CHALLENGES AND OPPORTUNITIES OF INDIGENOUS BAMBOO AND ITS ENVIRONMENTAL CONSERVATION IN KIENI FOREST, GAKOE LOCATION OF KIAMBU COUNTY, KENYA

BY

JESSICA E. N. MUKIRI (BSc. Biology)

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DECLARATION

Declaration by candidate

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

Jessica E.N.Mukiri
Bsc (Hons) Biology
Reg. No: N50/CTY/PT/25641/2011

Signature…… Date……
Department of Environmental Science

Declaration by Supervisors

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

Dr. Gladys Gathuru

Signature …… Date ……..
Department of Environmental Science
Kenyatta University
Nairobi

Dr. Dionysious K. Kiambi

Signature…|……|…….. Date…….
Executive Director
African Biodiversity Conservation and Innovation Centre,
Nairobi

DEDICATION

I dedicate this work to all lovers of Knowledge and Science

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I want to thank God and the Universe for guidance on the path I have taken, which has landed me in the field of Environmental Science. I feel this is where I belong. Thank you.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS AND ACRONYMS

ECLAC	Economic Commission for Latin America and the Caribbean
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GoK	Government of Kenya
INBAR	International Network for Bamboo and Rattan
IDRC	International Development and Research Centre
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KSh	Kenya Shilling
MEA	Multilateral Environmental Agreements
MENR	Ministry of Environment and Natural Resources
SPSS	Statistical Package for the Social Sciences software
UN	United Nations
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
USD 1 =	KSh 89

ABSTRACT

Yushania alpina formerly known as *Arundinaria alpina* is the only species of native bamboo indigenous forests in Kenya. It plays an integral part in the indigenous forests in which it occurs. Bamboo is a fast growing, renewable, widespread, low cost, environment enhancing resource with great potential in environmental conservation and poverty alleviation. The lack of rules surrounding bamboo exploitation in Kenya has resulted in unsustainable harvesting and utilization of bamboo. There is currently limited information on the challenges and opportunities of *Y. alpina* in Kenya, particularly in areas it naturally occurs such as in Kieni forest and thus the objectives of the study were to: To determine whether the community is aware of the ecological value of *Yushania alpina*; To assess the economic potential of bamboo to the local communities living in Gakoe location; and identify the challenges and opportunities on bamboo cultivation and its environmental conservation. A cross sectional survey was undertaken, where simple random sampling was used in primary data collection through a participatory consultative approach. A total of 124 questionnaires were administered to household heads over a period of four months here important information including the socio-demography of the area was collected. In addition, observation and photography were also used in data collection. Secondary data were collected from text books, scientific journals, periodicals, reports, published and unpublished theses, International Network for Bamboo and Rattan (INBAR) data bank and the Internet. Quantitative data were analysed using descriptive statistics such as means and percentages as well as a correlation analysis was performed, data were also organized and then categorized into themes and the usefulness of the information was evaluated in answering research questions. The study established that community was aware of the ecological value of *Y. alpina* with 89% of respondents being aware that it is eaten by animals and over 66% of respondents' acknowledging the importance of *Y. alpina* within Kieni Forest. A weak positive correlation ($r=0.028$) implied that education was not a contributing factor when it came to identifying the animals which ate *Y. alpina.* A Pearson's correlation found that ($r=0.207$) at a significance of $p<0.05$, implying that the higher the education level attained, respondents acknowledged that deforestation of bamboo in Kieni forest resulted in environmental consequences. The study found within Gakoe location *Y. alpina's* a number of economic related activities with *Y. alpina* selling seedlings accounted for (46%) and making bamboo products accounted for (36%) of *Y. alpina* related economic activities. The study also highlighted the challenges which *Y. alpina* cultivation and conservation face, which included an unstable market, limiting policy guidelines as well as shortage of capacity in technical knowledge of bamboo. *Y. alpina* has many untapped opportunities and the Kiambu County Government should consider being more proactive and facilitate its citizens in exploiting the sector. More community members also need to be sensitized on the benefits of *Y. alpina* through community forest station as well as radio programs.

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

Bamboo is a fast growing, renewable, widespread, low cost, environment enhancing resource with great potential to improve poverty alleviation and environment conservation. Africa has a total of only 1.4 million hectares of bamboo, much of which is distributed over Eastern Africa (Kibwage *et al.*, 2008).

Yushania alpina formerly known as *Arundinaria alpina* is the only species of native forests in Kenya (Kigomo, 2007a). Kenya's bamboo has been under threat since the 1940s, as *Y. alpina* in highland catchment areas was cleared and replaced with softwood the result of this about 150,000 hectares indigenous bamboo remaining (Ministry of Wildlife and Foresty , 2010) . Throughout the 1960's, areas with *Yushania alpina* were further cleared to grow crops such as potatoes, cabbage and tea. Many of these areas were harvested for timber with little replacement. The lack of rules and regulations surrounding bamboo exploitation in Kenya resulted in wasteful harvesting and utilization of bamboo to the extent that in 1986 a Presidential ban was imposed to protect further depletion of the resource (Kigomo, 2007a). Exceptions to the ban in the form of controlled licensing by government officials have led to poor governance, and in the absence of any real control over the amount of bamboo that is officially extracted from the forest, large quantities of bamboo continue to be harvested illegally, resulting in lost public revenue as well as degradation of the environment (Kigomo, 2007a).

In 2008, the Government of Kenya (GoK) launched Kenya Vision 2030 as the new blueprint for the long-term development of the country, of which the focus is to create a "Globally competitive and prosperous country with a high quality of life by 2030". To achieve Vision 2030 the government needs to maintain the natural systems such as

conservation of indigenous bamboo forests that support agriculture, energy supplies, water supplies, livelihood strategies, and tourism (Government of Kenya, 2007; Oloo, 2010).

1.2 Problem Statement

The well-being of humans is dependent on the sustainability of their environment. The loss of indigenous forests is a critical environmental problem. Currently, less than 3% of Kenya's land is covered by forests. One of the aims by the Forestry Policy of 2014 increase its cover by 10% in the next 20 years by planting 7.6 billion trees (Mott MacDonald, 2010). The goods and services that the forests provide make a huge contribution to Kenya's economy (Government of Kenya, 2007).

Economic activities related to bamboo are site-specific, highly diverse and present challenges for official data collection. Disaggregated data provides a challenge for integrated planning and management of the environment and undertaking total economic valuation (GoK, 2013). Bamboo can serve as a conservation incentive and an emphasis on the need for research to demonstrate the economic and income generation potential of indigenous plants. Therefore, this study seeks to provide vital information on *Yushania alpina* is essential to promoting sustainable use of bamboo and its conservation efforts in Kenya.

1.3 Research Questions

The study was guided by the following research questions:

i. According to age, gender, level of education and gender how aware are the community of Gakoe location regarding the ecological value of bamboo?
ii. Does occupation of community in Gakoe location affect the potential of bamboo in Gakoe location?

iii. What are the constraints and opportunities facing indigenous bamboo conservation in Gakoe location?

1.4 Objectives of the Study

The general objective of the research was to evaluate the Challenges and Opportunities of indigenous bamboo cultivation and its environmental conservation in Kieni Forest, Gakoe location in Kiambu County.

Specifically, the study aimed:

i. To determine whether the community was aware of the ecological value of *Yushania alpina*.
ii. To assess the economic potential of bamboo to the local communities living in Gakoe location.
iii. 'To Identify the challenges and opportunites faced by the local community in cultivation and conservation of indigenous bamboo.

1.5 Hypotheses

i. The community is not aware of the ecological value of *Yushania alpina* because of low education levels in Gakoe location.
ii. *Y. aplina* is has high economic turnover in Gakoe location due to occupation of community members in Gakoe location.

1.6 Significance of the Study

Limited systematic documentation of the challenges and opportunities of indigenous bamboo in Kenya make it difficult for sustainable use of *Y. alpina*, this contributing to wasteful harvesting of this natural resource. In the quest to conserve indigenous bamboo species for its economic potential, the local community will also have the opportunity to acquire conservation skills which can be applied to monitor and safeguard other biological species, enhancing sustainable environmental management

practices. Indigenous bamboo can contribute to economic growth, job creation and poverty reduction, in addition to influencing well-being and social outcomes, such as purification of water (Kigomo, 2007a; Lobovikov *et al.,* 2005).

The information gained from this study is imperative to successful planning and decision making, and can be used to strengthen the National Environmental Information Management System which was launched in collaboration with UNEP to generate environmental data. This information can assist Kenya's progress towards achieving the targets associated with the Sustainable Development Goals and its efforts to achieve Vision 2030.

1.7 Conceptual framework

Indigenous bamboo is obtained mainly from the natural forest and partly from on-farm forestry. *Y. alpina* is either illegally, or legally harvested from the forests or sold as products/seedlings to community members. The continued unregulated exploitation of indigenous bamboo from forests results in a number of losses including but not limited to loss in biodiversity, loss in soil fertility, loss of water catchment areas and loss in revenue for the government. Situations such as these are often difficult to remedy as they will require time and money to reverse their damaging effects (Figure 1.1).

Livelihoods are likely to improve if the full economic potential is exploited in a positive way. This translates to job creation for the youth and also generation of more revenue for the government. The preservation of indigenous species can result in increased soil conservation, water retention and also conservation of wildlife. The framkework is developed from (Awadh, 2010).

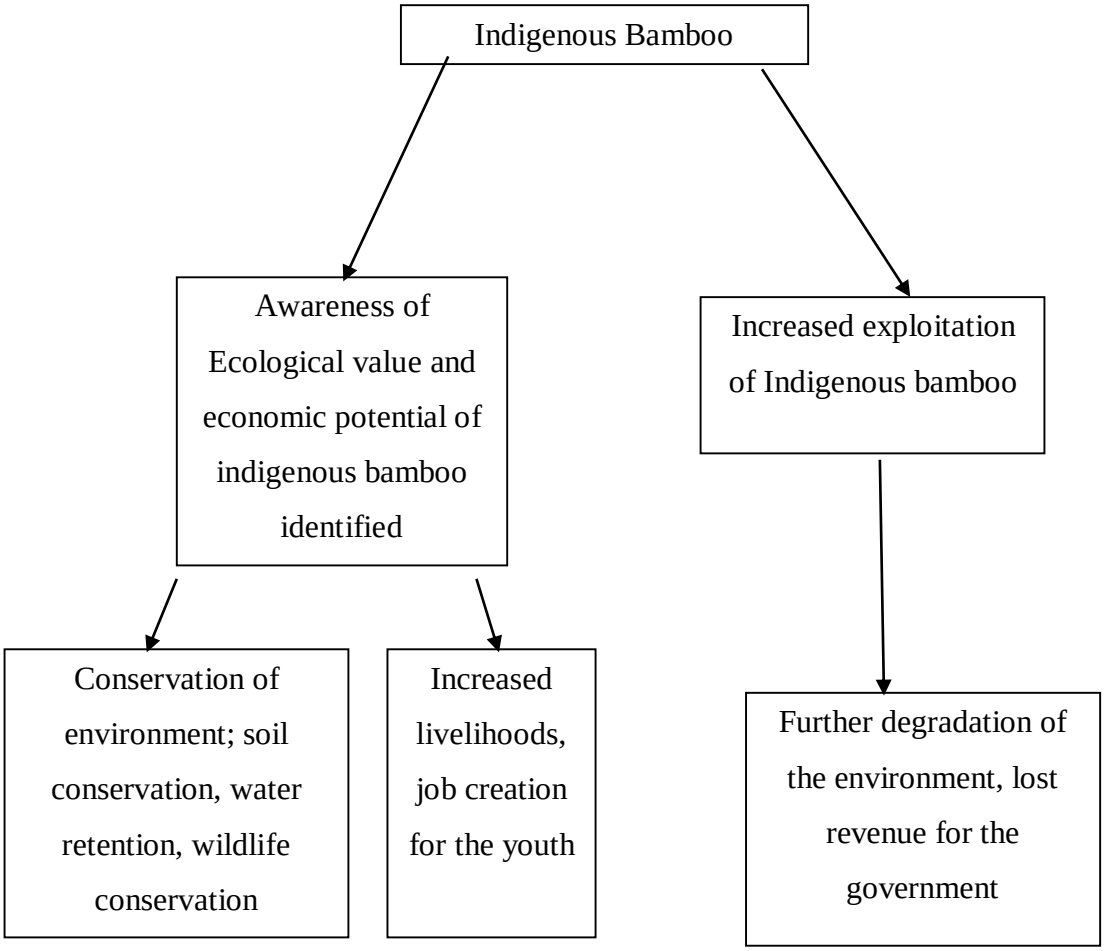

Figure 1.1: Indigenous bamboo economic potential and ecological value framework

1.8 Definition of Terms

Culm - the stem of a grass or cereal plant, especially that bearing the flower (Lobovikov *et al.*, 2005).

Ecological value - this is the level of benefits that the environment, water, minerals, biota, and all other factors that make up natural ecosystems, provide to support native life forms (Fernandez-Gimenez,1993).

Ecological awareness – the mindset that supports sustainable consumption and production decisions and provides a foundation for society as a whole, to assume

responsibility in the achievement of environmentally responsible behaviour, and therefore sustain development (Fernandez-Gimenez,1993).

Economic potential - the income that is generated from a particular product if some or all its resources are partially or fully employed according to Watts (2008).

Rhizome a continuously growing horizontal underground stem that puts out lateral shoots and adventitious roots at intervals (Clayton *et al.*,2006).

Sustainability - Improving the quality of human life while living within the carrying capacity of supporting eco-systems. Sustainability is important as it ensures that we have and will continue to have all benefits that we derive from forests (Ekpenyong,2009).

Wilding- Bamboo seeds collected from the forest (Kigomo, 2007a)

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter reviews the prevailing literature surrounding the issues that influence the sustainability of indigenous bamboo in relation to the international scenario, Kenya and Gakoe within Kieni forest. Various aspects of pre-existing research are thoroughly examined in global, continental, regional, and national and county area perspective. The literature review involved the methodical search for applicable literature and its analysis to better inform the understanding of the research question and its current status in literary texts. For this study, information was drawn from books, relevant research studies, e-journals, magazines, government publications, Kenya Forest Service publications and the internet. An analysis was undertaken based on the following main themes: General description of Bamboo, Distribution on Indigenous bamboo, *Yushania alpina*, Environmental Awareness, Economic Potential, Constraints and Opportunities, Policy and Legislation.

2.1 General Description of Bamboo

Bamboo belongs to the Gramineae family and has approximately 90 genera with over 1,200 species. Bamboo flower rarely and in irregular cycles, which are not yet clearly understood. Thus taxonomists do not always agree on the identification of bamboo species and genera, but modern genetic analysis may shed new light on bamboo taxonomy (Lobovikov *et al.,* 2005).

Bamboo is naturally distributed in the tropical and subtropical belt between approximately 46° north and 47° south latitudes, and is commonly found in Africa, Asia and Central and South America. Some species may also grow successfully in mild temperate zones in Europe and North America (Muller & Rebelo, 2011).

According to (Kigomo, 2007b) bamboo shoots and culms grow from the dense root rhizome system. There are two main categories of rhizomes: monopodial and sympodial. Monopodial rhizomes grow horizontally, often at a surprisingly faster rate, and thus their given nickname 'runners'. The rhizome buds develop either upward, generating a culm, or horizontally, with a new tract of the rhizomal net. Monopodial bamboos generate an open clump with culms distant from each other and can be invasive. They are usually found in temperate regions and include the genera *Phyllostachys* and *Pleioblastus*. Sympodial rhizomes are short and thick, and the culms above ground are close together in a compact clump, which expands evenly around its circumference (Kigomo, 2007b; Lobovikov *et al.,* 2005). *Yushania alpina* belongs to the *Yushania* genus of bamboo which belongs to the Poceae family a woody bamboo, of the Bambusea tribe and the Bambusodea supertribe. The species of *Yushania* bamboo are evergreen, spreading and less throng; they are found in Asia regions within the Himalayan and Taiwanese mountain ranges as well as the subtropics of Africa at high altitudes.

The cultural significance of bamboo in Asia has led to the extensive application of bamboo in enhancing the economic and ecological wellbeing of resource-dependent communities in Asia (Ongugo *et al.*, 2012).This has also been supported by systematic studies of the potential of bamboo's previous and current uses, and the social, cultural and political perspectives of these resources, which have been invaluable in promoting development through innovative and sustainable uses of bamboo and rattan in Asia.

Organizations such as The International Network for Bamboo and Rattan (INBAR) are dedicated to improving the social, economic, and environmental benefits of bamboo and rattan, which has resulted in comprehensive research of bamboos

resulting to advances of bamboo and rattan in Asia (Lobovikov *et al.,* 2005). INBAR has facilitated and coordinated research (including action-research) on biodiversity and genetic conservation, production systems, processing and utilisation and socio-economics and policy, while promoting capacity building at the national level. A number of rural development programs are being implemented in Asia. INBAR has also been instrumental in promoting technology transfer and information exchange between network partners (World Bamboo Organisation, 2012).

INBAR connects a global network of partners from the government, private, and not-for-profit sectors in over 50 countries to define and implement a global agenda for sustainable development through bamboo and rattan. Through their research, there is evidence that replication in Latin America and Africa of the success stories of usage of bamboo from South and South-East Asia is yet to be assessed despite the immense interest from the private sector, non- governmental organizations and government institutions, in using bamboo to fuel rural development in the region. According to Lobovikov *et al.,* 2005 it is evident that the dearth of information on the bamboo sector has been the main constraint to the development of systematic and sustainable development programs. Thus, there is need for further research to find the cause and solutions to make bamboo economically and ecologically viable in Africa.

2.2 Distribution of Indigenous Bamboo of Kenya

From the world's cover of 14 million hectares of bamboo, 85% is distributed mainly in the Asian tropical region. Africa has a total of only 1.4 million hectares, much of which is distributed over Eastern Africa in which Kenya's share is about 150,000 hectares (Oloo, 2010; Kigomo, 2007a).

According to Lobovikov *et al.,* (2005) and Kigomo, (1988), there has been no proper inventory of bamboo resources in Africa. Forty three species have been documented

as being native to Eastern Africa, several species under the genera *Yushania, Oreobambos* and *Oxytenanthera* have been described as occurring more widely. The remaining 40 species under 11 genera occur principally in Madagascar.

There is little literature surrounding indigenous bamboo in Kenya; most of the available research dates back to the 1980's, suggesting that there is a lack of current and up-to-date literature. This includes the Kenya Forest Research Institute's attempt to sum up some regional data on bamboo forest cover and species distribution in the late 1980s (Lobovikov *et al.,* 2005). The lack of current literature can be attributed to the lack of interest from the Kenyan Government as a result of the bamboo ban still being implemented and *Y.alpina's*; economic value not being well documented.

2.3 *Yushania alpina* (*Arundinaria alpina*; African alpine bamboo)

2.3.1 Occurrence

The species flourishes between 2290 and 3360 m above sea level. It occurs gregariously (not in clumps) within mountain forests in tropical Africa (Ongugo *et al.,* 2000). This species is found growing in the highlands of Ethiopia, Southern Sudan, Congo, Zaire, Rwanda, Uganda, Kenya, Tanzania and Zambia (Lobovikov *et al.,* 2005).

In Kenya, *Y. alpina* is the only indigenous bamboo species and occurs in irregular patches in the central highlands, particularly in Timboroa plateau (31,000 ha), Aberdare Range (65,000 ha), Mount Kenya, Mt. Elgon, and Mau Range (51,000 ha) (Ongugo *et al.,* 2000). The total cover area of *Y. alpina* in Kenya is about 150,000 hectares (Kigomo, 2007a). In its natural environment, it grows together with several tree species including *Hagenia abysinica, Juniperus procera, Ocotea usambarensis,*

Podocarpus gracilior and *P. milanjianus.* The wildlife associated with bamboo forests includes elephants, buffalo, bushbucks and Syke's monkeys which use it as a food source (Ongugo *et al.,* 2000; Kigomo, 1988)

2.4 Community Ecological Awareness of Indigenous Bamboo

Communities that live adjacent to forests, play a critical role in the conservation and management of natural resources. These communities heavily depend on the natural resources for their livelihoods such as energy from fuel wood, water, meat and other ecosystem functions such as water purification, soil conservation, and carbon storage.

Bamboos are well known for their vigorous growth and variety of uses. They play major ecological roles in the areas in which they occur. This has forced human beings to introduce bamboo species in areas where they do not naturally occur (Lewis, Miles, & Miles, 2008). Hunde (2008) justifies this introduction by stating that indigenous bamboo is restricted to limited agro-ecological sites and that many agro-ecological sites may not be suitable for indigenous species. Hence, species such as *Bambusa balcooa*, *Bambusa tulda*, *Bambusa vulgaris,* and *Dendrocalamus asper* among others have been introduced in Ethiopia to increase the bamboo diversity (Hunde, 2008).

However, Zimmerman (2008) points out that typically, the species that coexist in ecosystems have evolved together for many generations. These populations have established balanced interactions with each other that enable all populations in the area to remain relatively stable. (Gordon, 1998) supports this view by adding that native species are good for native wildlife. Occasionally, however, natural or human-made disruptions occur that have unforeseen consequences to populations in an ecosystem. This is mainly the case with exotic species that become invasive species, due to the

fact that areas in which they are introduced may have better resources than their native ecosystem and they rarely have natural checks. This is best exemplified by the Golden Bamboo (*Phyllostachys aurea*), an exotic bamboo from China which has developed into an invasive species in Miami, Florida (Gordon, 1998). This bamboo is fast growing and will quickly spread via underground rhizomes. Despite containment efforts, the rhizomes of Golden bamboo will often find their way out of confinement to infest nearby areas. Golden bamboo will grow in sparsely wooded secondary forests, and does best in full sunlight (Gordon, 1998). *P. aurea* will continue to grow and spread in less than desirable environments.

Similarly to the Golden Bamboo, some exotic bamboo species are a threat to rare riparian habitats by forming impenetrable thickets where they infest, and crowd out all native plant life. Another major problem with invasive plant species as explained by Zimmerman (2008), is the several years it takes scientists to thoroughly study the potential invasiveness of the said species, further highlighting the importance that should be accorded to native plant species, which are rarely invasive.

One of the study's objectives is to determine if the community is aware of the ecological value of *Yushania alpina*. Ecological awareness is as an important aspect of environmental awareness and according to Fernandez-Gimenez (1993), environmental awareness is considered a mindset that supports sustainable consumption and production decisions and provides a foundation for society as a whole, to assume responsibility in the achievement of environmentally responsible behaviour, and therefore sustain development. She further explains that indigenous people's knowledge consists of the biological world including climate soils, water, vegetation, wildlife, and domestic livestock and thus this knowledge can take several

forms: taxonomic and structural knowledge; distributions; interactions among organisms and practical skills and methods for the management and use of natural materials.

The citizen's awareness and its pro-environmental actions play a crucial role in making environmental policy successful (Iizuk, 2000). The report by Izuk, (2000) states that awareness of environmental issues are not considered to have weight compared to other social issues such as conflict, corruption and food security. He further emphasises that sustainable environmental management is not possible without community involvement which requires that people be informed about how their day to day activities affect the environment.

With illiteracy being pervasive in many African populations, there is low uptake of dissemination and assimilation of current information necessary for their understanding, which has resulted in a serious gap in environmental awareness among many Africans (Ekpenyong, 2009).This information is further supported by claims that there are relatively limited number of studies on environmental awareness in developing countries and those published, lack a policy or oriented view (Iizuk, 2000). Therefore, it is important that an empirical study on environmental awareness is carried out in developing countries in order to: firstly, collect basic information, secondly, justify the validity of method; and thirdly, incorporate the outcome into the environmental policy making process.

People's awareness is now considered as a tool to promote environmental policy and has the potential to be powerful in the environmental sphere. As per Agenda 21 (Unite Nations, 1992), the increasing role of citizen's participation on global agenda, the emergence of global environmental issues which demand holistic solution, the rapid

development of information technology, the increasing globalisation of economy and its impacts on environment all indicate the necessity of a method which induces changes in individual's behaviour in the long term.

Yushania alpina is indigenous to Kenya and has been exploited for years regardless of its ban in 1986 (Ongugo *et al.,* 2000; KEFRI, 2008). Although it is not an integral part of Kenya's economy, it plays a very important role socially, economically and ecologically in areas where it occurs naturally and where it is introduced. The draft bamboo policy of 2010 stated that until bamboo has an economic value, the remaining bamboo forests will continue to be under threat.

In Kenya, research on bamboo has taken place since the 1980's where the ecological importance of *Yushania alpina* was first documented by Were in 1988. Since then, a series of studies have been conducted; further emphasising the significance of bamboo. The study by Were(1988) on *Y. alpina* highlights how the species interacts with flora and fauna. It highlighted the importance of *Y. alpina* and the vital role it plays in the survival of a number of species as well as in water retention and soil conservation. This was further supported by Kigomo (1988); Ongugo *et al.,* (2000) and Lobovikov *et al.,* (2005), who described the distribution of *Y. alpina* throughout East Africa. Kigomo, (1988); Clayton *et al.,* (2006); Lobovikov *et al.,* (2005); Kigomo (2007b) and KEFRI (2008) further gave *Y. alpina's* botanical description and growing habits. Two studies, including the IDRC's report by Minae (1989), highlight the challenges of socio-economics of bamboo in Kenya. The studies' main findings are that the supply of bamboo could not meet its demand and thus encourages the uptake of planting bamboo by farmers as live fences. The study also sets a number of measures such as developing policy to promote bamboo throughout the country. The IDRC report

however fails to relate the aspect of ecological awareness of indigenous bamboo. Nevertheless, Minae (1989) emphasizes that a socio-economic feasibility study needs to be conducted so more is known on the economic and biophysical potentials of introducing and establishing other bamboo species for production. As such measuring the ecological awareness of indigenous bamboo is important in gathering information on *Y. alpina*. Nonetheless, this report was insightful on a number of areas that had not been documented before.

The study by Ongugo *et al.*, (2012) demonstrates the benefits of growing a number of exotic species of bamboo in the Kenya. The study also encourages communities in Mt Kenya area to adopt habits of planting bamboo as it has positive benefits to the environment. The socio-economic aspects of this study include the socio-economic status of local communities within Mt Kenya, the status of bamboo cultivation, the processing and cultivation in Mt Kenya and potential human-wildlife conflicts that might arise due to bamboo cultivation. However, this study fails to measure ecological awareness of indigenous bamboo within the community around Mt Kenya. Furthermore, due to the fast growth rate of Eucalyptus, a number of farmers in the Mount Kenya region prefer planting this tree, which is considered more profitable. This tree however, is said to be detrimental to the environment and bamboo has been suggested as an environmentally-friendlier alternative (Divya, 2014; Ongugo *et al.*, 2012).

2.5 Economic Activities Related To Bamboo

World Bamboo Organization (2012), states that the most economic viable species belong to *Arundinaria*, *Bambusa*, *Cephalostachyum*, *Dendrocalamus*, *Melocanna* and *Ochlandra* genera. The list of possible uses of bamboo is extensive as it is a very

versatile material. Around the world, bamboo is used for over 1500 purposes (Muller & Rebelo, 2011).

Bamboo as a plant is used for ornamental, ecological and agro-forestry purposes. Bamboo as a material is used in the cottage industries, wood industry, pulp and paper industry, food and beverage industries, for machine processed products, bioenergy and in the chemical industry (Liamm, 2013)

Kigomo (2007a) noted that there are 48 uses of bamboo in Kenya. He further stated that *Yushania alpina* is mainly used for fencing (mostly untreated) and the construction of nursery beds, houses (in very remote areas), basket weaving and for covering coffee. Kigomo (1988) states that in the 1940's, bamboo was used for carrying arrows and storage of food materials (in hollow cut culms).

Bamboo is also used for making curios, ornamental baskets, tooth picks, lampshades, and pen-holders; (Ongugo *et al.*, 2000; Kigomo, 2007a). Although Kigomo (2007a) lists the uses of bamboo in Kenya, the information provided is not based on a comprehensive survey, hence the need for the proposed research. Moreover, Kigomo (2007a) fails to capture the value of bamboo that is used within communities.

2.6 Economic Potential of Indigenous Bamboo

Economic potential can be defined as the income that is generated from a particular product if some or all its resources are partially or fully employed according to Watts (2008). Worldwide, over 2.5 billion people trade in or use bamboo in domestic trade and subsistence use. The trade was estimated to be worth USD 4.5 billion per year in 1999 and global exports of USD 2.7 billion. Additional (non-priced) socio-economic

benefits attributed to bamboo include enhancement of women's and marginalized groups' economic position and mainstreaming of the rural poor in market economies (Boa, 2006)

Commercial consumption of bamboo in the world is to the tune of USD 10 billion and is expected to reach USD 20 billion by 2015 (Muller & Rebelo, 2011). There has been a growing awareness in recent years that bamboo is a vital component of development and an effective means to improve the livelihoods of rural people. Bamboo's lightweight, high elasticity and resistance to rupture makes it ideal for housing in areas prone to natural calamities.

More than a billion people live in homes made of bamboo, or employ it as the key element in their structural cladding or roofing (Magati *et al.,* 2012). Bamboo is commonly used to make fences and shade homes, and to construct bridges. With tensile strength as strong as steel, and a weight-to-strength ratio greater than graphite, bamboo poles have been lashed together for scaffolding for many years. It is an important species for landscape and provides shade, windbreak and acoustical barriers. Bamboo and its related industries provide income, food and housing to over 2.5 billion people in the developing countries. It is a viable replacement for wood as an industrial raw material for traditional and modern sectors and is integrally involved in culture and arts (Brias, 2006).

Large and continually growing local, national and international markets exist for handicrafts, boards, fibre products, paper and pulp, different variations of timber sticks, charcoal and intermediate products for further processing, such as slivers and splits (Letsholo *et al.,* 2007). Bamboo poles are widely used for house construction in

many countries, while bamboo shoots have become high value food exports in China worth USD 50 million per annum (World Bamboo Organisation, 2012). Appropriate market-based selection of products can provide flexibility to producers to ensure income during crop failures, thus promoting sustainable resource use and development (Magati *et al.*, 2012). The International Trade of Bamboo and Rattan 2012 ranks Kenya as 38th in the world in terms of exporting Bamboo goods which accounted for USD 2490 million, however this figure was an estimate data due to lack of accurate data.

As stated earlier, in Africa the success of bamboo has not been well-documented. However, bamboo has started gaining popularity after several studies such as one by Erie *et al.*, (2011) in Nigeria, Endalamaw *et al.*, 2013 in Ethiopia and Ingram & Tieguhong, (2013) in Cameroon, highlighting the diversity and uses of bamboo species in their respective countries. There is a general consensus in many regions that investment in bamboo technology can become more profitable bearing in mind that it is the fastest growing 'tree', which can be repeatedly cut without having to be replanted.

Furthermore, bamboo finds uses in the paper, food, housing, furniture and craft industries, which are key economic activities in many African countries. The IDRC's report on 'Green Gold' (Kigomo, 1992) was the first of its kind to indicate the potential value of bamboo in Kenya. The authors pointed out the importance of introducing exotic species since *Y. alpina* only occurs in the highlands. The report further mentioned the lack of awareness of the economic potential of bamboo; hindering bamboo development in the country. To provide more information on this, several studies have been carried out in Kenya since then. For example the study of Magati, Kibwage *et al.*, (2012), which examined the economic and financial benefits and costs

of farming bamboo as a crop substitute of tobacco in four districts in South Nyanza, Kenya, and showed that bamboo, can be a more profitable substitute. This is in response to the World Health Organisation's Framework Convention on Tobacco Control whose aim is to mitigate the tobacco epidemic and for signatories such as Kenya to provide support for economically viable alternatives. The results of the study highlighted that total enterprise cost of farming bamboo is higher at KShs 56,835 compared to the KShs 35,084 for tobacco net income per acre. Furthermore, the net income per acre for bamboo is KShs 183,600 and that of tobacco is KShs 58,452, which is only 31% of what a bamboo farmer would make. However, this is possible if it is well managed, and the government and the people in South Nyanza are committed towards bamboo cultivation. The benefits of this include restoration of the environment and food security. The authors urged the government to contribute towards encouraging farmers to grow bamboo and provide incentives to the farmers. The study primarily focused on exotic species introduced to the area such as *D. giganteus* and *B. vulgaris* since *Y. alpina* is not suitable for low land areas. It is important to highlight that though the study did not cover the ecological awareness of bamboo by the community, it did however show economic potential of bamboo, making it a sustainable alternative to tobacco. The study also took into consideration other products such as baskets that could be made from bamboo to generate more income and thus improving the livelihoods of the community.

A United Nations Industrial Development Organization (UNIDO) report (Brias, 2006) on 'Bamboo Plantations for the Eastern Africa Bamboo Project, Kenya, With a Feasibility Study For a 100 Ha Plantation' gives a detailed account of all bamboo-related activities within Kenya and also gives a projection of the economic potential of bamboo in various parts of the country. This report primarily focused on 10 exotic

bamboo species. The report further states that 99.4% of bamboo utilized throughout Kenya is extracted from Government forests, 88% of which is illegal. This in turn forces a black market nature of bamboo trade in Kenya, making it very difficult to estimate the market value of bamboo. The report assumed the real cost of *Y. alpina* to be about KShs 40 per culm, therefore meaning the total value of illegally extracted culms to be about KShs 112 million. More worryingly, by the time the bamboos reach the processing areas or hardware stores, this value will be multiplied many times over.

Ongugo *et al*.,(2000) give a detailed account of the market value of bamboo in Kenya. This study focused on the current market of bamboo within Kenya focusing both on *Y. alpina* and exotic bamboo species. The study is of great significance, however it is rather out-dated and thus highlighting the importance on evaluating the economic potential of indigenous bamboo all over again, given the many drastic economic changes that have occurred in the last decade.

2.7 Constraints and Opportunities of Conservation of Indigenous Bamboo

As stated earlier, bamboo has over 1500 documented uses and presents several opportunities making it ideal for economic, environmental conservation, household and industrial use, highlighting how bamboos are among the plants most widely used by humans (Liamm,2013). These examples highlight the versatility of bamboo species and new ventures, especially job opportunities in various fields such as marketing, biodiversity conservation, construction, farming and many more that this non-timber species offers (Brias, 2006; Muller & Rebelo, 2011; Yiping *et al.*,2010; Clayton *et al.*, 2006; Romualdo, 2006; Awadh, 2010; Ongugo *et al.*, 2000).

According to (African Development Bank, 2014) the main challenge Kenya is facing today is to generate economic growth that is more inclusive in order to more effectively reduce poverty across the country. The country aims to do this with a low carbon footprint. Investment in Bamboo sector can be a key tool, success in bamboo alleviating people from poverty is seen in Asia (Lobovikov *et al.,* 2005). Such success stories have been witnessed in Kenya with various newspapers publishing stories on millionaires arising from bamboo (Kiarie, 2014; Ondongo, 2012).

However, bamboo has not been exploited to its full potential in the many regions where it occurs. A number of studies have highlighted reasons as to why bamboo farming has not been popular within Africa (Lobovikov *et al.,* 2005) and in Kenya (KEFRI, 2008; Statz *et al.,* 2007; Kigomo, 2007a; Ongugo *et al.,* 2000). The major constraints include; lack of awareness, inadequate technology, market-chain systems for bamboo product and the lack of policy, as discussed by (Ongugo *et al.,* 2012; KEFRI, 2008; Kigomo, , 2007a; Statz *et al.,* 2007; Brias, 2006; Ongugo *et al.,* 2000; Minae, 1989).

For bamboo to thrive, it is important that the constraints are identified and addressed for progress to occur. It is also essential that the economic and ecological values of bamboo are acknowledged and exploited to their full potential. This will ensure that there is sufficient knowledge and skill sets to guarantee that future generations can benefit from this resource.

2.8 Policy and Legislation in Kenya

Kenya has several laws and regulations that shed light on how bamboo should be managed. However, there is a draft policy that is singularly directed to bamboo usage. Below are some of the guidelines:

The Constitution of Kenya, 2010, is the supreme legislative instrument in Kenya, which provides every person the right to a clean and healthy environment as stipulated in Chapter 4, Article 42. The Article confirms the sustainable use of natural resources such as indigenous bamboo. Further on, Article 69 under Chapter 5 outlines obligations with regards to the respect of the environment, which include elimination of processes and activities that are likely to endanger the environment. The Fourth Schedule puts emphasis on protection of the environment as well as natural resources with view of establishing a durable and sustainable system of development, bamboo if utilised in the right manner can assist in achieving this. The second part of the schedule focuses on implementation of government policies on natural resources and environmental conservation including soil and water conservation as well as forestry, bamboo can be used to conserve the environment.

In line with the new constitution as indicated in chapter 11 on devolution of the government, an outline of the county government's powers, functions and responsibilities are discussed. The objectives of devolution include the promotion of social and economic development, as well as the provision of proximate, easily accessible services throughout Kenya. The County Governments Act 2012 gives functions of various bodies so as to achieve its main objectives. Sustainable use of *Y. alpina* and exotic species in counties can aid counties in achieving social and economic development. Counties where bamboo occurs naturally should take advantage of this grass.

Kenya's Vision 2030 (2007), outlines Kenya's long-term national planning strategy, covering the period 2008 – 2030. The Vision is based on three 'pillars': economic,

social and political. The environment is identified as a key area under the social pillar, where the goal of a clean, secure and sustainable environment by 2030 is envisioned. The goals for 2012 include increasing the forest cover from 3% to 4%, to achieve this flagship environment projects that are related to forest management were initated and this include the water catchment management initiaitve, which calls for rehabilitating the 5 water towers (notably, Mau Escarpment, Mount Kenya, Aberdares Range, Cherengani Hills and Mount Elgon). It is important to note that *Yushania alpina* occurs in all these forests, further highlighting the need to protect these areas.

In addition to Vision 2030, the Second Medium Term Plan (MTP) of 2013 - 2017 recognises the importance of bamboo in Forest Conservation and Management. The MTP highlight that ecosystem and participatory forest management plans will be prepared to support sustainable forest management. Bamboo as an avenue for commercial forestry and other nature based enterprises will be promoted for poverty alleviation and environmental sustainability. This programme will be implemented both on farmlands and dry-lands in collaboration with Community Forest Associations. Farm and dry-land provide the best opportunity for increasing the tree cover to 10 per cent. Farmers will be encouraged to integrate planting of appropriate tree species on their land to increase the availability of tree products on farm and also attain the requisite forest cover.

The Environmental Management and Coordination Act (EMCA), 1999 provides for the establishment of an appropriate legal and institutional framework for the management of the environment. Bamboo can help achieve a number of processes outlined in this act such as environmental restoration, environmental conservation just to name a few.

The National Environment Policy, 2013, mandates for environmental protection and conservation. Bamboo is presented under the section on Management of ecosystems and sustainable use of natural resources. Here, it is acknowledged that ecosystems provide a wide range of goods and services. These include provisioning, regulating, cultural and supporting services.

The Forests Act, 2005, provides for the establishment, development and sustainable management, including conservation and rational utilisation of forest resources for the socio-economic development of the country. It recognises that forests contribute to a number of ecosystem services. The Act recognises bamboo, as a "Tree". Bamboo is also regarded as part of the "indigenous forest", which means a forest that has come about by natural regeneration of trees, primarily native to Kenya, and includes mangrove and bamboo forests.

Kenya's last authoritative statement regarding the forest policy was contained in Sessional Paper No.1 of 1968. Due to significant changes in the country such as increasing population densities, leading to further exploitation of natural resources, there was need to amend the old policy; thus the formation of the Forest Policy of 2007.

The new Forest Policy 2007 addresses indigenous forest management, farm forestry, industrial forest development, dry land forestry, forest health and protection, private sector involvement and participatory forest management. It recognizes that there are benefits arising from involvement of local communities and other stakeholders in forest management. The policy recognises bamboo as part of the indigenous forest just at the Forest Act 2007 does. It highlights the importance of indigenous forests and

acknowledges that they are among the most complex ecosystems that need efficient management.

The Draft Bamboo Policy's (2010), main objective is to show bamboo's potential as a significant non-timber forest resource. Bamboo can play a role in the reduction of timber consumption, environmental and forest protection, poverty alleviation through the generation of income and employment in both the rural economy and industrial development. The draft policy further highlights that the current ban needs to be rescinded and a comprehensive utilisation policy put into place. The policy's goals are: recognise bamboo as a significant non-timber forest resource acknowledging its full ecological and economic potential in the country; acknowledge the goals and principles of Kenya Vision 2030, National Climate Change Response Strategy, as well as other sectoral polices; and sustainable development of bamboo resources for conservation of critical watersheds, and the promotion of the bamboo industry. This Draft Policy also targets private bamboo plantations as well as a proposed legal and institutional framework that will ensure this natural resource will benefit Kenya and its entire people.

Sessional Paper No.1 of 1999 and the Water Act 2002, state that under this Act, the Minister may declare an area to be a protected catchment area and order, require, regulate or prohibit certain forestry activities considered to be not in public interest. This Act is ideal for catchment protection and protection of water sources within the forests such as the natural bamboo ecosystem range in the country.

The Energy Act (2006), ensures that all key stake holders including ministries, NGOs and other organizations address environmental problems related to usage and supply

of energy sources (charcoal and fuel wood). The Act supports the promotion and development of renewable sources of energy, especially through agroforestry and the conservation of energy through appropriate technologies. Due to high consumption of fuel wood in Kenya, bamboo can substitute wood as an energy source.

In addition to the above frameworks, Kenya is a signatory to several multilateral environmental agreements (MEAs) that address the importance of indigenous bamboo, some of the MEAs Kenya has ratified include the Convention on Biodiversity (CBD), African Convention on the Conservation of Nature and Natural Resources, Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter illustrates the research design used to collect data. It further describes the locale, as it shows the environmental profile of Kieni area, Gakoe Location. Sampling procedures and data collection methods that were used in the study are also discussed. Finally, the data analysis and presentation procedures are laid out.

The study engaged community members living in Gakoe Location, which is within a 5 Km radius from Kieni forest and the Kenya Forest Service Station Unit. The close proximity of the forest supposed that there would be a high frequency of interacting with the forest, making the community suitable candidates to partake in the study regarding ecological awareness as well as any activity.

3.1 Limitations of the Study

i. Respondents who were engaged in economic activities related to bamboo did not have receipts of purchases and sales made. Therefore the study only relied on what the respondents said.

ii. Language barrier. Competent local research assistants were trained and used in the study for language translation purposes.

3.2 Assumptions of the Study

The study assumed that there would a small number bamboo-related economic activities in Gakoe area and that respondents would be willing to partake in the study to establish the constraints and other important factors

3.3 Study Area

Kieni forest station is a gazetted forest under Legal Notice No.48 of 1943. It is located in the Kikuyu escarpment which is part of the Aberdare forest reserve ecosystem. It boarders Kimakia forest to the North East, Ragia forest to the North, Kinale forest to the south and Kamae forest station to the West.

Kieni forest station has a total area of 13,723.6 Ha and is divided into three blocks namely Kieni, Ndaragu and Gakoe. The blocks are further subdivided into 5 beats, which are the smallest administrative units, Kieni (station beat); Ndaragu (Makohokoho and Gacharage) and Gakoe (Gakoe, Mataara). For this study, Gakoe area was the main focus. The area lies between latitude 1° 05'00S, and longitude 36° 49' 00E at an average altitude of 1768m above sea level (Figure 3.1)

The western part of Kieni forest can be described as almost flat while the eastern part of the forest is characterized by gentle slopes of indigenous forest. Dominant topographical features in Kieni ecosystem include: valleys, ridges and hanging hill tops (Kenya Forestry Services, 2012).

The forest lies at an altitude of 2,200 to 2,684 m above sea level. The area experiences a total rainfall of between 1,150 mm and 2,560 mm annually. The long rain season is between March and June, while the short rain season is between October and December. The driest months are February and September (Kenya Forestry Services, 2012).

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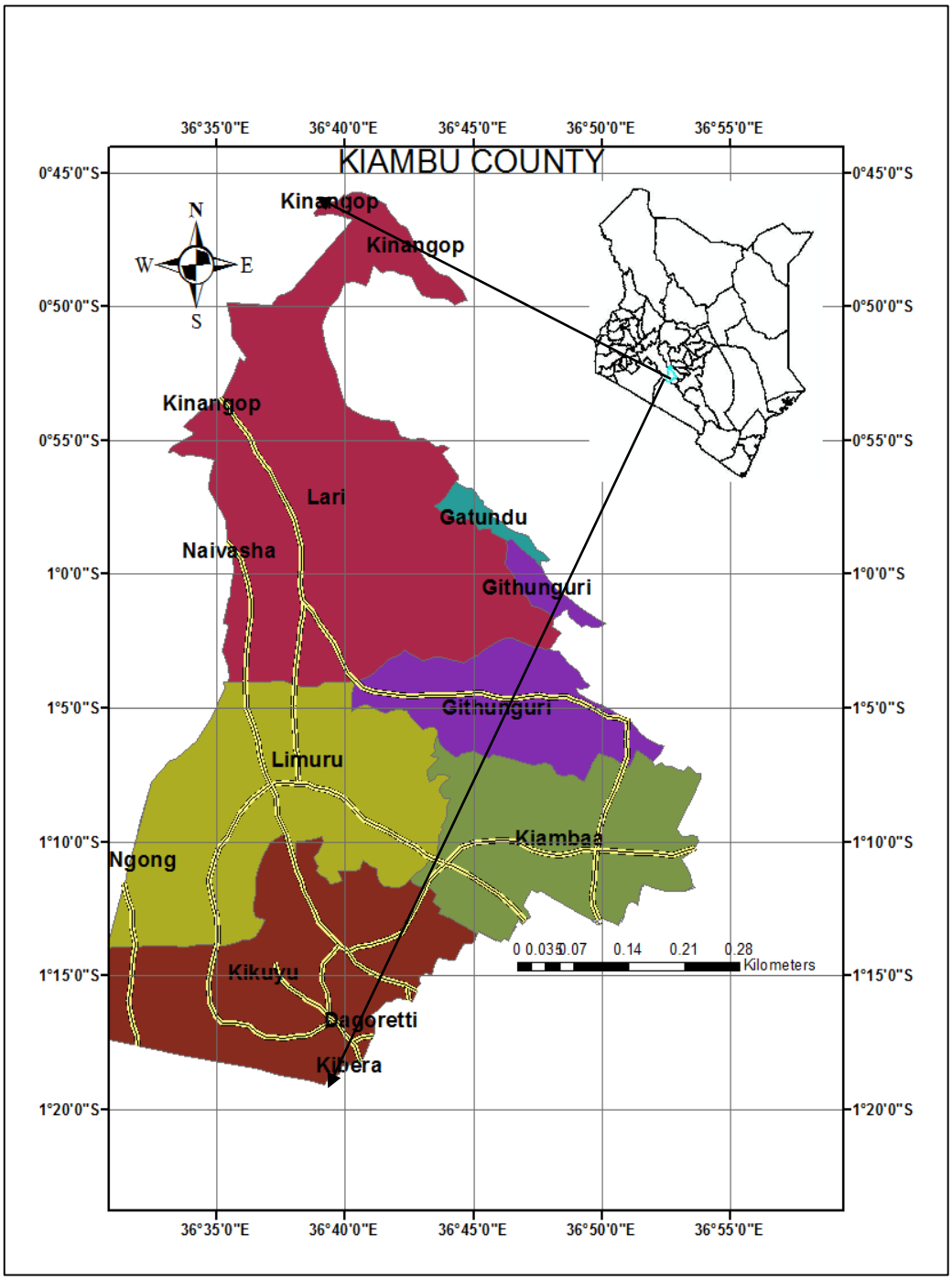

Figure 3.1: Map Showing the study site which is in Gatundu location, Kiambu County adapted from (Kenya Forestry Services, 2012)

Kieni forest ecosystem lies within volcanic rocks of tertiary age (including, tuffs, porphyritic olivine, trychalates, basalts and basaltic agglomerates). The soils of Kieni forest are rich in organic matter, making them very fertile. This leads to thick development of forest undergrowth.

There exists variation in vegetation structure, cover and composition in the indigenous forest except in plantations where monoculture is practiced. Vegetation zones and species distribution depends on variation in climatic zones and altitude.

3.3.1 Vegetation

Vegetation types are divided among exotic, which constitutes species such as *Eucalyptus*, *Cupressus*, *Pine* and *Acacia mearnzii* and occupies a space of 1552.9 Ha. The other divisions are dominated by indigenous shrub type vegetation that occupy 7789.1 Ha of the forest and include rare and restricted forest tree species that occur on the lower parts of the forest. These include *Ocotea usambarensis* and *Olea hochstetteri*. Bamboo covers 4222.6 Ha and occurs between 2400m and 3000 m above sea level. They cover most of the northern part of Kieni forest. Lastly, grasslands cover 159 Ha to give Kieni forest a rich floral diversity (Kenya Forestry Services, 2012).

3.3.2 Fauna

Kieni ecosystem constitutes an important reservoir for biodiversity. The ecosystem is rich in a wide range of fauna ranging from small to big game. The animals are of great conservation interest especially in the whole of the Aberdares National Park region, which is a World Heritage Site under the *United Nations Educational, Scientific and Cultural Organization***.** Animals that are dominant in the indigenous sections of the forest include the African elephant (*Lexodonta africana),* the duiker (*Neotrragus*

moschatus), Bush pig (*patomochoerus porcuso),* Porcupines (*Hystrux africaeustalis),* Bush baby (*Galago Senegalenses),* Mongoose ***(****Helogale parvula*) and tree hyrax (*Dendrohyrax arboreus)*. There also exists a number of primates such as Black and white Colobus *(Colobus guereza)*, Skye's monkey (*Cercopithecus mitis*) and Baboons (Kenya Forestry Services, 2012).

The ecosystem is also an Important Bird Area (IBA), which provides a critical habitat for endangered, rare or a significant number of different bird species. These include Abbott's starling (*Cinnyricinclus femoralis*), Jackson's francolin (*Francolinus jacskoni*), Hunter's Cisticola (*Cisticola hunter*), African Green ibis (*Mesembrinibis cayennesis*), Red-chested Owlet (*Glaucidium tephronotum*) and Crowned hawk eagle (*Stephanoaetus coronatus*) (Kenya Forestry Services, 2012).

Another point that further highlights the important economic and ecological values of Kieni forest is its watershed and water catchment capabilities. The ecosystem is a source of four (4) rivers namely Chania, Kariminu, Ndarugu and Thiririka rivers, while a chain of streams bisects this forest. The ecosystem is a vital watershed, providing water to households and farms adjacent to the reserve before flowing down to feed big rivers that sustain thousands of lives in Eastern and Coastal provinces.

3.3.3 Economic Activity

Agriculture is the main economic activity for the communities living adjacent to Kieni forest. It was observed that the communities living adjacent to Gakoe forest block are mainly agriculturalist. The key agricultural activities that are practiced include growing cash crops such as tea and coffee, dairy farming, subsistence farming and agro

forestry consisting of both indigenous and exotic species, where the dominant species is *Grevillea robusta*.

The agricultural activities depend on the existence of Kieni forest indirectly or directly. The forest regulates the micro climate of the area in terms of temperature, rainfall, soil fertility and pollinators. The forest is also a source of water for micro irrigation activities, fodder for the dairy industry and fire wood for domestic use (Kenya Forestry Services, 2012).

3.4 Study design

The study adopted descriptive research design which determines and reports the way things are (Mugenda & Mugenda, 2003). Descriptive design was best in this study as the study was carried out within a limited geographical scope and was simple to conduct. Cross sectional survey was undertaken which is descriptive in nature, it involves gathering of information from a population or a sample at a point in time (Mugenda & Mugenda, 2003). This research design was able to measure the independent variables such as the socio demographic characteristics of the given sample size. The dependent variables were economic activities, economic potential and awareness of ecological benefits of bamboo within the community.

3.5 Target Population

The residents of Gakoe are mainly agriculturists, with over 80% of the community being involved in agricultural activities in one way or another. The 2009 census report states that Gakoe has a total of 3,841 inhabitants and 470 households. For this study, questionnaires were distributed to heads of households.

3.6 Sampling Techniques and Sample Size Determination

To identify the households, there was communication with the sub-chief who gave his assistance by providing a list of all the households. Simple random sampling was employed.

The sample size was determined by rule of thumb, described as a conventional or commonly accepted amount (Neuman, 2011). He states that the smaller the population, the larger the sampling ratio has to be for a sample. For a small population of fewer than 500, a large sampling ratio of 30 % is used. As per the 2009 census, there are 470 households in Gakoe, using a sampling ratio of 30%, 141 households were identified. Mugenda & Mugenda, 2003 recommend that 10% of sample size population is needed to account for non-response which equals 14 households. Therefore, a total of 155 households were identified and used for this study. The study involved heads of households answering semi-structured questionnaires.

The study engaged heads of household members living in Gakoe Location, which is within a 5 Km radius from Kieni forest and the Kenya Forest Service Station Unit. The close proximity of the forest supposed that there would be a high frequency of interacting with the forest, making the community suitable candidates to partake in the study regarding ecological awareness as well as any activity.

All the households in Gakoe were first numbered then chosen randomly by drawing out a number from a hat, until the number required was completed. The study employed five assistants who were selected by the chief, they were conversant with the study area, and were also conversant with all the local languages spoken within Gakoe that would assist when distributing the questionnaires. The lead researcher with the assistants would go directly to the household number drawn from the hat. In the

case where the researcher and assistants could not locate a household, the chief was used to give guidance.

3.7 Research Instrument

The key research instrument used in this study was a semi-structured questionnaire (see Appendix 1) , which poses a number of advantages when conducting this type of research due to the ability of the principal investigator to generate a large amount of detailed data. Data collected from such an instrument is often easy to analyse and is reliable.

Semi-structured questionnaires were selected as the means of data collection because of two primary considerations. First, they are well suited for the exploration of the perceptions and opinions of respondents regarding complex and sometimes sensitive issues and enable probing for more information and clarification of answers. Secondly, they were well suited to document the varied professional, educational and personal histories of the sample group.

Key questions were asked to identify the key economic activities, as well as to observe the ecological value of *Y. alpina.* The questionnaire was extensively pre-tested for clarity and comprehensiveness. Three questionnaires were distributed during the pre-testing; this resulted in removal of irrelevant information which ensured that the instrument is both valid and reliable.

3.8 Data Collection

Data used was obtained from primary and secondary sources. Secondary data were collected via an extensive desktop review and analysis from text books, scientific

journals, periodicals, and reports, published and unpublished theses. To support the review and analysis, primary data was collected through a participatory consultative approach and discussions with key respondents to collect the relevant data on the ecological and economic potential of bamboo in the Kieni forest area. The assignment employed a simple structured survey to capture quantitative information. During the data collection period, all the social-demographic information required for the study was collected, this included age, gender, education status, occupation and land size. Ethical considerations were assumed when distributing questionnaires; all respondents were above 18 which is the legal age in Kenya. Consent to answer the questionnaire was given, participants were also assured privacy and that all information obtained would remain strictly confidential.

Field observations consisted of systematically observing and documenting bamboo related economic activities in their natural setting. This helped to verify the information given by the respondents and to understand the situation on the ground. Photographs were taken to capture images significant to the study.

The data was collected from a sample size of 155 household heads that were in a radius of 5 km around Kieni forest of the Aberdare range forests, Gakoe Location in Kiambu County. The main respondents who were head of households that had interactions in one way or the other with Kieni Forest were randomly sampled. For the purpose of answering research questions, the researcher, assisted by well-trained research assistants which included a 2 hour workshop was held in which a mock administration of handling of questionnaires was undertaken to ensure the assistants were conversant with the process. A total of 124 questionnaires according to Baruch & Holtom, (2008) a response rate of over 60% in any study is deemed to be adequate. Therefore, the

response rate of 80% during data collection, was very adequate for analysis, recommendations and conclusions.

3.9 Data analysis

The questionnaires were first checked for completeness, cleaned and coded to represent specific responses to specific questions using the Statistical Package for the Social Sciences software (SPSS). Quantitative data was analysed using descriptive statistics such as means and percentages of sociodemographic information collected including age, occupation, land size, educational level attained. Correlation analysis was conducted to determine the relationship between community members and the various variables that help to identify or determine the objectives related to economic potential of bamboo as well as the ecological value of indigenous bamboo. The collected information was then categorized in themes in line with the studies objectives and data was then analysed. The results were presented in the form of text, table, charts and photographs.

CHAPTER 4: RESULTS AND DISCUSSION

4.0 Introduction

This chapter discusses relevant data which was collected, here data is analysed as per objective. The chapter first discusses the important socio-demography of the area, it then discusses the first objective, the second objective and lastly the last objective. In this chapter both descriptive and inferential statistics are discussed.

4.1 Demographic Data

The socio-demographic variables used in the study were age see table 4.1, gender ,education status, occupation and land size these were imperative to determining the awareness of the ecological value and economic potential of *Yushinia alpina* bamboo in Gakoe location.

Table 4.1: Age of respondents

Age (years)	Number of respondents	Percent (%)
18-35	49	39.9
36-60	59	47.5
61	16	12.6
Total	124	100.0

Most of the respondents were aged between 36 and 60 years. They represent 47.5% of the respondents (Table 4.1). This group was very important as it represents a group of older adults who had crucial experiences and information about the area. The results of the study were further enhanced by a 39.9% of young adults aged between 18 and 35 years. Over 40% of the population survive through sustenance farming, this means that a majority of the population is able to observe and notice most drastic changes in

the environment. Among these is the importance of bamboo to the surrounding communities, which proved useful environmental and socio-economic benefits.

In this study, 34% of household heads were women and 66% were men. The study found that both women and men were involved in farming and business activities.

Table 4.2: Education level attained

Education level attained	**Number of respondents**	**Percent (%)**
Primary	40	32.3
Secondary	52	41.9
Tertiary	28	22.6
Other	4	3.2
Total	124	100.0

On average, the households have basic education. This is confirmed by education variables which indicate 74.2% having a primary education, 41.9% having a secondary education, and 22.6 % having been educated till tertiary, only 3.2% of the respondents had no form of formal education (Table 4.2).

Forty six point two per cent (46%) of the respondents were involved in farming. This is supported by the fact that Kieni Forest is located in Central Kenya, a region known for fertile lands (KFMP, 2011-2013). Figure 4.1 shows the different occupations within the community; 37% are involved in business activities, showing people are participating in the economy of the area. Twelve percent (12%) of the respondents were involved in other activities, or were unemployed at the time of data collection.

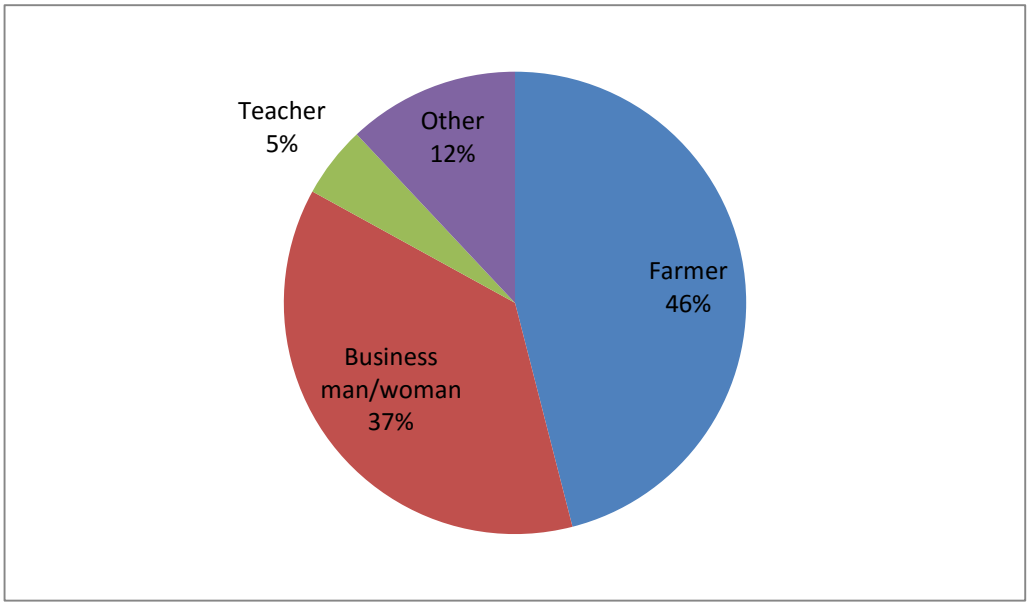

Figure 4.1: Occupation of respondents

Agriculture was an important activity in Gakoe. The major cash crops observed in the area were tea and pineapple. However, due to a growing population density and sub-division of land, a majority of the residents only had small portions of land for farming purposes. This is shown in Table 4.3 where 56.3% of the respondents used 0.2 hectares or less of land and only 2.9% used more than 0.8 hectares. More importantly, 97.1% of people practiced agricultural activities on less than 0.8 hectares.

Table 4.3: Size of land used for agricultural activities

Land size (ha)	**Frequency**	**Percent (%)**
less or equal to 0.2	70	56.3
0.24-0.40	34	27.7
0.41- 0.8	16	13.0
0.81 and more	4	2.9
Total	124	100.0

4.2 Awareness of the Ecological Value of *Yushania alpina*.

Respondents were asked questions regarding the animals that feed on *Y. alpina* in the area. A total of 89% of the respondents reported seeing or having knowledge of animals feeding on *Y. alpina* with elephants being the most common at 57%. Domesticated animals such as cows, goats and donkeys were observed eating bamboo shoots or grass by a 24 % of the respondents. Only 11% were unaware of any animals feeding on *Y. alpina*. The close proximity of Kieni forest and Gakoe settlement as well as the frequent visits members of the community take to and fro, it was evident that communities had witnessed the associated with bamboo and wildlife. The community also noted that domesticated animals such as goats caused destruction of young bamboo by feeding on them (Figure 4.2).

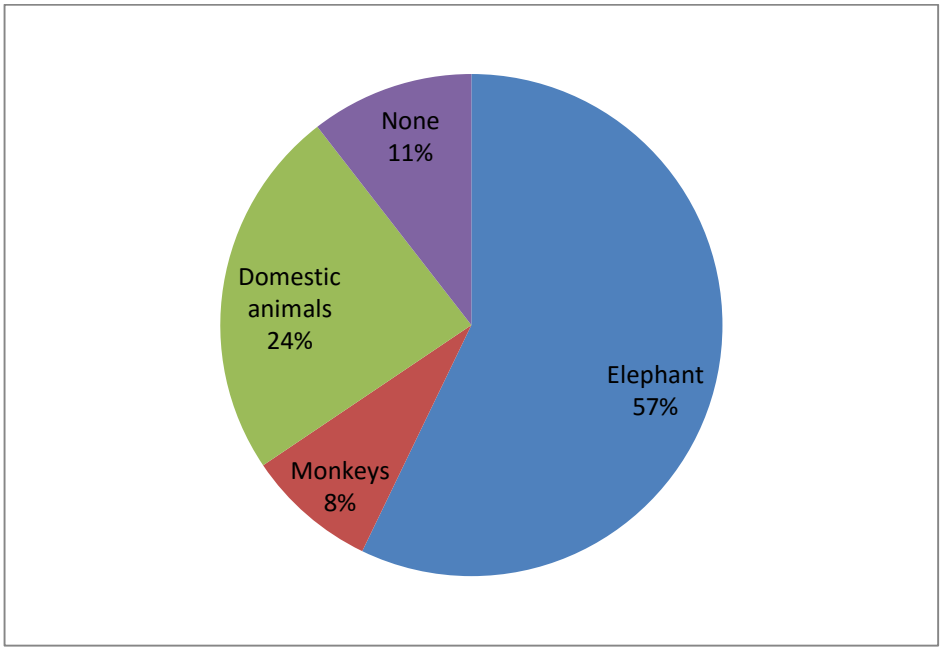

Figure 4.2: The Animals that feed on bamboo

To support the objective, a series of questions were asked to determine the importance of bamboo. These results are presented in Figure 4.4.

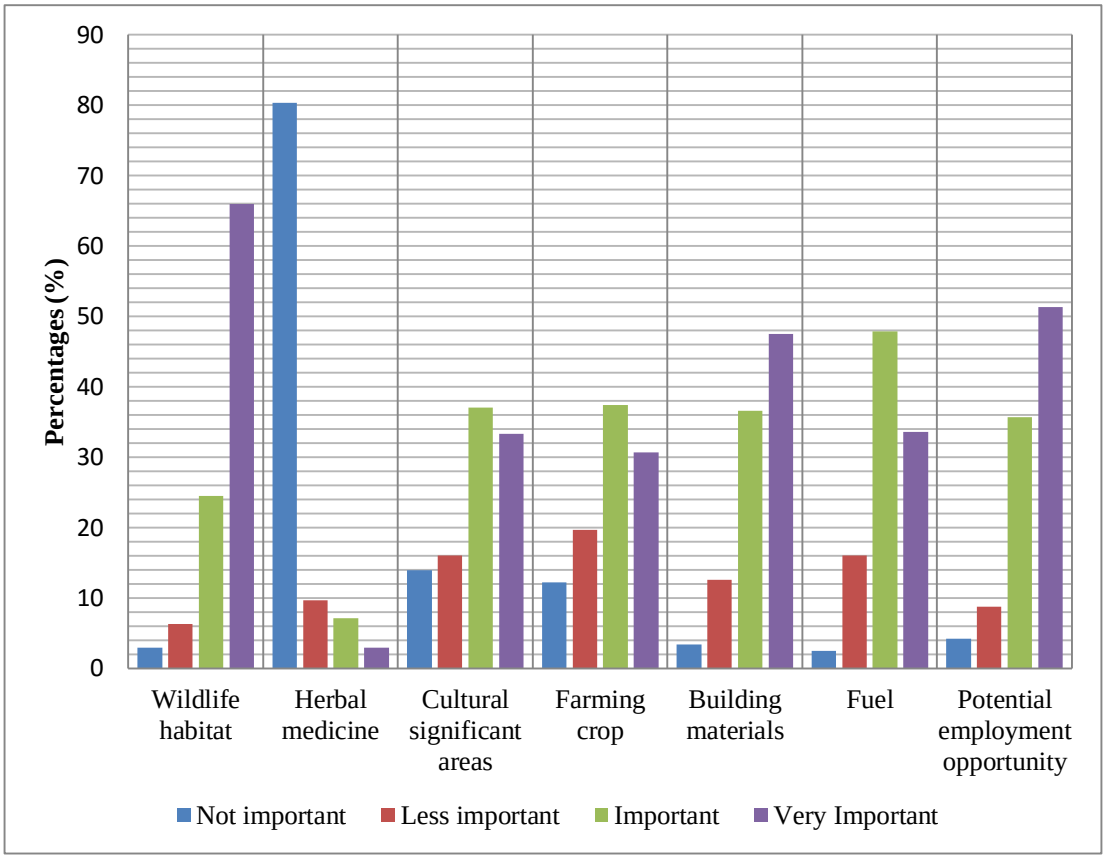

Figure 4.3: Graph showing how respondents ranked the ecological value of bamboo

The results showed that 66% of the respondents ranked that bamboo is a vital component of wildlife habitat. They understood that bamboo is needed for food especially for wild animals such as elephants and monkeys. In addition, 51.3% of the community acknowledged that bamboo had a high potential to create jobs and is valued for its youth employment opportunity; with the current high rates of unemployment in the country (Vision 2030, 2007). Bamboo for fuel (firewood), building materials, a potential farming crop and recreation and cultural significance was seen equally among the respondents. Only 2.9% of the respondents reported bamboo as having herbal medicinal properties. However, Ongungo *et al.*, (2000) documented that bamboo was used as medicine to treat malaria in Cherengani, Mt. Elgon and Mau regions.

Lastly respondents were asked to rank the likely consequences of forest degradation of bamboo (Figure 4.4).

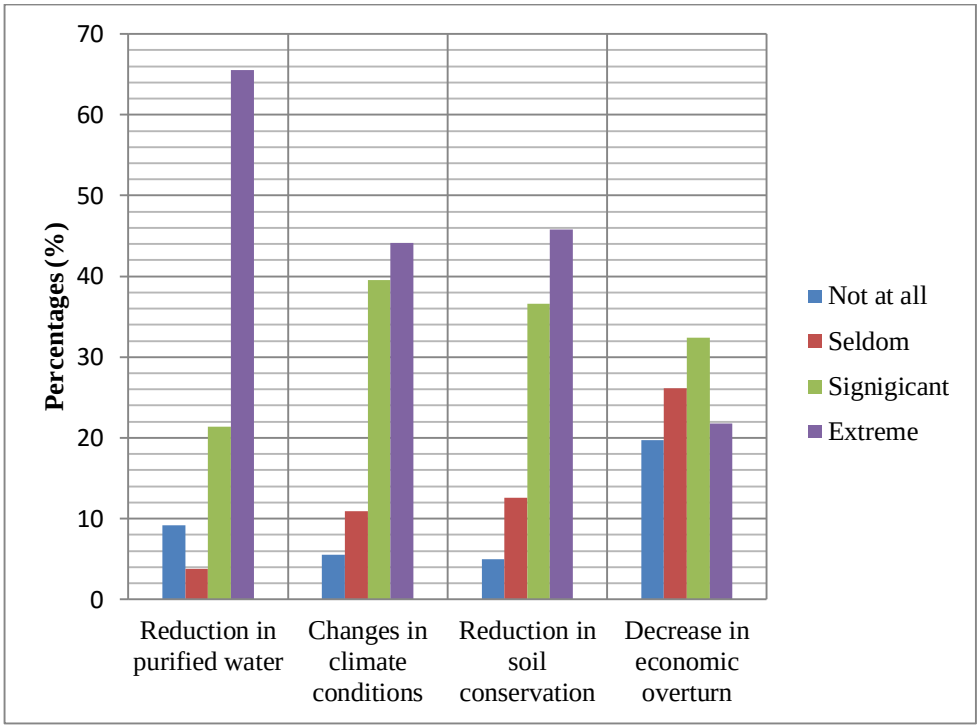

Figure 4.4: Graph showing how respondents rated the likely consequences of the environment if Bamboo deforestation were to occur

The respondents acknowledged that deforestation of bamboo is related to reduction in purified water, changes in climate and reduction in soil fertility. They however did not see this to have a major impact on economic turnover. These results highlight that respondents are aware of the ecological value of bamboo as over 60% of respondents recognising that deforestation of bamboo would result in extreme reduced purified water, however there was a disconnect between bamboo and its economic value as seen in Figure 4.4 only 22% respondents acknowledged that there would be an extreme decrease in economic overturn as. As stated in the Draft Bamboo Policy of 2010; until bamboo is seen to have an economic value there will be continued wasteful harvesting and misuse of this resource.

4.2.1 Ecological Value of *Y. alpina*

Table 4.4: Pearson correlation between Education & Animals that eat bamboo, and correlation.

		Education	What animals do you know that eat *Y. alpina* in this area?
Education	**Pearson Correlation**	1	.028
	Sig. (2-tailed)		.665
	N	124	124

The correlation of knowledge of animals that eat bamboo and level of education attained was (r=0.028) which is a weak positive correlation implying that the education level one attained does not directly affect the knowledge of comprehending which animals eat *Y. alpina* (Table 4.4). Educational status was tested as it was the biggest factor in knowledge uptake.

Table 4.5 Pearson correlation between education status of respondent and the likely consequences of forest degradation of Bamboo

			What are the likely consequences of forest degradation of Bamboo:			
		Education	**1 Reduction in purified water**	**2.Changes in climate conditions**	**3.Reduction in soil conservation**	**4.Decrease in economic turnover**
Education	**Pearson Correlation**	1	.207**	.206**	.234**	.077
	Sig. (2-tailed)		.001	.001	.000	.236
	N	124	124	124	124	124
** Correlation is significant at the 0.05 level (2-tailed)						

A Pearson correlation coefficient that was computed to assess the relationship between education level attained and the likely consequences that would occur if degradation of bamboo were to occur (Table 4.5).

The correlation of education and knowledge of reduction in purified water if degradation of indigenous bamboo were to occur in Kieni forest was ($r=0.207$) at a significance of $p<0.05$, which is a positive correlation implying that the higher the education level attained, the more respondents acknowledged that deforestation of bamboo in Kieni forest resulted in reduction of purified water.

In the second scenario, the correlation of education and knowledge of changes in climate conditions if degradation of indigenous bamboo were to occur in Kieni forest was ($r=0.206$) at a significance of $p<0.05$, which is a positive correlation implying that the higher the education level attained respondents were aware that deforestation of bamboo in Kieni forest results in reduction of purified water.

A Pearson's correlation test was conducted, the correlation of educational level attained and knowledge of reduction in soil conservation if degradation of indigenous bamboo were to occur in Kieni forest was ($r=0.234$) at a significance of $p<0.05$ which is a positive correlation implying that that knowledge of reduction in soil conservation if the indigenous bamboo in Kieni forest was degraded was better understood as the education level increased in the respondents.

The correlation of education and knowledge of decrease in economic turnover if degradation of indigenous bamboo were to occur in Kieni forest was ($r=0.07$) which

is a weak positive correlation, implying that knowledge of decrease of economic turnover if deforestation of bamboo in Kieni forest was not dependent on education level and community members regardless of their educational status were not aware that economic turnover is a possible effect if bamboo degradation were to occur.

4.3 Economic Potential of *Yushania alpina*

4.3.1 Bamboo Related Economic Activities

To identify and assess the current economic activities associated with *Yushania alpina*. specific questions were asked to identify the current economic activities associated with bamboo (Figure 4.5).

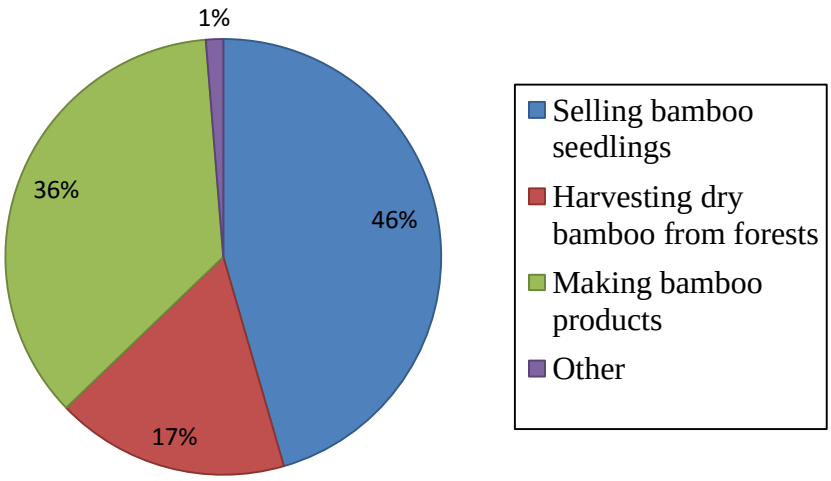

Figure 4.5: Response categories in (%) to the question 'What type of bamboo activity are you involved in?'.

Selling bamboo seedlings (46%) and making bamboo products proved to be the most common income generating ventures (36%). Bamboo products, harvested from the forest, as well as other economic activities were also reported. These findings further supports activities as documented by Kigomo, (2007a).

Plate 4.1: Bamboo Nursery

Plate 4.1 represents one of the many different types of bamboo nurseries present in the area. These nurseries are maintained in groups and are located in the Kenya Forest Station as well as in homesteads. Nurseries comprise mostly of indigenous bamboo seedlings at 93%, while exotic species accounting for 7% of seedling produced, such as giant bamboo which is gaining popularity in the area due to its high returns. Respondents noted that seedlings are retrieved as wildings from the forest or bought from KEFRI. The high rate of production of *Y. alpina* seedlings is due to the high number of clients purchasing the product. From this study, respondents answered that 85.8% of clients are from within the community, 9.5% of clients were from the government which uses the seedlings for restoration of river beds. 4.7% of clients were from private companies.

Table 4.6 Bamboo products made within Gakoe location

Bamboo Product	**Frequency of products made (n=32)**	**Percent (%)**
Furniture	3	9.7
Baskets	27	85.5
Other	2	4.8
Total	32	100

The study also revealed that 36% of respondents who used bamboo made bamboo products. Table 4.6 shows that 85.5% of the respondents were involved in the production of baskets which KEFRI (2008) and Brias(2006) have previously observed. Less than 15% of the respondents were involved in making furniture and other bamboo products.

Baskets were the most popularly produced product. Plate 4.2 shows an example of a bamboo basket being made, Plate 4.3 shows a finished bamboo basked and Plate 4.4 shows the product in use. Baskets produced are used mainly to collect tea. Production of bamboo products takes a short period of time with respondents making up to 5 baskets in a day. The material which is indigenous bamboo from the forest is locally available and cheap as respondents are allowed to collect material from the forest paying a small fee. The high demand for baskets in the area is also a reason why respondents engage in producing bamboo baskets.

Plate 4.2: Production of bamboo basket

Plate 4.3: Finished bamboo basket

Plate 4.4: Tea pickers using bamboo baskets

The researcher was also interested in observing the products that the community members used. Majority (86.3%) of the respondents use bamboo products. Baskets were observed as the most popular bamboo product in the household and are mainly used for picking tea. The use of bamboo for furniture, fences, plants as aesthetics and firewood is also common practice within the area, due to its affordability, availability and quality of the products that are made from bamboo, (Table 4.8).

Table 4.7: Bamboo products found in Households

Bamboo Product	**Frequency of products found in households (n=206)**	**Percent (%)**
bamboo furniture	18	16.8
bamboo fence	15	14.0
bamboo plants	16	15.0
bamboo basket	40	37.4
Bamboo firewood	15	14.0
Other	3	2.8
Total	107	100

4.4 Economic Potential of Bamboo in Gakoe location

It was noted that an indigenous bamboo seedling sold for an average of KSh 100 and Giant bamboo at the average price of KSh 500. The net margin from selling indigenous bamboo seedlings was KSh 3,000 per month. The study determined that bamboo retailers sell more than 30 bamboo seedlings per month at a unit price of KSh 100.

However, the price is inflated during the high season which is throughout the rainy season between March- June long rains and October-December short rains due to higher demand. Extra information gathered from this study demonstrated that the sales of bamboo seedlings largely depended on the weather patterns. During the low seasons which is the dry season, the gross margin average is KSh 3,000 or less, February and September are the driest months in this area. However, during the rainy season, farmers can each reach a gross margin between KSh 100,000 – 10,000,000.

As bamboo baskets are the most used product in the area, they have proved to have great economic returns. Bamboo baskets were cheaper to make as the raw material (bamboo) was taken from within the homestead or from the Kieni Forest at no purchase cost, they retailed for at an average price of KSh 300 – KSh 399 and lasted longer than other types of baskets. They proved very useful in carrying agricultural products, especially during tea picking. On average, the respondent earns between KSh 12,000 – KSh 15,960 per month from selling bamboo baskets.

Y. alpina culms that are harvested from the forest can be used for several purposes and retail for KSh 80 a culm as compared to KSh 1,500 with giant bamboo. The community members preferred the bamboo products that were made from *Y. alpina* as they were durable and easily accessible.

There are a number of economic generating activities within Gakoe location. However, these economic turnovers cannot be compared to those of Asia (Junqi, 2014) . There is a great potential for bamboo in this area, which has not been fully exploited.

4.4.1 Correlation of economic potential vs Educational status and Gender

Correlation analysis was used to assess if indigenous bamboo has no economic potential to the community living in Gakoe location. The variables measured were: educational status and gender, as well as type of profitable bamboo activities one is involved in.

Table 4.8: A Pearson correlation between education status and gender of respondent and importance and what type of profitable bamboo activity they are involved in.

		What type of profitable bamboo activity are you in involved in	Educational status	Gender
Type of profitable bamboo activity are you in involved in	**Pearson Correlation**	1	.014	-.023
	Sig. (2-tailed)		.835	.729
	N	124	124	124

The results that were run (Table 4.8). A Pearson correlation coefficient was computed to assess the relationship between educational status and type of profitable bamboo activities undertaken. There was a weak positive correlation (r=0.014) between educational status and type of profitable bamboo activity. This implies that, the relationship between the types of bamboo-related profitable activity is not dependent on educational status.

A Pearson correlation coefficient was computed to assess the relationship between gender and what the income gained for bamboo is used for (r=-0.23) which is negative correlation which implies that there is no correlation between gender and the profitable bamboo economic activity one is involved in.

4.5 The challenges and opportunities of indigenous bamboo and its environmental conservation.

Over 70% of the target population took notice that bamboo had great economic potential by creating jobs such as basket weaving, which is a popular venture within the area. They also noted that bamboo could provide jobs such as carpentry. Other opportunities included environmental conservation. The community is well aware of the need to safeguard its environment. Over 50% of the respondents understood how bamboo's water retention capabilities are important when it comes to water conservation and the consequences of deforestation of this natural resource would result in decreased rainfall. With land use pressure becoming a problem within the area, competition for crops and pasture for animals and humans is becoming a major problem. About (70%) of the people also identified bamboo as livestock feed, they also described how livestock which is allowed to graze in the forest is a threat to *Y. alpina* as they eat and destroy seedlings. The fast growing nature of indigenous bamboo was seen as a major opportunity as a source of energy especially by those who need bamboo for firewood, *Y. alpina* was described as a cleaner source of energy by the respondents.

The lack of market and a regulatory framework which is still in draft stages make it hard for local residents to invest in *Y. alpina* . Locals would preferably stick to farming practices such as tea and pineapple farming which already have a stable market than plant bamboo to produce culms. Bamboo culms have a niche market which is difficult to tap into. This explains the small number of nurseries selling *Y. alpina* seedlings within the area as well as bamboo used for aesthetics rather than a commercial crop.

Another reason explaining why residents hesitate to engage in *Y. alpina* is that the cost of indigenous bamboo seedlings is very high, at KShs 100 compared to KShs 20 for various species of trees sold within the area. A total of 63% respondents said they would rather farm Eucalyptus because of its cheaper seedling price. Farmers who sold seedlings confirmed that *Y. alpina* was mostly bought by private companies (72 %) as compared to the local community members (8%). The community is aware of the ecological value of *Y. alpina,* however, there are still gaps within this knowledge. They were not aware that bamboo could be used as a source of food, by eating the shoots. There was a disconnect between how the ecological value of bamboo could result in loss in economic turnover for them.

The respondents were also not aware of the full economic potential of bamboo. Over 70 % of the respondents were hesitant to cultivate bamboo as they did not know what do with the culms. They were not aware that bamboo is a multibillion industry which includes products such as, paper, textiles and fibres. This as a result of no cultural significance to bamboo which explains it high uptake and use in Asia (Word Bamboo Organisation, 2012). The forest station and the community forest association headquarters in which community members can find information on other forest flora had little to no information on *Y. alpina.* Certified local training schools which would build capacity on how to use bamboo for those who wanted to learn skills were no available such training are offered at KEFRI- Karura, respondents who displayed these skills had learnt, from relatives or neighbours. However, all of the respondents expressed interest in learning more about *Y. alpina* and skills that could eventually uplift their economic status.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusion

Bamboo is a versatile crop with many uses. It has important direct and indirect economic and ecological benefits such as providing housing, furniture, artisan products and soil and water conservation. The bamboo sector is broad; at least 1,500 uses of bamboo have been identified globally. However, in Gakoe bamboo is not exploited to its full potential, economically and ecologically.

The economic significance of *Y. alpina and* its conservation capabilities make it one of the most sustainable and environmentally friendly plant in Kieni forest area.

It was found that respondents were aware of the ecological value of *Y. alpina* with 89% of respondents being aware that it is eaten by animals and over 66% of respondents' acknowledging the importance of *Y. alpina* within Kieni Forest. There was also a weak positive correlation ($r=0.028$) which implied that education was not a contributing factor when it came to identifying the animals which ate *Y. alpina.* However, when it came to ranking the likely consequences of *Y. alpina* a Pearson's correlation found that ($r=0.207$) at a significance of $p<0.05$, implying that the higher the education level attained, respondents acknowledged that deforestation of bamboo in Kieni forest resulted in environmental consequences such a decreased purified water, changes in climate conditions and soil erosion though there was a disconnect between *Y. alpina's* deforestation resulting in loss in economic turnover.

Within Gakoe location *Y. alpina's* economic potential has not been fully exploited. However there are a number of bamboo economic related activities, this included selling seedlings (46%) respondents and making bamboo products such as baskets

(85.5 %). It was found that there was no relation with Gender and the type of profitable activity one was involved in with (r= -0.023).

It was noted that bamboo had a number of opportunities and challenges within the area. Investing in *Y. alpina* is promising source of income. However, for most of the individuals, lack of technical knowledge on bamboo and lack of a stable market were the main hindrances. This poses a challenge as individuals will not gamble with an unsteady market.

5.1 Recommendations

This study has made recommendations for ensuring that *Y.aplina's* full potential is achieved within Kieni forest Gakoe location.

1. There should be a bamboo resource centre at the forest station so community members can gain knowledge on Bamboo, this including bamboo's ecological value as well as its economic potential.
2. A clear value chain of bamboo should be documented and a regulatory framework should be developed to further support any economic activities community would want to venture into.
3. Community members frequently listen to radio, the local radio stations should provide shows that discuss the ecological value and economic potential of *Y. alpina* as a means of information dissemination.
4. Subsidiaries on *Y. alpina* seedlings to encourage community to grow bamboo.

5.1.1 Areas of further research

During the study a number of issues were raised and thus the need for further research on these areas:

- Within Gakoe land division has resulted in small land holdings. This has resulted in community members abandoning livestock farming as there is no land to grow feeds and buying feeds is expensive. *Y. alpina* has been shown to be used a livestock feed and because it can grow on minimal space a study needs to be conducted to assess the nutritional value of *Y. alpina* as compared to Napier grass as livestock feed.
- From the study we can identify that *Y. alpina* is used as fuel wood though the community members preferred hard woods and complained that *Y. alpina* would not last very long when combusted, however, according to (Yiping *et al.*, 2010) bamboo stores most carbon in the form of charcoal thus a study is needed to test the efficiency of *Y. alpina* charcoal. *Y. alpina* as charcoal can used as a means of conserving and reducing the pressure off hardwoods that are harvested for charcoal.

REFERENCES

African Development Bank. (2014). *Kenya :Country Strategy Paper 2014-2018.* Tunis: African Development Bank.

Awadh, A. (2010). *An Assessment of the Viability and Potential of Bamboo Mirco Enterprises in Environmental Conservation and Poverty Alleviation in Nairobi City,Kenya.* Nairobi: TobacootoBamboo Project.

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. Human Relations. *Human Relations*, 61(8), 1139-1160.

Boa, E. (2006). *Bamboo Marketing for the Eastern Africa Bamboo Project Kenya and Ethiopia.* Vienna: UNIO.

Brias, V. (2006). *Bamboo Plantations for the Eastern Africa Bamboo Project Kenya, With a Feasibility Study For a 100 Ha Plantation.* Vienna: UNIDO.

Clayton, W., Vorontsova, M., Harman, K., & Wlliamson, H. (2006, September 26). *GrassBase - The Online World Grass Flora*. Retrieved September 8, 2013, from The Board of Trustees, Royal Botanic Gardens, Kew: http://www.kew.org/data/grasses-db/index.htm

Divya, K. (2014, April 14). *Tackling the demon of eucalyptus, at last*. Retrieved May 20, 2014, from http://www.deccanherald.com/: http://www.deccanherald.com/content/397946/tackling-demon-eucalyptus-last.html

Economic Commission for Latin America and the Caribbean. (2000). *Environmental Values, Valuation Methods, and Natural Disaster Damage Assessment.* Santiago de Chile: UN.

Ekpenyong, E. (2009). Environmental Awareness As A Panacea For Sustainable environmental management in Africa . *'IAIA09 Conference Proceedings',29th*

Annual Conference of the Impact Assessment and Human Well-Being (pp. 1-6). Accra: International Association for Impact Assessment.

Endalamaw, T., Lindner, A., & Pretzsch, J. (2013). Indicators and Determinants of Small-Scale Bambooo Commercialization in Ethiopia. *Forests, 4*(3), 710-729.

Erie, A., Ikhajiagbe, B., Mensah, J., & Akomeah, P. (2011). Bamboo, the Environment and the Economy: Sustainable Future for Nigerian Investors. *Libyan Agriculture Research Center Journal International, 2*(5), 239-243.

Fernandez-Gimenez. (1993). The role of ecological perception in indigenous resource management: a case study from the Mongolian forest-steppe. *Nomadic Peoples, 33*, 31-46.

GoK. (1999). *Water Policy- Sessional Paper No.1 of 1999.* Nairobi: The Government Printer.

GoK. (2002). *Water Act 2002.* Nairobi: The Government Printer.

GoK. (2005). *Sessional Paper No.9 of 2005 on Forest Policy.* Nairobi: Government of Kenya.

GoK. (2006). *Energy Act 2006.* Nairobi: The Government Printer.

GoK. (2010). *The Constitution of Kenya.* Nairobi: The Government Printer.

GoK. (2012). *County Government Act.* Nairobi: The Government Printer.

GoK. (2013). *National Environment Policy 2013.* Nairobi: The Government Printer.

Google. (2014, Septemeber 29). *maps.google.com*. Retrieved from maps.google.com: https://www.google.com/maps/@-0.8879096,36.8026611,12z?hl=en-US

Gordon, D. (1998). Effects of invasive, non-indigenous plant species on ecosystem processes: lessons from Florida. *Ecological Applications, 8*(4), 975-989.

Government of Kenya. (1999). Sessional Paper No.9 of 1991 on Environment and Development. Nariobi, Kenya: Government of Printer.

Government of Kenya. (2007). *Kenya Vision 2030.* Nairobi: The Government Printer .

Hunde, T. (2008). *Report on newly introduced and indigenous bamboo species propagation status development status.* Addis Abbaba: Ethiopian Institute of Agricultural Research.

Iizuk, M. (2000). *Role of Environmental Awareness in Achieving Sustainable Development.* Vitacura, Santiago de Chile: Economic Commission for Latin America and the Caribbean .

Ingram, V., & Tieguhong, J. (2013). Bars to jars: Bamboo value chains in Cameron. *Ambio*, 320-333.

Jantzen, J. (2006). *The Economic Value of Natural and Environment Resources* . Amsterdam: Institute for Applied Environmental Economics.

Junqi, W. (2014). *International Trade of Bamboo and Rattan 2012.* Bejing: INBAR.

KEFRI. (2008). *Status of Bamboo Resources Development in Kenya.* Nairobi: KEFRI.

Kenya Agricultural Research Institute. (2012). *Food Security Report (Prepared by Kenya Agricultural Research Institute).* Washington: International Food Policy Research Institute. Retrieved from http://www.foodsecurityportal.org/.

Kenya Forestry Services. (2012). *Kieni Participatory Forest Management Plan (2011- 2015).* Nairobi: Kenya Forestry Services.

Kenya Institute for Public Policy Research and Analysis. (2013). *Kenya Economic Report 2013 Creating an Enabling Environment for Stimulating Investment for Competitive and Sustainable Counties.* Nairobi: Kenya Institute for Public Policy Research and Analysis.

Kiarie, L. (2014, June 24). Bamboo turns Kenyan farmers into millionaires. Nairobi: Standard Media. Retrieved June 24, 2014, from

http://www.standardmedia.co.ke/business/article/2000125862/bamboo-turns-kenyan-farmers-into-millionaires

Kibwage, J., Netondo, G., Odondo, A., Oindo, B., & Momanyi, G. (2008). Growth performance of bamboo in tobacco-growing regions in South Nyanza,Kenya. *Afr.J.Argic.Res*, 716-724.

Kibwage, J., Odondo, A., & Momanyi, G. (2008). Structure and performance of formal retailmarket for bamboo products in Kenya. *Scientific Research and Essay, 3*(6), 229-239.

Kigomo, B. N. (1988). *Bamboo resource in the East Africa region.* Bejing: INBAR.

Kigomo, B. N. (1992). *Green Gold in Africa.* Nairobi: KEFRI- IDRC.

Kigomo, B. N. (2007a). *An Overview of Bamboo and Rattan.* Nairobi: International Network for Bamboo and Rattan.

Kigomo, B. N. (2007b). *Guidelines for growing bamboo.* Nairobi: Kenya Forestry Research Institute.

Letsholo, P., Christiaans, H., & Kumar, K. (2007). *Designing Breakthrough Bamboo Products from Africa: A Case Study for Southern Africa Region.* Amsterdam: The Print.

Lewis, D., Miles, C., & Miles, H. (2008). *Farming Bamboo.* Raleigh:NC: Bluegrass Woodland.

Liam, O. (2013, August 29). *thebambootradingcompany*. Retrieved from http://www.thebambootradingcompany.com/: http://www.thebambootradingcompany.com/

Lobovikov, M., Paudel, S., Piazza, M., Ren, H., & Wu, J. (2005). *World Bamboo Resources: A thematic study prepared in the framework of the Global Forest Resources Assessment 2005.* Rome: Food and Agriculture organization of the United.

Magati, P., Kibwage, J., Omondi, G., Ruigu, G., & Omwansa, W. (2012). A Cost-benefit Analysis of Subtituting Bamboo for Tabacoo: A Case Study of Smallholder Tobacco Farmers in South Nyanza Kenya. *Science Journal of Agricultural Research & Management, 2012*, 1-9. doi:10.7237/sjarm/204

Minae, S. (1989). *Socio-economic issues in bamboo production and utilization.* Nairobi: KEFRI-IDRC.

Ministry of Environment and Natural Resources. (1994). *Kenya Forestry Master Plan: Development Programmes.* Nairobi: Ministry of Environment and Natural.

Ministry of Wildlife and Foresty . (2010, July). Draft Bamboo Policy. Nairobi, Kenya: Ministry of Forestry and Wildlife.

Mott MacDonald. (2010). *Developing countries, monitoring and reporting on greenhouse gas emissions, policies and measures: Country Report Kenya.* Amsterdam: European Union.

Mugenda, M., & Mugenda, G. A. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi: African Centre for Technology Studies, 1999.

Muller, I., & Rebelo, C. (2011). *Bamboo Worldwide:The Current Market & Future Potential.* Chicago: Ecoplanet Bamboo.

Neuman, W. L. (2011). *Basics of Social Research: Qualitative and Quantitative Approaches, 7th ed,international ed.* Boston: Pearson Education, Limited, 2011.

Oloo, W. O. (2010). *Second National Communication to UNFCCC.* Nairobi: Kenya Forestry Research Institute.

Ondongo, P. (2012, July 26). Fast-growing bamboo fuels farmer's passion. Nairobi: Daily Nation.

Ongugo, P., Langat, D., & Musalia, W. (2012). *Ecological and Socio- economic study on Bamboo farming in the Western Mt. Kenya Region.* Nariobi: KEFRI-NMK.

Ongugo, P., Sigu, G., Kariuki, J., Luvanda, A., & Kigomo, B. (2000). *Production to Consumption Systems. A Case Study of the Bamboo Sector in Kenya.* Nairobi: KEFRI.

Romualdo, L. (2006). *Sustainable Livelihoods for Reducing Poverty.* Wuyishan City : INBAR.

Sigu, G. (1994). The Need for Conservation of Arundinaria aplina K.Schum in Kenya and its Ecological Significance. *Proceeding 4th International Bamboo Workshop* (pp. 48-50). Bejing: INBAR.

Statz, J., Dede, P., & Adenew, B. (2007). *Bamboo Marketing for the Eastern Africa Bamboo Project Kenya and Ethiopia.* Vienna: UNIDO.

United Nations Environment Programme. (2012). *The Role and Contribution of Montane Forests and Related Ecosystem Services to the Kenyan Economy.* Nairobi: UNON, Publishing Services Section.

Watts, M. (2008). United States Economy. Redmond, WA, United States America. Retrieved 09 22, 2013

Were, J. (1988). Arundinaria alpine in Kenya. *in Bamboo current research, proceedings* (pp. 32-33). Cochin, India: INBAR.

World Bamboo Organization . (2012). The 9th World Bamboo Congress Proceedings . *9th World Bamboo Resources Proceedings 10th - 15th April* (p. 22). Massachusetts: World Bamboo Organization .

Yiping, L., Yanxia, L., Buckingham, K., Henley, G., & Guomo, Z. (2010). *Bamboo and Climate Change Mitigation: a comparative analysis of carbon sequestration.* Beijing: INBAR.

Zimmerman, M. (2008). Environment. Microsoft Encarta 2009 Electroni Encycolopedia. Microsoft.

APPENDIX 1 QUESTIONNAIRE

QUESTIONNAIRE FOR HEAD OF HOUSEHOLDS

My Name is Jessica Mukiri. I am a Masters student of Environmental Science at Kenyatta University. The research that I am currently conducting is part of my degree program. My goal is to evaluate the economic potential of Bamboo in Kieni Forest area. My humble request is that you kindly answer the questions through this questionnaire. All information given will be confidential.

QUESTIONNAIRE SERIAL

NUMBER:……

Date of distribution:	Questionnaire number:
County:	District:
Division:	Location:
Sub-location:	Village:
Name of the Enumerator:	

<u>Socio-demographic Information</u> (Circle appropriate answer)

1. **Age of respondent?**
   a. 18 to 35
   b. 36 to 60
   c. 61 and older
2. **Gender :**
   a. Male
   b. Female
3. **Educational status:**
   a. Primary
   b. Secondary

c. Tertiary

d. Others……

…...

4. **Occupation:**

a. Farmer

b. Business man/woman

c. Teacher

d. Other

……

5. **Household size :**

a. 1 – 3

b. 4 – 6

c. 7 – 9

d. 10 +

SECTION A

1. **What type of bamboo activity are you involved in?**

a. None

b. Selling Bamboo seedlings

c. Harvesting dry Bamboo from forests

d. Making Bamboo products

e. Other……

……

……..

If you answered (1a) go straight to Section B. If you answered (1b) go to question 2; If you answered (1c) go to question 8. If you answered 1d go to question 14.

2. What is the income gained from Bamboo used for?

a. Supporting Family (i.e. food and daily needs)

b. Education

c. Farming and community development

d. Other……
……
……..

BAMBOO SEEDLINGS

3. **How long have you been selling Bamboo seedlings?**
   a. 0 – 6 months
   b. 7 – 12 months
   c. 1 – 2 years
   d. Other……
4. **Do you sell the *Yushina alpina* varities of Bamboo? Circle [YES / NO]**
   a. If **NO** – Please specify which variety of bamboo seedlings you sell……..
5. **What is your cost price per seedling?**
   a. 0 – 50 Ksh
   b. 50-100Ksh
   c. Other ……
6. **How many seedlings do you sell in a month?**
   a. Less than 10
   b. 10-20
   c. 20-30
   d. 30 +
7. **Where do you harvest your seedlings from?**

   ……
   ……
8. **Who are your likely customers?**
   a. Individuals
   b. Government
   c. Private Companies
      (name them)
   d. Other……
      .

BAMBOO HARVESTED FROM FOREST

9. How many culms of bamboo are harvested from the forest?

a. 1-3
b. 4-6
c. 7-9
d. 10+

10. How many bamboo related trips do you make to the forest in a week?

a. 1-2
b. 3-4
c. 5-6
d. 7 (i.e. every day)
e. Other……
.

11. What is the primary purpose of the bamboo harvested from the forest?

a. Building structures
b. Energy source
c. Commercial use (sold for firewood)
d. Other……
…

If you answered (c);

e. What is the selling unit:…….
f. What is the price her unit?.....

12. How do you access the forest?

……..

13. How do you transport the bamboo to buyers?.....

BAMBOO PRODUCTS

14. What Bamboo products do you supply?

a. Furniture
b. Baskets

c. In its raw state (culm)

d. Other……..

15. How long have you been making Bamboo products?

.....

16. Where do you get your bamboo from?

a. Forest

b. Farms

c. Other……

……..

17. How long does it take to make your product?

a. 1-2 weeks

b. 3-4 weeks

c. A month or more.

18. How much do you sell your bamboo products for per item?

a. 100-199Ksh

b. 200-299Ksh

c. 300-399Ksh

d. 400+Ksh

19. How many products do you sell within a week?

a. 1-3

b. 4-6

c. 7-9

d. 10+

20. Who are you likely clientele?

a. Local community members

b. Government

c. Private companies

d. Other……..

SECTION B:

ENVIRONMENT

21. What name of Bamboo species are you familiar with?

a. Mirangi
b. *Yushania alpine*
c. Bamboo
d. Other – Specify

22. What animals do you know that eat bamboo in this area?

a. Elephants
b. Monkeys
c. Other…….

23. Do you use Bamboo products within your household? Circle. [YES / NO]

24. If YES, which products do you use?

a. Bamboo furniture
b. Bamboo fence
c. Bamboo plants
d. Bamboo baskets
e. Bamboo firewood
f. Others specify……

25. Why do you prefer Bamboo products?

a. Affordable
b. Easily accessible
c. Only option
d. Other specify……..

26. Rank the importance and value of Bamboo to the local community in the specified areas using:

1 – Not Important

2 – Less Important

3 – Important

4 – Very Important

	VALUE	RANKING
1	Wildlife habitat	
2	Building materials	
3	Recreational and culturally significant areas	
4	Fuel wood	
5	Potential Farming crop	
6	Increase employment opportunities	
7	Herbal medicines	

27. What are the likely consequences of forest degradation of bamboo? Rank each on a scale of 1 – 4; based on most likely outcomes.

1 = not at all

2 = seldom

3 = significant

4 = extreme

Reduction in purified water	

Changes in climate conditions	
Reduction in soil conservation	
Decrease in economic turn over	

28. What constraints and opportunities are there for the cultivation of bamboo, list below:

OPPORTUNITIES	**CONSTRAINTS**

29. Other relevant information or notes beneficial to this study:

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…….....

Thank you for your time and efforts