation of natural ecosystem and KTDA's own environmental policy.**

This also presents a real concern and threat to the credibility of the SAN system. Given that the activity is carried out by sub-contractors/suppliers it was recommended in the research audit report and agreed that the audited factories be given a chance to put in place appropriate corrective action and in all KTDA managed factories, pending an onsite check within 60 days from the date of the audit report.

Results from recent audits carried out by RA-Cert indicate that Factories that were not covered by the research audit are still using fuel wood from indigenous tree species contrary to KTDA's own policy. Some factories may loss their RA certificate if this situation is not corrected immediately

We therefore take this opportunity to sound a stern warning to all those managers that are still bent on this practice that the consequences of their action will be dire in addition to losing the RA cert certificate and the reprisal effect of the same

You are therefore asked with immediate effect to put measures in place that will make sure that the factory operate without the use of indigenous and food/fruit trees as source of fuel wood and to make sure that the factory does not have any indigenous tree stocks in your yard

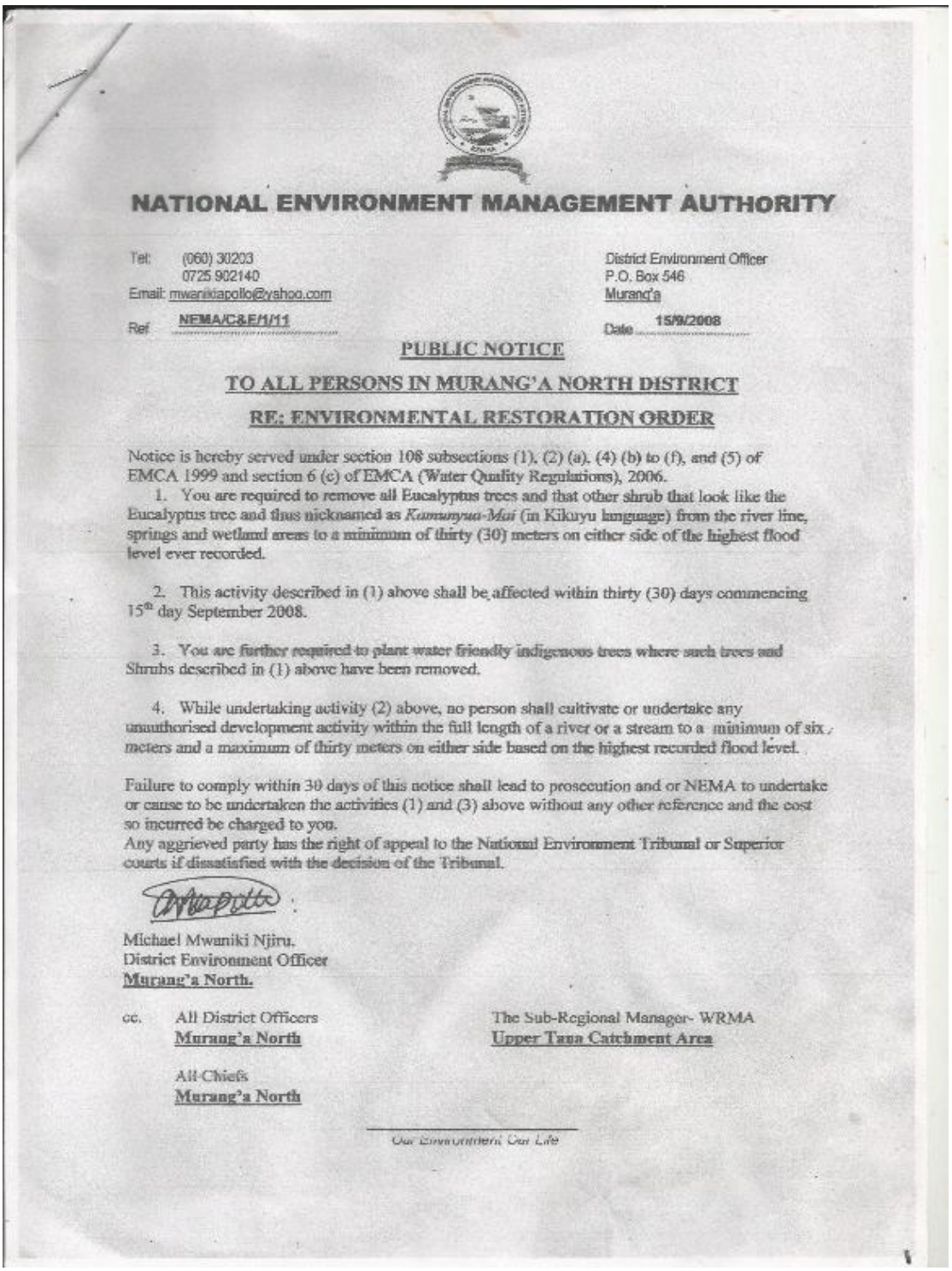
[redacted]

ALFRED NJAGI
GENERAL MANAGER - OPERATIONS

CC MD, F&SD, WFDM; SM-FO, RMs

Directors:
L. S. Tiampati (Managing/Chairman), B. K. Ngari (Finance &Strategy), Arthur Rimberia, Julius Kipng'etich

Appendix XI: Environmental Restoration Order by NEMA



NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

Tel: (060) 30203
0725 902140
Email: mwanikiapollo@yahoo.com

District Environment Officer
P.O. Box 546
Murang'a

Ref NEMA/C&E/1/11

Date 15/9/2008

PUBLIC NOTICE

TO ALL PERSONS IN MURANG'A NORTH DISTRICT

RE: ENVIRONMENTAL RESTORATION ORDER

Notice is hereby served under section 108 subsections (1), (2) (a), (4) (b) to (f), and (5) of EMCA 1999 and section 6 (c) of EMCA (Water Quality Regulations), 2006.

1. You are required to remove all Eucalyptus trees and that other shrub that look like the Eucalyptus tree and thus nicknamed as *Kamunyua-Mai* (in Kikuyu language) from the river line, springs and wetland areas to a minimum of thirty (30) meters on either side of the highest flood level ever recorded.

2. This activity described in (1) above shall be affected within thirty (30) days commencing 15th day September 2008.

3. You are further required to plant water friendly indigenous trees where such trees and Shrubs described in (1) above have been removed.

4. While undertaking activity (2) above, no person shall cultivate or undertake any unauthorised development activity within the full length of a river or a stream to a minimum of six meters and a maximum of thirty meters on either side based on the highest recorded flood level.

Failure to comply within 30 days of this notice shall lead to prosecution and or NEMA to undertake or cause to be undertaken the activities (1) and (3) above without any other reference and the cost so incurred be charged to you.
Any aggrieved party has the right of appeal to the National Environment Tribunal or Superior courts if dissatisfied with the decision of the Tribunal.

Michael Mwaniki Njiru.
District Environment Officer
Murang'a North.

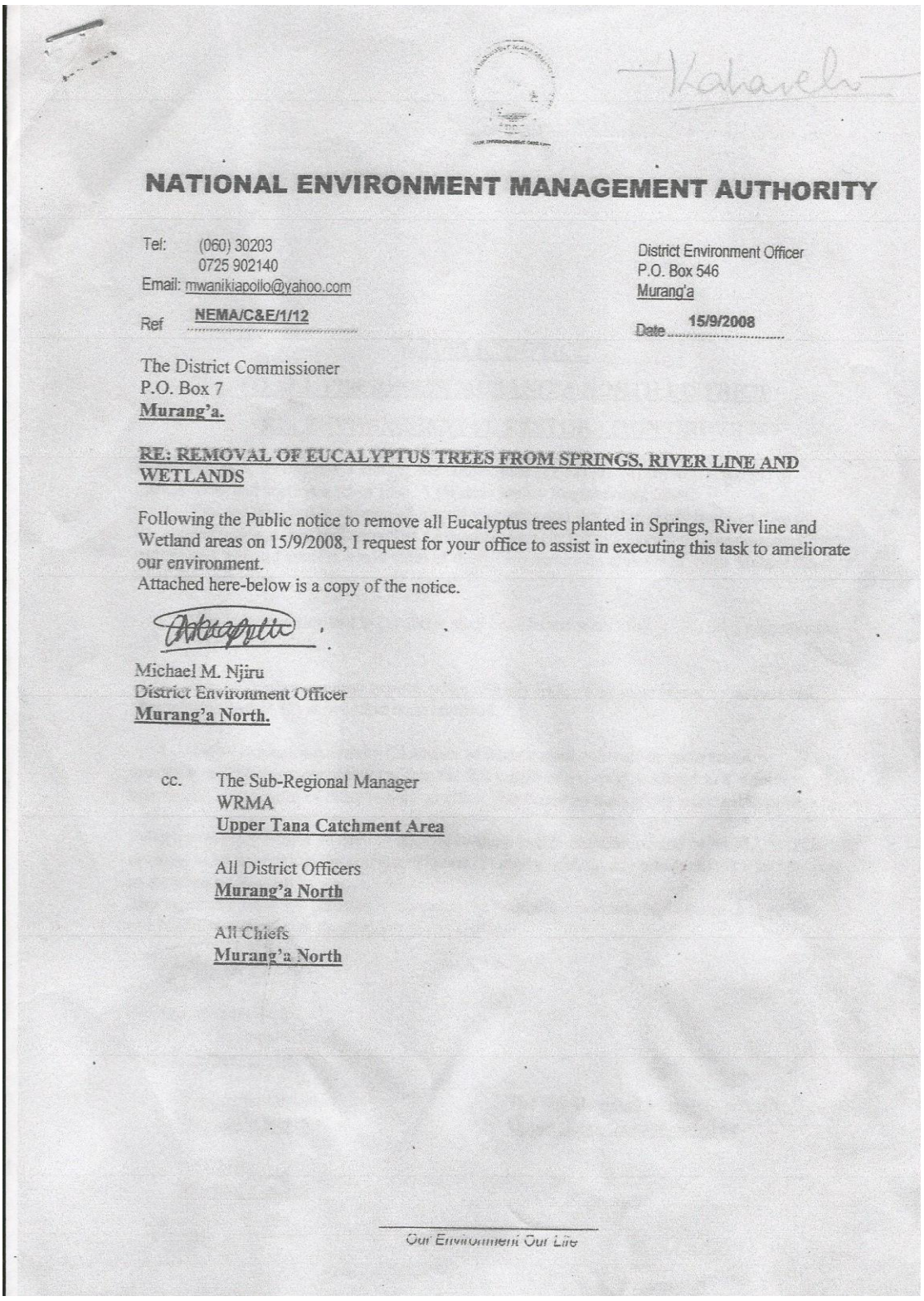
cc. All District Officers
Murang'a North

All Chiefs
Murang'a North

The Sub-Regional Manager- WRMA
Upper Tana Catchment Area

Our Environment, Our Life

Appendix XII: Circular for Removal of Eucalyptus Trees from Water Points



NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

Tel: (060) 30203
0725 902140
Email: mwanikiapollo@yahoo.com

Ref NEMA/C&E/1/12

District Environment Officer
P.O. Box 546
Murang'a

Date 15/9/2008

The District Commissioner
P.O. Box 7
Murang'a.

RE: REMOVAL OF EUCALYPTUS TREES FROM SPRINGS, RIVER LINE AND WETLANDS

Following the Public notice to remove all Eucalyptus trees planted in Springs, River line and Wetland areas on 15/9/2008, I request for your office to assist in executing this task to ameliorate our environment.
Attached here-below is a copy of the notice.

Michael M. Njiru
District Environment Officer
Murang'a North.

cc. The Sub-Regional Manager
WRMA
Upper Tana Catchment Area

All District Officers
Murang'a North

All Chiefs
Murang'a North

Our Environment Our Life

Appendix XIII: Role of Tea Factories on the Afforestation Policy in Relation To the Respondents Education Levels

		Respondents Education Level					
		Primary	Secondary	Tertiary	University	No formal education	Total
Tea factories have been using fuelwood in processing Tea leaves	Strongly agree	83	152	29	10	16	290
Total		83	152	29	10	16	290
Tea factories purchase fuelwood from mainly Tea farmers	Strongly disagree	0	0	0	0	12	12
	Somehow disagree	0	0	0	4	4	8
	Don't know	0	0	2	6	0	8
	Somehow agree	0	40	27	0	0	67
	Strongly agree	83	112	0	0	0	195
Total		83	152	29	10	16	290
Tea factories purchase fuelwood from those farms with many trees only	Strongly disagree	0	87	29	10	16	142
	Somehow disagree	46	65	0	0	0	111
	Don't know	19	0	0	0	0	19
	Somehow agree	15	0	0	0	0	15
	Strongly agree	3	0	0	0	0	3
Total		83	152	29	10	16	290
The fuelwood used by Tea factories has led to reduced tree cover in the village	Strongly disagree	0	0	0	0	3	3
	Somehow disagree	0	0	0	0	13	13
	Don't know	0	0	0	2	0	2
	Somehow agree	0	33	29	8	0	70
	Strongly agree	83	119	0	0	0	202
Total		83	152	29	10	16	290
Reduced tree cover may have negative effects to the environment	Strongly disagree	0	0	0	0	3	3
	Somehow disagree	0	0	0	0	10	10
	Don't know	0	0	0	0	1	1
	Somehow agree	0	20	29	10	2	61
	Strongly agree	83	132	0	0	0	215
Total		83	152	29	10	16	290
Farmers purchase tree seedlings from Tea factories at will	Strongly disagree	0	0	0	0	11	11
	Somehow disagree	0	0	0	9	5	14
	Don't know	0	17	29	1	0	47
	Somehow agree	0	120	0	0	0	120
	Strongly agree	83	15	0	0	0	98
Total		83	152	29	10	16	290
Tea factories advise farmers on achieving the afforestation policy	Strongly disagree	0	0	0	0	13	13
	Somehow disagree	0	11	29	10	3	53
	Don't know	0	9	0	0	0	9
	Somehow agree	0	102	0	0	0	102
	Strongly agree	83	30	0	0	0	113
Total		83	152	29	10	16	290

		Respondents Education Level					
		Primary	Secondary	Tertiary	University	No formal education	Total
Tea factories have been using fuelwood in processing Tea leaves	Strongly agree	83	152	29	10	16	290

		Respondents Education Level					
		Primary	Secondary	Tertiary	University	No formal education	Total
All farmers should be enlightened on the afforestation policy	Somehow disagree	0	0	0	0	11	11
	Don't know	0	0	0	0	1	1
	Somehow agree	0	2	29	10	4	45
	Strongly agree	83	150	0	0	0	233
Total		83	152	29	10	16	290
Farmers are given free seedlings by the Tea factories to plant	Strongly disagree	53	152	29	10	16	260
	Somehow disagree	24	0	0	0	0	24
	Don't know	4	0	0	0	0	4
	Somehow agree	1	0	0	0	0	1
	Strongly agree	1	0	0	0	0	1
Total		83	152	29	10	16	290
Maintaining a recommended tree cover at individual farm is important	Strongly disagree	0	0	0	0	16	16
	Somehow disagree	0	0	12	10	0	22
	Don't know	0	0	9	0	0	9
	Somehow agree	0	32	8	0	0	40
	Strongly agree	83	120	0	0	0	203
Total		83	152	29	10	16	290