

**FACTORS INFLUENCING THE USE OF BAMBOO AS A FLOORING
CONSTRUCTION MATERIAL: A CASE OF GARDEN CITY PROJECT –NAIROBI
COUNTY, KENYA**

BY

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DECLARATION

I hereby declare that this project is my original work and has not been presented for any award in any university. No part of this report should be duplicated, presented or reproduced in any form without my prior consent.

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L50/82756/2012

This project has been submitted for examination with my approval as the University Supervisor.

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DEDICATION

To my parents Mr. and Mrs. Gichohi, siblings Nyambura and Gathungu; your love is my anchor. To my lovely wife Tina Yabann Ndirangu; thank you for understanding all the late nights and all the travel. Your support in this continues to be a pillar of my success.

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ABBREVIATIONS AND ACRONYMS

INBAR- International Network for Bamboo and Rattan

UNIDO-United Nation Industrial Development Organization

KEFRI- Kenya Forestry Research Institute

ICSHT- International Centre for Science and High Technology

LBL- Laminated Bamboo Lumber

ICBO- International Conference of Building Officials

ABSTRACT

The purpose of this study was to examine the factors influencing the use of bamboo as a flooring construction material in Kenya with a case of Garden City Project, Thika Road-Nairobi. The objectives were to investigate the sustainability, economic implication, aesthetics and the durability of bamboo as a flooring construction material. The type of flooring used in construction makes a significant difference in the appearance and finishing of a project that in turn increases its value. For this reason, hardwood flooring would typically be the number one choice at Garden City since it presents a combination of beauty and durability; the project has instead adopted one of the latest additions of flooring types, the bamboo flooring which is a more sustainable solution. Resource availability has declined and resource demands increased in today's modern developing country Kenya, thus becoming increasingly necessary to explore opportunities for new, sustainable building materials like bamboo, technology needed to adopt it in the construction industry and purpose to improve the consumer awareness in Kenya. A descriptive survey was used where various consultants in the construction industry were closely selected as respondents. The study made use of primary data, in form of self-administered questionnaires, which was designed following the conceptual framework. Data was analyzed by means of qualitative and quantitative techniques. The explanations of the study findings were concluded by use of cross pattern analysis and proportions in descriptive statistical tools by computing the standard deviations, frequencies and mean. Summary data from the study was presented in the form of tables, ensuring easy understanding and deduction of similar trends and patterns. In conclusion, all the factors studied during this research were found to significantly affect the use of bamboo as a flooring material with sustainability being the most influential.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Bamboo is one of the oldest and most versatile building materials with many applications in the field of construction, particularly in developing countries; Bamboo is a grass that is the fastest growing plant currently known, (Liese, 1987). It is strong and lightweight and can often be used without processing or finishing. In spite of these clear advantages, the use of bamboo has been largely restricted to temporary structures and lower grade buildings due to limited natural durability, difficulties in jointing, a lack of structural design data and exclusion from building codes, (Xiao et al, 2008). The upside of using bamboo flooring is the renew-ability of bamboo as a resource. It is comparable to many hard woods, such as maple, but grows in a fraction of a time. It could take over 100 years for a hard wood tree to mature to the point where it can be used as a material for flooring. Over time this can take a huge toll on forests around the world. Bamboo, being a grass, readily regrows and matures in roughly 4 years making it a sustainable option. Sustainable building materials are defined as being materials that are low in toxicity, possible to maintain without having adverse effects on health, renewable, recyclable, energy and resource efficient, locally available, and affordable, (Froeschle, 1999).

After defining priority areas, Garden City Project was carefully chosen and assumed to be highly representative of the country to collect raw data on the present state of the use of bamboo flooring in construction. The case investigated the chain of activities to which bamboo is subjected, through the various stages of intermediate sales and processing, to the consumer of the final product. The system included processing of the material as an indication of the benefits related to cost as well as its durability and sustainability as a construction material. Garden City Project was selected, it being a mixed use green development which has the scale and scope to change the horizon of North West Nairobi, making it a viable choice. The site is located on a prime 32 acre plot of land adjacent to the upgraded Thika Road. It will incorporate the largest mall in East Africa and 420 housing units. The purpose of this was to narrow down the scope of

study to bamboo use in construction and apply the data collected and analyzed to illustrate results found in a detailed representative manner.

Bamboo as a construction material, a case of Garden City Building Project, was focused on its main use in the project which is flooring. Bamboo flooring is a quality product that can be used widely and has a large, global consumer market. It has certain advantages over wooden floors due to its smoothness, brightness, stability, high resistance, insulation qualities and flexibility. Bamboo flooring has a soft natural luster and maintains the natural gloss and elegance of bamboo fiber. This flooring is attractive to the demanding markets in Europe, Japan and North America. The estimated annual production of bamboo flooring in China was 17.5 million m² in 2004. Exports account for some 65 percent of total production, (Customs General Administration of China, 2004).

1.2 Statement of the Problem

Since 1985 the Kenyan Forestry Research Institute (KEFRI) under the direction of Bernard Kigomo has been researching on reforestation and cultivating indigenous and exotic species of bamboo in Kenya. Since 1989 studies were made on the socio-economic potential of the use of bamboo. In 1995 Kigomo published "Guidelines for establishment and managing plantations of bamboo in Kenya". All studies and research of KEFRI suggest a similar conclusion: The potential of utilization of bamboo as a raw material from sustainable managed forests and plantations and its positive side effects for rural economy, preservation of environment and wildlife as well as water catchment is not yet recognized in Kenya. Against this background, it seemed promising to promote the use of bamboo as a building Material, determine its availability in Kenya as well as the previous implications it has had on the construction industry. Resource availability has declined and resource demands increased in today's modern developing country Kenya, thus becoming increasingly necessary to explore opportunities for new, sustainable building materials like bamboo, technology needed to adopt it in the construction industry and assess and purpose to improve the consumer awareness in Kenya. A number of interventions are required for reducing the barriers to effective development of the

bamboo sector in construction in Kenya. The major critical areas are those related to policy, improvement of the resource base, product manufacture, preservation and product durability, marketing and research.

1.3 Purpose of the study

The purpose of this study was to examine the factors influencing the use of bamboo as a flooring construction material: a case of Garden City Project, Nairobi County, Kenya.

1.4 Objectives of the study

1. To investigate the sustainability of bamboo use in Kenya as a flooring construction material.
2. To investigate the cost/economic implication of bamboo as a material resource in the construction industry
3. To assess the durability of use of bamboo as a flooring construction material.
4. To assess the aesthetic quality of bamboo as a flooring construction material

1.5 Research questions

The study was guided by the following research questions:

- i. How sustainable is the use of bamboo in Kenya as a flooring construction material?
- ii. What are the cost/economic implications of using bamboo on the construction industry?
- iii. What is the durability of bamboo as a flooring construction material?
- iv. Is bamboo flooring an aesthetically pleasant construction material?

1.6 Significance of the study

Bamboo was selected for research in this project because of its economic productivity which can reach up to an annual yield of 20-40 tons per hectare on a managed plantation (Kibwage et al 2007). This has been well documented in Asian countries and the significance of this research was to study the cost implications with regard to its use in construction. Construction done with bamboo can be very durable if it is well immunized and well selected with the best quality of the material, the research sought to investigate the durability of bamboo as well.

Since there is no commercial value placed on bamboo and it has been widely replaced by cash crop plantations, the destruction to Kenya's biodiversity and water catchment has been immense. While it may take over 100 years to replace a hardwood tree such as a Brazilian teak, bamboo reaches full maturity suitable for hardwood applications in about 4 years, and can actually regenerate without replacing or replanting says Kibwage. Preservation of the environment seems only to work if Kenya's population will be able to profit directly from it.

In addition, bamboo plays a very valuable environmental role. Its complex root system can act as a fantastic water filter, removing nutrients and dangerous poisons such as heavy metals and not get it into the food chain. As such, introducing the cultivation of bamboo could have a lot to offer in the slum areas, where it can be used to clean up waste water, one of the major problems we have in Kenya.

1.7 Delimitation of the Study

Locally, bamboo is used for handicrafts, residential fencing, horticultural flower farming, farm props for banana plantations, furniture and other minor cottage industry products like basketry and toothpicks. The government of Kenya is investing Sh 120 million in a bamboo processing venture intended to conserve its fast receding forest cover, (Joseph Abuje, 2014). The bamboo project is aimed at making bamboo products such as wooden jewelry, curtains and furniture that would be sold both locally and internationally. The venture which brings on board Kenya

Forestry and Research Institute (KEFRI) is geared towards extraction of a wide range of products from the yushina alpine, a highland bamboo that grows in rainy forests.

This study was limited to research on bamboo as a construction material in Kenya, Garden City and its sustainability in the construction industry as compared to other hardwoods in terms of strength, durability and economic benefits. The choice of Garden City Project is due to the various advantages presented, such as ease of access for the site, the researcher's structural engineering background which allows access to the Kenyan construction industry database for information sourcing, close interaction with the Chinese contractor with vast knowledge on bamboo acquired in China and finally recent job travels to countries like China among others have enabled collection of information on this topic.

1.8 Limitations of the Study

Limitations to this study that the researcher hoped to mitigate to achieve the research goals and objectives are discussed. Firstly, there was the factor of time, which acted as a constraint especially during data collection. But being in the construction industry, working hours doubled up as part of research time, apart from the frequent travels that came with the line and nature of work, the researcher planned proper scheduling of the time available to work on the research.

Cost implications served as another limitation, as much as it would be more beneficial to the study to visit areas outside of Kenya that have adopted bamboo as a sustainable construction material, the researcher had to limit the study to internet research and interviews with people exposed to bamboo production and processing.

Lack of exposure in the construction industry and product acceptance in society posed as a setback for the research as well, i.e. at the processing and utilization level, lack of production skills and limited markets; this study will attempt to create awareness and concept designs that

promote bamboo as a building material to the highest acceptance and the most representative use as has been done in other countries.

Respondents not being ready to answer questionnaires was a possible challenge; the questionnaires clearly explained what the intent of this research was and its importance, and not just as an educational requirement to the researcher in the master's degree but to the construction industry at large. This ensured that questions are answered correctly and in a timely manner.

Lastly on completion of the research, the transfer of building technologies from Asian countries to Kenya in an attempt to venture into bamboo as a finished product instead of having to export it for this process may not be achievable at this stage. With the Government support, there are many opportunities for development with bamboo based subsistence and economic activities and these would also be highly beneficial to adoption in the Kenyan market.

1.9 Basic Assumptions of the Study

There are a few things that were accepted as true or certain to happen though none proven, one is that Garden City project was a good representation of the construction population as far as the bamboo research is concerned and the respondents used in the research would answer the questions accurately and in a timely manner. Secondly, the designing and production process of bamboo would catch up with methods used in Kenya's every day's practice constructing involving other materials like timber, steel, concrete and brickwork; and that Kenya's climatic conditions were favorable for the natural production of bamboo in small as well as large scale farming practices. Another assumption was that the research project was very attractive for investment and will help to improve the development and utilization of the resource; and finally that the area of coverage and productivity of the resource would be improved, so that the country will entertain the maximum benefit of the various advantages of bamboo in construction.

1.10 Definition of Significant Terms

Aesthetics- attribute concerned with beauty or appearance

Bamboo flooring- a form of wood flooring, although it is made from a grass (bamboo) rather than a timber

Cost- In this research project cost is used to refer to the end product cost

Culms- the hollow stem of bamboo, especially that bearing the flower

Durability- the ability to withstand wear, tear, pressure, or damage over a period of time

Embodied energy- the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery.

Green buildings- a structure using processes that are environmentally conscious and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition.

Hardness- a measure of a materials resistance to localized plastic deformation.

Rattan- the thin pliable stems of a palm, used to make furniture

Strength- stress a material can withstand without permanent deformation.

Sustainability- capacity of something to maintain itself without jeopardising the potential for people in the future to meet their needs

Wood flooring -any product manufactured from timber that is designed for use as flooring, either structural or aesthetic.

1.11 Organization of the study

The study was organized in five chapters.

Chapter one contains the introduction to the research paper, which sets the stage for the study and puts the topic in perspective. Chapter two contains the literature review of the study. Chapter three discusses the methodology of the study. Chapter four gives an analysis of the results. In chapter five, conclusions were drawn from the findings, results discussed and recommendations offered for improvements to this work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter entails a review of the literature with careful examination of content pointing towards answers to the research questions. It includes scholarly journals, scholarly books, authoritative databases and primary sources. The purpose of the literature review is to test the research questions against what already is known about the subject of bamboo as a construction material, in Kenya and other countries, and to offer an overview of significant literature published on the same.

2.1.1 Bamboo Globally

Yan Xiao, Masafumi Inoue, Shyam K. Paudel in their book 'Modern Bamboo Structures: Proceedings of the First International Conference', in 2008 stated, "Bamboo materials are well available in the world. Bamboo has much shorter maturity than trees, thus can be harvested with shorter cycles of plantation. Despite the fact that human society has a long history of using bamboo, there is still a lack of modern and industrialized application of bamboo materials in construction. Promoting the application of bamboo in construction could provide a potential solution to the sustainable, green and environment-friendly development of construction industry."

The World Commission on Environment and Development at their final meeting stated that: "We remain convinced that it is possible to build a future that is prosperous, just, and secure, possibility depends on all countries adopting the objective of sustainable development as the overriding goal and test of national policy and international co-operation, (Mohamad, Banfill and Menzies, 2009). The diminishing wood resource and restrictions imposed on felling in natural forests, particularly in the tropics, have focused world attention on the need to identify a substitute material which should be renewable, environmentally friendly and widely available. In view of its rapid growth (exceeding most fast growing woods), a ready adaptability to most

climatic and edaphic conditions and properties superior to most juvenile fast growing wood, bamboo emerges as a very suitable alternative. However, in order to fully exploit the potential of bamboo, development effort should be directed at the key areas of preservation, jointing, structural design and codification. In addition, socioeconomic, appropriateness and technical studies will be essential to identify factors which govern current bamboo usage, and those which will influence its use in the future. Once these issues have been addressed, bamboo will be ideally placed to become a principal engineering and construction material for the twenty first century and beyond as mentioned in the International Network for Bamboo and Rattan (INBAR) Technical Report No16. The most recent and comprehensive information on international bamboo is collected in INBAR's online International Bamboo and Rattan Database. The database has been tracing bamboo and rattan internationally since the early 1960s.

Previous studies of bamboo in INBAR have revealed the potential of this plant resource in improving the livelihood of the people, particularly those in rural areas and in the informal sector. Dependence comes through multiple use of bamboo in people's daily lives - culms are used for house construction and props, and for crafts to generate off-farm incomes. The bamboo can also be used to meet environmental goals. With improved production and marketing skills, the bamboo sector could attract many actors at subsistence and national levels as it is a natural material, with low capital requirements. As focus is drawn toward more sustainable construction practices, use of bamboo as a structural building material is growing as a topic of interest. It is highly renewable, has low-embodied energy, and has the highest strength-to-weight ratio of steel, concrete, and timber. Composite lumber made from bamboo, termed laminated bamboo lumber (LBL), has gained the particular interest of researchers and practitioners of late, since it has bamboo's mechanical properties but can be manufactured in well-defined dimensions, similar to commercially available wood products. Its primary drawbacks are that it is difficult to connect and is more costly than competing, locally available materials.

2.1.2 Bamboo Regionally

In Ghana bamboo is extracted from natural sources mainly from community lands, farmlands and from forest reserves. The raw or unprocessed culms are either sold as props for construction or used directly by rural households, or may be processed by few large and numerous small scale processors into a variety of products mainly for sale on rural and urban markets and for household consumption, (Obiri and Oteng-Amoako, 2007). It is necessary for the forest services and private sector in Africa to promote bamboo planting for rehabilitating degraded lands and as an alternative source of timber. The root system of bamboo effectively secures the soil mantle. Bamboo is a fast growing woody plant and has the potential to rapidly generate a canopy that protects exposed, barren, or degraded mountainsides, (Kenya Forestry Research Institute, 2007). The International Network for Bamboo and Rattan (INBAR), the world's only intergovernmental organisations dedicated to the sustainable development of bamboo and rattan, and Chinese partners have also demonstrated that laminated bamboo can be used in structural applications, presenting new opportunities to standardize bamboo-based construction and produce modern modular housing designs that are potentially suitable for East African markets (Xiao, Shan, Chen, Zhou, She, and Yang, 2010).

United Nation Industrial Development Organization (UNIDO) has been involved in a ten year partnership with developing countries in the low cost building materials and other initiatives, through its International Centre for Science and High Technology, (Trieste, 2008). Trieste continues to say that countries high on the 'needs list' for low cost building projects include Tanzania, Kenya, Malawi, Mozambique, Sudan, Uganda and Zambia. Bamboo is widely grown in developing countries; new technologies have been developed to overcome problems when using bamboo caused by moisture and insects. The availability of, and ability to use primary raw materials, such as bamboo, will diminish dependence on conventional materials and products in the construction sector. There is a need to modernize the bamboo-based industry sector by introducing better technologies, processing and manufacturing supports, as well as improved managerial practices. The scope of the institutions that deal with building materials and technologies should be widened to include greater awareness about the importance of

bamboo in economic development and training of human resources in the processing of bamboo for engineering purposes.

2.1.3 Bamboo Locally

Bamboo has been increasing in importance as a non-timber forest product in Kenya over the past decade, (Kibwage, Frith and Paudel, 2011). Locally, bamboo is used for handicrafts, residential fencing, horticultural flower farming, farm props for banana plantations, furniture and other minor cottage industry products like basketry and toothpicks. Almost all of the bamboo products made in the country are used domestically. As regards construction, there is only one project identified by the researcher that has used bamboo flooring. This is a private development in Mageta Road, Lavington area comprising of four villas each measuring approximately 320m². One of the suppliers, Greatwall Enterprises, a Chinese firm has indicated that most of its sales are to individual home owners thus the limited information as to the number of projects that have used bamboo flooring. Jacob K. Kibwage, Oliver B. Frith and Shyam Krishna Paudel in their journal “Bamboo as a building material for meeting East Africa’s housing needs”, states that bamboo raw materials are scarce due to over exploitation from public forestland. Therefore, there is need to establish bamboo farms to ensure a sustainable supply for the handicraft, construction and horticultural industries amongst others. They posited that, “Ethiopia has a rich diversity of traditional bamboo housing designs, practices and skills. However, we also found that the sustainability of Ethiopian bamboo architecture is under threat from modernization, decreasing availability of bamboo resources, increased rural populations, and lack of adequate processing skills and modern designs. Despite these challenges, our economic analysis indicates that using bamboo for the development of tourist lodges and, or, low-income urban housing offer a financially viable means of developing the bamboo construction sector.”

From the Guidelines for Growing Bamboo, KEFRI Guideline Series: No. 4 (2007) it is directed that in order to be able to tap the existing potentials for development of the bamboo sector, it will be necessary for public and private sectors to recognize that bamboo is an important and

valuable commodity and not merely a minor non-wood forest product and for governments and NGOs concerned to pay adequate attention to the development and management of bamboo resources. Development plans for enhancing production and utilization should be formulated. The speed of replenishing the resource base should be increased by supporting farmers and rehabilitating public forests. It will also be necessary to coordinate the sustainable production of bamboo in public forests by ensuring the implementation of effective harvesting regimes. The public and private sectors will also be required to promote the cultivation of bamboo in homesteads as well as in small, medium, and large plantations and to ensure that research, production, marketing and utilization are coordinated in order that potential opportunities and benefits effectively reach the farmers, entrepreneurs, and traders. The above mentioned with focus more effort on aggressive dissemination of research results and technology transfer within Africa and other parts of the world with formulation of a policy statement on the development of non-timber forest products that would enhance development of bamboo particularly by local communities will also be necessary (KEFRI, 2007).

Consumer awareness plays a key role in the research involving introduction of bamboo as a new resource in the construction industry in Kenya. By increasing a potential or current consumer's knowledge about it, service and technology, a healthy economic environment is established in which all parties involved are informed and businesses are accountable on both ends. Education is a life-long process of constantly acquiring relevant information, knowledge and skills. Consumer education is an important part of this process and is a basic consumer right that must be introduced at early stages of introducing a product, case in point, bamboo.

This section of the literature review provides a structure of sections each of which addresses a specific theme and elaborating on researched materials on my study topic of use of bamboo as a construction material. Not much has been documented on consumer awareness and this research seeks to bridge that gap.

2.2 Sustainability of Bamboo as a construction material

With increasing global attention towards the potentially devastating effects of climate change has come an increasing focus on the role of deforestation and land use change. Fuelled by an ever growing demand for wood products, tropical deforestation continues to increase at an alarming rate. To successfully reverse the current trends of deforestation and forest degradation, it is imperative that market demands for wood and timber products that cause such land use change, are addressed. Bamboo matures in a fraction of the time of tropical hard woods (4yrs compared to 20+ for species such as teak, mahogany, ironwood, rosewood etc) and with new technology that enables the processing of bamboo for high end products such as flooring, decking, construction and furniture, bamboo represents a sustainable alternative.

Bamboo, a native, renewable East African forest resource, could be one alternative source of sustainable building material that can help the region meet its housing needs. Decades of research by bamboo practitioners has validated that, when treated and used properly, bamboo is a sound structural and engineering material, which, due to its strength, flexibility and versatility, is a suitable material for use in housing, (Kibwage et al, 2011).

In India, and in many other developing countries, it is important that professionals and entrepreneurs working in various technical areas of the construction industry become participants in promoting sustainable development, (Trieste, 2008). A sustainable building is a structure that is designed, built, renovated, operated or reused in a resource-efficient manner. A sustainable building may cost a lot to build, but over the long term there are savings related to lower operating costs.

The uses of bamboo makes a significant contribution to rural income and employment, although the rapidly diminishing supplies of forest bamboo through indiscriminate clearing of natural forests and the lack of priority in its development join forces to erode its status, (Kigomo, 2007).

While bamboo has considerable potential for meeting regional housing needs in East Africa, several questions remain over whether bamboo is able to meet housing needs at the larger

scales, necessitated by the current housing crisis, in a sustainable, economic, and technically viable way. Environmentalists and architectural organisations are working hard to promote green design throughout Kenya and to position their country as a leader in sustainable construction and energy-efficient design. The country is slowly joining the league of countries employing green or environmentally sustainable architecture in real estate development. However, the full realization of green technology is being hampered by lack of properly trained personnel in the field. Most ‘experts’ in the field usually incorporate an element or two of green design and then label the project green resulting in misinformation to the general public, (http://www.standardmedia.co.ke/?articleID=2000059805&story_title=%91Green-revolution%92-in-Kenya). This research aims to address how a sustainable supply chain of bamboo raw materials for processing and a larger-scale, economically viable bamboo housing industry can be established in Kenya and adopted in green buildings.

2.2.1. Availability of bamboo in Kenya

Most of the bamboo resources in Kenya comprise one indigenous species, *Yushania alpina*, which was formerly known as *Arundinaria alpina*. This species, which is commonly known as “alpine bamboo”, occurs naturally on the main mountains and highland ranges of Kenya and eastern Africa. Among the most important minor forest products, bamboo has continued to gain recognition. Once upon a time in Kenya, bamboo was regarded as a weed; today it is considered as a multipurpose plant and as a valuable timber substitute. Bamboo raw materials are however scarce due to the current ban on bamboo extraction from public forests, (Kigomo, 2007). Even if the ban were to be lifted, the cover of bamboo resource is presently low due to excisions of indigenous forests where bamboo was dominant. This calls for production of raw materials from farms not only to ensure expanded supply, but also to get the materials nearer to the market yards.

A study carried out by M. N Muchiri and M. O. Muga in 2013 lead to a number of conclusions about bamboo in undisturbed stands at Kamae, Kieni, Kinale and Ragia Forest Stations in Central Province in Kenya. One of these conclusions pointed out that one hectare of undisturbed

bamboo stand can produce 10 500 bamboo culms with green and oven dry weight of 100 tons and 55 tons, respectively; Selective cutting of bamboo triggers regeneration. They stated that the culms mean stoking density (21000 culms ha⁻¹) in their study is one and half times that reported in earlier studies in the same geographical area (Wimbush, 1945; Kigomo 1995, 1988, 2007, and Kant et al 1992). The possible reason for this is that there has been no harvesting of bamboo culms in the study area for more than a decade, which is more than the life cycle of bamboo.

The dominant species of bamboo in Kenya is the indigenous *Arundinaria alpina* (K.Schum), locally known as Mirangi (Kikuyu), Techani (Pokot), Tegek (Kips.), Tekek (Sebei), Modi (Luo) and Mianzi (Kiswahili), (Ongugo, Sigu, Kariuki, Luvanda and Kigomo, 2000). *Arundinaria alpina* grows to 20 m tall in ideal conditions, but at high altitudes, the culms are relatively slender and short. Culms are thick-walled and branches emerge at the upper nodes. Shoots are produced during the rainy season and culms live for between seven and fourteen years. In the study carried out by P.O Ongugo et al., it was established that *A. alpinain* natural stands had an average stem length of 10.2 m and a diameter of 7.5 cm. Bamboos from farmlands were on average found to be smaller, with an average length of 9.6 m and diameter of 6.2 cm. The study also established that the main sources of bamboo are government forests on which about 99.4 % of the total area produced. The remaining 0.6 % is produced on farmlands. This was done over a decade ago and my research includes determining new and correct facts on the availability of bamboo for construction purposes in Kenya.

Bamboo species grow naturally on the mountains and highlands of Eastern African Countries and in the medium lowlands of other African countries (KEFRI, 2007). Although bamboo has traditionally played an important role in the rural economies of East Africa, due to indiscriminate clearing of natural forests and the lack of government policies to support development, bamboo resources have diminished rapidly across East Africa, with subsequent erosion in the status of the resource (KEFRI, 2007).

Alex Carrere (2008) posited “I did some research on the availability of bamboo in Kenya and found some interesting results. Bamboo does seem to be a viable material in Kenya, but its logging is restricted by the government. This may or may not be a problem for us or local

farmers, but it is worth taking note of the issue. Another detail to note is that current demand for the bamboo material is higher than the supply. Therefore it may be hard to obtain some easily and cheaply.” There are about 150,000 hectares of bamboo forests in Kenya, partly pure and partly in mixture with trees and shrubs. Bamboo in Kenya play a very important role in fencing, house construction, water harvesting, cottage industries dealing with matchsticks, baskets, tooth-picks, various other handicrafts and, in agricultural farming especially for supporting horticultural crops. The bamboo resources in Kenya consist of indigenous *Arundinaria alpina* K. Schum and introduced (exotic) species. The indigenous bamboo species is mainly found in gazetted indigenous forests and small proportions are in farmlands. (Source: FAO (2005). The total area of bamboo reported by the five African countries makes up over 2.7 million hectares. This equals 4.1 percent of their total forest area. Bamboo has not been commercialized in Africa, although other organizations have done research on the bamboo production in East Africa and implemented community based initiatives to start building a market. This study seeks to bridge the gap between findings from previous research done and implementation of application of bamboo in construction since it is currently still lacking.

2.3 Cost Implications of Bamboo as a material resource in Construction

Bamboo is an extremely fast growing plant, with some species obtaining growth surges of 100cm per 24 hour period. Most bamboo species grow to their full height within a single growing season. Over the following seasons the walls of each culm (or stem) dry and harden, reaching maturity within 3 to 5 years. After a maximum life, which varies by species and climate, the individual bamboo culm will collapse and decay, although the plant itself may survive. Furthermore bamboo tolerates poor soils, which makes it useful for planting on degraded land. (Hunter, 2003) This needs to be investigated with respect to available soil types in Kenya, considering that it would reduce costs incurred during land preparation for bamboo farming.

Costs for selected bamboo processing activities was estimated by P.O Ongugo, G. O. Sigu, J. G. Kariuki, A. M Luvanda and B.N. Kigomo in 2000 in the journal “Production-to-Consumption

Systems: A Case Study of the Bamboo Sector in Kenya”. The average daily wage rates for laborers in the study areas were between Ksh. 150 at peak season and Ksh. 100 at low season. With minimal research to refer to, cost-Benefit analysis implications will be assessed at the end of the study to determine whether bamboo flooring is a less expensive construction material as opposed to what already exists in terms of wood products and other competing flooring materials in construction.

In the case of garden city Estate, the four different types of houses under construction, which are two bedrooms duplex, the standard two bedrooms, three bedroom duplex and the standard three bedrooms all with varying areas in square meters, bamboo is being used for flooring and is being imported from China. The cost of using bamboo in flooring is sh.3200 per square metre as compared to locally available mahogany flooring which is sh.3600 per square metre. The wet areas are being floored with ceramic tiles which cost sh.1800 per square metre. One of the factors that contribute to a stylish home is the kind of finishing that is employed on the floor and this is the purpose of choosing the wooden flooring; wooden flooring is being adopted in many high end construction buildings thus the need to look for an alternative to the red oak and mahogany which are not sustainable tree species in green buildings technology. Bamboo is a popular flooring choice for the eco-conscious crowd because it is considered a rapidly renewable resource. In other words, bamboo grows so quickly that when it is harvested for flooring, it can be replaced very quickly. Bamboo Flooring has several benefits including its relatively easy upkeep, the strength of the wood and its overall adaptability. Bamboo also provides a natural beauty and the warm feel of a wood floor underfoot, (Frank Angwa, May 2014)

2.3.1 Cost of Processing Bamboo into Construction Material (Technology)

The basic cultivation and harvesting methods for plantation bamboo have been explained by David Farrelly (1984). There is no consideration for its final intended usage when bamboo is harvested. The high initial moisture content of bamboo may easily cause splitting. The

uncertainty of age of the harvested bamboo will create problems in processing and utilization. Some of the factors that should be taken into consideration for the improvement of the harvesting technique are age, desired quality, and the properties of the end uses. Although humanitarian emergencies may require that bamboo be harvested at any time of year, good crop management and harvesting procedures can really increase the productivity and durability of bamboo crops, (Boucher et al., 2009). However, a satisfactory and systematic harvesting technique of wild bamboo has not yet been well established.

Planting is done in March and September and planting materials are obtained during the rainy season when the shoots are coming up i.e. March and September. Rotting and transportation from the source and poor management are the main problems encountered by bamboo farmers, (Oberthur, Aliguma et al., 2009). Many processing stages are involved depending on the product, since this paper solely seeks to investigate an end product that supports construction in Kenya, processes that are involved in this case, as well as practicability in the country, will be researched.

Many view the lack of internationally recognized standards as a serious impediment to the expanded use of structural bamboo. “The lack of codes and standards has kept architects and designers away from bamboo, even from expressing their requirements for bamboo as a building material”, accords a 1997 INBAR newsletter. This was remedied in 2000, when the International Conference of Building Officials (ICBO) passed the “Acceptance Criteria for Structural Bamboo” (AC162). The publication of this document is a big deal for people wanting to use bamboo structurally, according to DeBoer, “AC162 includes formulas for engineers to use and testing criteria for whatever species you’d want to use,” he reports. In order for building officials to approve structures supported primarily by bamboo, the material must be standardized in a manner similar to wood. This requires extensive strength testing of species to be utilized. With known structural values, calculations can then be made by structural engineers and architects. Technology and design for bamboo-based constructions have made considerable progress, resulting in impressive designs in Latin America and in the Far East, thus application of the same locally shall be investigated.

Typical large scale processing involves sorting the raw bamboo culms on delivery by gatherers to cull out defected ones and cross-cutting the culms into desired lengths for splitting, denodding and cleaning. The split culms are treated by boiling in water and insecticide/other chemical mixture and dried by solar kiln dryer or air/sun drying. The treated culms are then smooth-planed and a number of pieces glued together and pressed at a temperature range from 90-100°C and pressure of 200 kg per cubic centimeter. The output goes through final planning to yield the pre-finished product, e.g. bamboo ply that is either sold to domestic furniture companies or further processed into finished products for construction i.e. Ply bamboo, ceiling panels floorings, window blinds, (Obiri and Oteng-Amoako, 2007).

The technology involved in conversion of bamboo into construction material will be used as an indicator of cost. The research will cover bamboo use in Garden City estate and the difference between importing the finished product from China and what cost implications would be to process the bamboo from raw material within the country given the resource availability in Kenya.

2.4 Durability of Bamboo Flooring

Hardness is the main factor in durability. Bamboo flooring can be as soft as pine and harder than ironbark depending on the species of bamboo used and when it was harvested, (Oberthur, Aliguma et al., 2009). There are two major kinds of bamboo flooring on the market. Engineered bamboo, and stranded bamboo. Engineered bamboo is not one hundred percent bamboo, but it is much more durable than true bamboo. It also offers better moisture resistance than true bamboo, which will prevent it from warping and buckling even in very damp climates. Stranded bamboo is made with fibers of bamboo which have been shredded. The shredded fibers are then mixed with an adhesive, and pressure is applied to make the bamboo flooring sheets, this type of bamboo flooring is the most durable. As much as it has commendable durability, bamboo floor will scratch and dent just as much as any other hardwood flooring thus care has to be taken when dealing just as normal wooden floors.

In wood the strongest fibers are packed in the center of the trunk while in bamboo the stems are full of cavities and distributed most densely in the outer surface region which makes it very stiff, as a consequence the most stable fibers structures in bamboo are most dense in the regions of greatest longitudinal stress, (Properties of Bamboo).

2.5 Conceptual framework

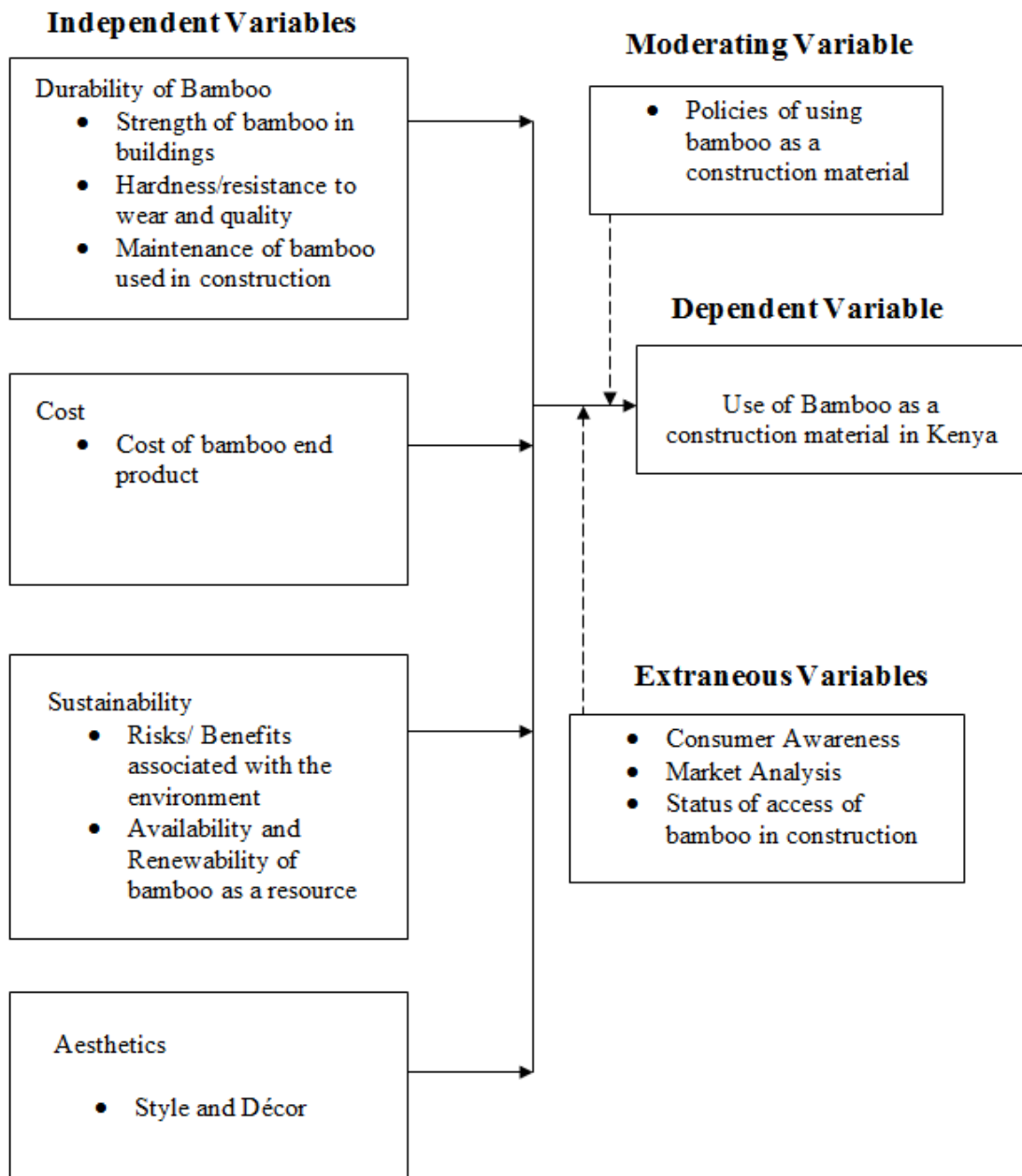


Figure 2.5: Conceptual Framework

2.6 Knowledge Gap

Research was done and a paper written by P.O Ongugo, G. O. Sigu, J. G. Kariuki, A. M Luvanda and B.N. Kigomo in 2000 and mention bamboo usage on a small scale as plant supports in the horticulture industry, especially the flower industry around Lake Naivasha, as a raw material in the handicraft industry, and in the construction industry for fencing and interior decorations. It is also used as partitioning materials. Fencing uses about 74 % of all the bamboo harvested in the study areas, the flower industry 20 %, the construction industry 4 % and the rest of the sectors use about two percent. This research seeks to explore possibilities of increasing that percentage used in construction and primarily investigating whether it is a higher or lower than what was given in the above citation. In addition the research will unearth all the factors that have hindered the large scale use of bamboo as a construction material in Kenya.

2.7 Summary of Literature Review

Bamboo is a certain type of grass that grows very rapidly. There are many different types of bamboo that vary in size and root structure, but specific species of bamboo are extremely useful as a construction material (Bethany Albert, 2011). It is strong, lighter than steel, and consumes little energy to produce. As a building material, it is fire resistant and earthquake resistant. These are attributes that make this resource a viable research with the need to develop Kenya's construction industry with a sustainable and economically viable material that at the same time does not compromise structural stability. Recently, the International Network for Bamboo and Rattan (INBAR), the world's only intergovernmental organization dedicated to the sustainable development of bamboo and rattan, and Chinese partners have also demonstrated that laminated bamboo can be used in structural applications, presenting new opportunities to standardize bamboo-based construction and produce modern modular housing designs that are potentially suitable for East African markets.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design and the methods that were adopted in the research study. It states the target population and procedures that were used to determine the target from the accessible population that was investigated. The data collection instrument that was used, their validity, reliability and how they were administered are another aspects discussed in this chapter. The procedure that was used for analysis and presentation of findings of the study is also highlighted.

3.2 Research Design

The purpose of a descriptive research is to examine a phenomenon that is occurring at a specific place(s) and time and is concerned with conditions, practices, structures, differences or relationships that exist, opinions held, processes that are going on or trends that are evident. A descriptive survey was used in this study where participants in the construction industry were investigated concerning the introduction of bamboo as a construction material in Kenya.

In normal science, theory is developed through incremental empirical testing and extension (Kuhn, 1970). Thus, the theory-building process relies on past literature and empirical observation or experience as well as on the insight of the theorist to build incrementally more powerful theories. However, there are times when little is known about a phenomenon, current perspectives seem inadequate because they have little empirical substantiation, or they conflict with each other or common sense. Or, sometimes, serendipitous findings in a theory-testing study suggest the need for a new perspective. In these situations, theory building from descriptive survey research is particularly appropriate because theory building from case studies does not rely on previous literature or prior empirical evidence, (Eisenhardt, 1989).

This type of work is highly complementary to incremental theory building from normal science research.

Descriptive research involves describing and interpreting events, conditions, circumstances or situations that are occurring in the present, (Yin, 1994). It seeks to engage with and report the complexities of social activity in order to represent the meanings that individual social actors bring to their social settings. It excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research. Kathleen M. Eisenhardt in 1989 created a complete roadmap for executing this type of research than has existed in the past. This frame work from her book “Building Theories from Case Study Research” was adopted in this study of Garden City Project; to determine the influence of bamboo as a construction material in Kenya.

3.3 Target Population

The target population for a survey is the entire set of units for which the survey data are to be used to make inferences, retrieved from <http://srmo.sagepub.com/view/encyclopedia-of-survey> “Target Population: SAGE Research Methods”, (2014). Thus, the target population defines those units for which the findings of the survey are meant to generalize. Establishing study objectives is the first step in designing a survey. Defining the target population should be the second step. Target populations must be specifically defined, as the definition determines whether sampled cases are eligible or ineligible for the survey, (Paul J. Lavrakas, 2008). There are many different players in the construction process that have distinct roles in the research of bamboo in the industry, the ones selected have roles defined below that encapsulate the reason as to why they fall within the target population:

- **Contractors-** Contractors perform the construction work in accordance with the plans and specifications provided by the owner and are required to be licensed by state law.

- **Construction Managers (Project Managers)-** Generally, the construction manager does not perform construction work on projects, but is an agent for the owner. coordinates the construction project
- **Residential Construction Developer**
- The developer is generally the owner and the builder of the residential development. The developer acquires land, obtains approval, secures construction financing, and begins construction of the residential development in stages or phases of construction.
- **Architects and Engineers-** The architect and engineer design the plans to be used by the construction contractors. The plans provide the necessary detail (dimensions, materials to be used, location of fixtures, etc.) to the contractors. When the project is started, the architect or engineer may monitor the contractor's progress
- **Quantity Surveyors-** They are responsible for the cost of any building project - from initial estimates, right through to the final acquisition of materials. They are focused on providing clients value for money while adhering to the strict regulations which govern every aspect of the construction industry.
- **Sustainability/ Green consultants-** They specialize in energy efficiency and is a trusted source for technical and property management know-how in housing construction and residential living. Upgrading the buildings' energy systems, for example, is an integral part of building maintenance
- **Bamboo Suppliers-** The party that supplies goods or services, in this particular case bamboo products.

The team of the lead consultants, whose census was a total of 30, is given in Table 3.3 below. The census gives an official count of the target population which was selected bearing in mind the

significant roles of each in the construction industry. The use of census instead of sampling was carried out since the target population is small and the census will constrain extraneous variation as well as sharpen external validity.

Table 3.3: Target Population Census

Participant	Company	Number
Contractor Personnel	SinoHydro Cooperation Limited	4
Construction Managers (Project Managers)	Mentor Management	4
Residential Construction Developer	Actis	2
Architects	Leonard Design Architects	2
	Triad architects	2
Engineers	Arup International	2
	Metrix Engineers	2
	Loadline Engineers	2
Quantity Surveyors	YMR	4
Sustainability/ Green consultants	WEB Limited	4
Bamboo Suppliers	Great Wall Enterprises China	2
TOTAL		30

3.4 Methods of Data Collection

The study used primary data which was collected following the conceptual framework within the target population. Each construct was represented by a set of indicators which formed the question in the survey. Participants were also asked to respond to general questions and the researcher probed and explored their responses to identify and define people's perceptions, opinions and feelings about bamboo in the construction industry and to determine the degree of agreement that exists. The quality of the finding from qualitative research is directly dependent upon the skills, experience and sensitive of the researcher. In general, qualitative research generates rich, detailed and valid data that will contribute to in-depth understanding of the context. John D. Anderson in a journal "Qualitative and Quantitative research" in 2006 posited, "Qualitative analysis involves a continual interplay between theory and analysis. In analyzing qualitative data, we seek to discover patterns such as changes over time or possible causal links between variables."

Data triangulation also referred as data sources triangulation depicts the use of multiple data sources in the same study for validation purposes. There are three types of data triangulation; namely, time, space and person, (Denzin, 1970). These types of data triangulation come as the result of the idea that the robustness of data can vary based on the time data were collected, people involved in the data collection process and the setting from which the data were collected (Begley, 1996). Denzin extended the idea of triangulation beyond its conventional association with research methods and designs. Data triangulation entails gathering data through several sampling strategies, so that slices of data at different times and social situations, as well as on a variety of people, are gathered in order to enhance confidence in the ensuing findings. The idea of triangulation is very much associated with measurement practices in social and behavioral research. An early reference to triangulation was in relation to the idea of 'Unobtrusive Method' proposed by Webb et al. (1966), who suggested, "Once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced. The most persuasive evidence comes through a triangulation of measurement processes".

There are various ways in which qualitative researchers try to show that their findings are reliable (Coolican, 1994). Probably the most satisfactory approach is to see whether the findings obtained from a qualitative analysis can be replicated. This can be done by comparing the findings from an interview study with those from an observational study. Questionnaires were also used in this study. They contained designed questions which the respondents filled in their answers; these questionnaires contained closed ended questions and open ended ones. Open ended questions solicit specific details and were answered by the respondents in their own words. Closed ended questions consisted of multiple choices and their advantage is their simplicity as the multiple choices were printed right there in the questionnaires. The questions had the advantage of ensuring precise and relevant answers.

There were some unstructured questions which were perceived to be economical as they were used on a large sample at the same time; they were less time consuming and ensured the confidentiality of the respondents as no names were required, just direct and frank answers which did not require the presence of the researcher.

3.5 Validity of the Instrument

Data validity is the correctness and reasonableness of data. It refers to whether the questionnaire in this case measures what it intends to measure. Content validity is based on the adequacy with which the items in an instrument measure the attributes of the study (Nanally, 2000). To achieve this data was gathered from all people who were willing to provide the information. Sources were also protected.

Qualitative research has established its own place in research on teaching (Silverman, 1997), thus the quest for more sophisticated procedures to secure objectivity in this type of research is increasing (Miles and Huberman, 1994). Two critical issues in regard to objectivity are reliability and validity. This research specifically deals with enhancing the *internal validity* of qualitative research. In conceptualizing “internal validity”, we followed Miles and Huberman

(1994), who stated that internal validity has to do with questions such as “Do the findings of the study make sense?, Are they credible to the people we study and to our readers?, Do we have an authentic portrait of what we were looking at?”. Pedhazur and Pedhazur-Schmelkin (1991) described internal validity, though in the context of non-experimental research, as the *sine qua non* of meaningful research.

3.6 Reliability of the Instrument

Data is considered reliable when it is complete, accurate and unaltered. To ensure its accuracy it must be consistent and correct. Reliability is an extent to which any measuring procedure yields the same results on repeated trials (Carmines & Zellers, 1999). Reliability of the instrument was improved through piloting and pre-testing. Test and re-test technique was used; this is administering the same questionnaires twice to some of the respondents to assess the reliability of the instrument.

3.7 Data Collection Procedure

Data was collected by means of self-administered questionnaires. The self-administered questionnaires were designed utilizing concepts created from the preceding objectives and seeking to answer the research questions. A pilot test was not conducted because the target population comprised construction field specialists who were all conversant with materials used in the construction industry and by default Bamboo, since they were all involved in the Garden City Project. This in turn ensured that the respondents had sufficient knowledge and understanding to express a meaningful opinion about the factors affecting the use of bamboo as a flooring construction material.

The questionnaires were distributed to the target population within a week and were collected over a period of time leading to about 3 weeks after which data analysis commenced.

3.8 Data Analysis Techniques

Data collected was edited for accuracy, uniformity, consistency, completeness and arranged to enable coding and tabulation before the final analysis. The data obtained from the questionnaires was coded, organized, analyzed and presented. In summary, the qualitative and quantitative data analysis involved the following steps:

- Documentation of the data and the process of data collection
- Organization/categorization of the data into concepts
- Connection of the data to show how one concept may influence another
- Corroboration/legitimization, by evaluating alternative explanations, disconfirming evidence, and searching for negative cases
- Representing the account (reporting the findings)

The methods guaranteed easy understanding of presented data and information. The explanations of the study findings were concluded from analyzed data which was carried out by use of cross pattern analysis and proportions in descriptive statistical tools by computing the standard deviations, frequencies and mean. Summary data from the study was presented in the form of figures and tabulated, so that it is easy to understand and deduce similar trends and patterns. Among the possible ways of presenting the data in a figure are the following: frequency polygon; histogram; and bar chart; frequency polygons and histograms are used when the scores can be ordered from low to high, whereas bar charts are used when the scores are in the form of categories, (TV Cumberbatch's, 2004).

3.9 Operational definition of variables:

A good operational definition tells a person clearly how to perform or take a measurement. The variables were defined as per the research objectives shown in table 3.9.

Table 3.9: Variables Measurement and Analysis Summary

Variable	Type of Variable	Indicator	Measurement	Scale	Research Instrument	Method of Analysis	Reason
Economic Benefits <i>High</i> <i>Adequate</i> <i>Low</i>	Independent	- Cost of technology used in processing bamboo in construction -cost to bamboo consumers in the construction industry	-More than 70%=High 40-70%= Adequate Less than 40%= Low -Likert Scale 4 and 5 Point	Ordinal	Qualitative and quantitative	Descriptive statistical analysis by proportions and computing frequency, standard deviation and means	Gives typical scenario a population which can be modeled as a large proportion p of the census used in drawing conclusions
Sustainability <i>Yes or No</i>	Independent	-Climate -Environment -Availability	Present= Yes Absent= No	No-minal	Qualitative	Cross Pattern analysis using diverged techniques	Allows researcher to look beyond initial impressions and see data through multiple lenses
Durability <i>High</i> <i>Adequate</i> <i>Low</i>	Independent	-Operations in construction sites	More than 70%=High 40-70%= Adequate Less than 40%= Low -Likert Scale	Ordinal	Qualitative and quantitative	Descriptive statistical analysis by proportions and computing frequency, standard deviation and means	Gives typical scenario a population which can be modeled as a large proportion p of the census used in drawing conclusions

3.10 Ethical issues

This research involved collecting data about Bamboo as a construction material from the key participants in the construction industry. Since the research was conducted in a professional setting, there was no need to be aware of the ethics behind the research activity. As the researcher, I sought permission of the people whom the study involved. Personal opinions and bias were strictly kept away from the research while formulating the questionnaire. The research was conducted under the assumption that the findings will be strictly confidential. The results were also accurately represented and responses not taken out of context.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

The data collected was coded, analyzed and presented as given within this chapter. The presentation of the data is linked to the questionnaire in appendix 2. The following will be used to analyze the data: description of the item, main results, discussion, presentation and interpretation of the results.

4.2 Response Rate

Out of 30 questionnaires issued, 23 were returned and this accounted for 76.7% of the target population which was used for data analysis. On these same parameters, the survey response can be relied upon with the knowledge that all participants of the construction industry within the Garden City Project were interviewed and responded accordingly within the given proportions.

Table 4.2: Questionnaire Response Rate

Participant	Number of questionnaires issued	Number of questionnaires returned	Proportion of response %
Contractors	4	4	100
Project Managers	4	3	75
Construction Developer	2	0	0
Architects	4	2	50
Engineers	6	4	66.7
Quantity Surveyors	4	4	100
Sustainability/ Green consultants	4	4	100
Bamboo Suppliers	2	2	100
TOTAL	30	23	76.7

4.3 Demographic detail of the respondents

The following are the demographic details covering age, gender, nationality, level of education, experience levels within the construction industry and the varied professions of the respondents.

4.3.1 Age of the respondents

It was necessary to find out the age of the respondents to determine their knowledge and experience with focus on the influence of construction materials in a building project and in turn relevance to this research.

Table 4.3.1 Age of respondents

Age	Proportion of response %
21 – 30	47.8
31 – 40	43.5
41 – 50	8.7
Over 50 years	0
TOTAL	100

Majority of the respondents (47.8%) are aged between 21 – 30 years whereas (43.5%) of the respondents aged between 31 – 40 years while (8.7%) of the respondents are aged between 41 – 50 years. This indicates that most construction industry participants are middle aged.

4.3.2 Gender of the respondents

From the questionnaire, the results indicated that the majority of the respondents (65.2%) are male while (34.8%) are female. Being the construction industry, this unequal percentage can be

expected but a tremendous improvement over the years has been made to accommodate both genders effectively.

Table 4.3.2 Gender of respondents

Gender	Proportion of response %
Male	65.2
Female	34.8
Total	100

4.3.3 Nationality of respondents

The participants within the population targeted indicated that there are various nationalities that were working within the Garden City Project thus showing the diversity of not only getting a local perspective but an international one as well with a percentage of 73.9% being Kenyans and 26.1% being a mixture of Europeans and Chinese.

Table 4.3.3 Nationality of respondents

Nationality	Proportion of response %
Kenyan	73.9
Non- Kenyan	26.1
Total	100

4.3.4 Education level of the respondents

The research wanted to find out the highest level of education of the respondents so as to find out if they are learned and if they have necessary knowledge and skills concerning the influence of construction materials within a building project as well the necessity of improvement of materials within the industry.

Table 4.3.4: Education level of the respondents

Education level	Proportion of response %
Primary	0
Secondary	0
College	26.1
University Undergraduate	56.5
University Postgraduate	17.4
TOTAL	100

The results as shown by the figure above indicated that majority of the respondents (26.1% and 56.5%) have at least college and university education. This indicates that majority of the respondents are learned and exposed to knowledge concerning the construction industry and the influence of materials within construction process.

4.3.5 Working experience of the respondents

The respondents were asked to indicate the duration they have worked for their varied institutional environments so as to find out how experienced they are with their duties, responsibilities and their ability to deal with challenges involved in the construction industry.

Table 4.3.5: Working experience of the respondents

Year	Proportion of response %
1 – 5	47.8
6 -10	21.7
11-15	21.7
Above 15	8.8
TOTAL	100

From the table it shows that the majority of the respondents (47.8%) have worked in the institution for at least 1 - 5 years whereas (21.7%) of the respondents have worked in the institution for a period of 6 - 10 years whereas (21.7%) of the respondents have worked in the institution for a period of 11 - 15 years and (8.8%) of the respondents have worked for over 15 years. These statistics indicate that majority of the respondents understood operations within the institution.

4.3.6 Project Participation of the respondents

The response of the Participants indicated that every individual within the target population of this research was at that time participating in the Garden City Project.

Table 4.3.6: Project Participation

Status	Proportion of response %
Currently Active	100
Completed	0
TOTAL	100

4.4 Opinion Information regarding the use of Bamboo as a construction material

4.4.1 Unlikelihood for Choosing Bamboo as a construction material

Preferences of choosing bamboo as a construction material according to the respondents was limited to the options in Table 4.4.1 as to why they would not necessarily select it as an option within the market. Where 8.7% of the respondents generally did not like Bamboo products, a majority 60.9 % were satisfied with competing products currently in the market, 30.4% could not afford bamboo products and none of the respondents were unwilling to pay for these products. This goes to show that with better/ more exposure to bamboo products in construction, end users are likely to embrace the change seeing that minority are against it or are not necessarily aware of the cost implications and several advantages over commonly used wood products.

Table 4.4.1 Reasons for unlikelihood of choosing locally available bamboo in construction

Reason	Proportion of response %
Do not want a Product like this	8.7
Satisfied with competing products currently available	60.9
Cannot afford to pay for a product like this	30.4
Not willing to pay for a product like this	0
TOTAL	100

4.5 Factors Affecting Choice of Construction Materials

4.5.1 Cost

Cost considerations must include the initial cost of purchase and the life cycle costs of materials. Life cycle costs include maintenance, replacement, demolition and disposal. Maintenance cost considerations must also factor in additional environmental costs such as the emission of volatile organic compounds (VOCs) when repainting for example. According to table 4.4.1.1, 100% of the respondents agree that cost is an important factor to consider when choosing construction materials.

Table 4.5.1.1 Cost

Response	Proportion of response %
Important	100
Not Important	0
TOTAL	100

The scale used for costing bamboo used in Garden City Project is per square meter area and the rate is Ksh.3200/ SQM. The participants gave a response of 60.9% agreeing that the cost of bamboo is cheaper as compared to other flooring used in construction in Kenya whereas 39.1% disagree with this as shown in table 4.5.1.2.

Table 4.5.1.2 Cost Comparison with Wood

Response	Proportion of response %
Cheaper	60.9
Not Cheaper	39.1
TOTAL	100

4.5.2 Availability

Availability may influence material selection decisions. From table 4.5.2, 100% of the respondents agree that availability is an important factor to consider in material selection. If they cannot be avoided, long delivery lead-in times must be allowed for as delays may cause project hold-ups and cost and energy losses which in turn causes the budget of the project to inflate both financially and time-wise. The source of materials must be considered to keep transport costs and resultant emissions to a minimum. The heavier or more bulky materials are, the greater the transport costs will be – where possible, heavy and bulky materials in particular should be sourced locally.

Table 4.5.2 Availability

Response	Proportion of response %
Important	100
Not Important	0
TOTAL	100

4.5.3 Aesthetics

The choice of materials for a project requires considerations of aesthetic appeal. Majority of the respondents (69.6%) agree while 30.4% disagree with this. Generally, elements with higher maintenance requirements are likely to have lower initial costs but they may also have higher whole-life expenditure costs. As much as aesthetics are directly proportional to cost, it is still an important factor to consider when choosing materials especially when it comes to the finishes of the building in a project.

Table 4.5.3 Importance of Style and Décor in Material selection

Response	Proportion of response %
Important	69.6
Not Important	30.4
TOTAL	100

4.5.4 Sustainability

The total energy used in the extraction, production, transportation and construction of a building material is the embodied energy of that material. As high consumers of energy, buildings have a significant impact on our environment. A majority of the respondents (95.7%) agree that sustainability is an important factor to consider when selecting materials for construction while 4.3% think that it is unimportant. The environmental impact of extraction such as large-scale mining, on scarce, non-renewable resources is obvious, but even the extraction of renewable resources will have some impact on the environment e.g. pollution. Sustainability is a factor that should affect choice of material in construction; this means the present use will not compromise future use by running out or harming the environment at any time.

Table 4.5.4 Importance of Sustainability in material selection

Response	Proportion of response %
Important	95.7
Not Important	4.3
TOTAL	100

4.5.5 Durability and Strength

A highly durable material may provide the most sustainable solution if it reduces maintenance or replacement requirements but a material should also be appropriate to the expected life of the building. Materials must be selected or designed for their ability to support the loads imposed by the building over the whole life of the building. 100% of the respondents consider durability and strength to be an important factor to consider in material selection. An appropriate structural system and correct selection of structural materials can reduce excess material use and waste and increase the building's adaptability for other uses. Durability considerations should include:

- the actual or serviceable life of the building
- maintenance requirements
- the minimum statutory requirements for the building element.

Table 4.5.5 Importance of Durability and Strength in material selection

Response	Proportion of response %
Important	100
Not Important	0
TOTAL	100

Table 4.5 Perceptions of respondents towards factors that affect purchase of construction materials

Factors	Totally unimportant %	Unimportant %	Important %	Very Important %
Costs implications	0	0	52.2	47.8
Availability of materials	0	0	43.5	56.5
Style and Décor	0	30.4	43.5	26.1
Sustainability	0	4.3	30.4	65.2
Durability and Strength	0	0	21.7	78.3

4.5.6 Descriptive analysis of factors affecting material choice in construction (using the means and standard deviation)

Here descriptive tools like the means and standard deviation were used; the variable or the factor with the greatest mean and least standard deviation was ranked the most influential factor affecting material choice in construction as shown in the table 4.5.6 below.

Table 4.5.6: Output of the descriptive analysis with reference to importance of factor in material selection

Factors	Proportion (%)	Mean	Standard deviation
Costs implications	100	3.48	0.50
Availability of materials	100	3.57	0.50
Style and Décor	69.6	2.96	0.75
Sustainability	95.6	3.61	0.57
Durability and Strength	100	3.78	0.41

From the table above, durability and strength emerged to be most influential with a proportion of 100%, a mean of 3.78 in the 4-point Likert scale and the standard deviation of 0.41 which is the least.

4.7 Problems Related to Bamboo Products in Construction in Kenya

High-embodied energy- Despite its rapidly renewable advantage, most of the bamboo flooring in the Kenya has to be shipped great distances such as from China or some other Asian country.

Green experts say this fact kills the sustainable mojo the product has.

Not a solid product- Unlike wood, which can be solid or engineered, all bamboo is made from laminated strips that are glued together. While this does not necessarily mean the product is inferior, it opens the possibility for delamination.

Inconsistent product quality- Bamboo is manufactured in many ways so performance depends on process and varies from product to product and company to company. Some bamboo floors are more durable than others or emit varying levels of volatile organic compounds such as formaldehyde, depending upon how they are manufactured.

Pricey- The current price of bamboo available locally as compared to the rates in other countries is relatively high. This is as a result of importation that comes along with added costs like custom tax.

Unawareness- Relatively high numbers of end-users in the construction industry in Kenya are not aware of the different locally available Bamboo products.

4.8 Solutions for Problems Related to Bamboo Products in Construction in Kenya

Bamboo production in Kenya can be expanded and manufacturing industries developed locally that will tremendously reduce the need for importation and in turn minimize the embodied energy and price in the market.

Certain measures should be implemented that encourage product testing before adoption that will ensure that before a product is released to the market it is of high quality and to the required standards. This followed by proper training of personnel involved with installation to ensure that the workmanship is satisfactory to avoid cases of failure and in this case delamination before the end of the designated design life.

The conditions for use of bamboo in the construction industry should be promoted and this can be enhanced by improved research and marketing and or advertising of the Bamboo currently available in the market for construction use.

4.9 Advantages of Bamboo over other Construction Materials in Kenya

Bamboo is considered to be environmentally friendly because it comes from a rapidly renewable resource. Bamboo flooring is durable as well as attractive. It is more resistant to expansion and contraction than solid wood and is also insect and mildew resistant.

4.9.1 Easy Maintenance

Bamboo is relatively easy to maintain. You just have to sweep or vacuum it regularly to remove small particle debris. You can also occasional damp mop it, or clean it with a non-wax, non-alkaline, hardwood or bamboo floor cleanser. A majority of the respondents (73.9%) agree that bamboo flooring is easy to maintain while 26.1% are neutral which can safely be assumed to the percentage of participants not exposed to Bamboo flooring maintenance.

Table 4.9.1 Bamboo is easy to maintain

Response	Proportion of response %
Agree	73.9
Disagree	0
Neutral	26.1
TOTAL	100

4.9.2 Relatively Inexpensive

Bamboo’s cost is given in areas represented by square feet or square meters. Locally the price of bamboo is Ksh. 3,200 per square meter. As compared to the price of Mahogany (Hardwood)

which is Ksh. 3,600 per square meter and Engineered Wood which is Ksh. 4,500 per square meter, bamboo is clearly a cheaper option. Ceramic tiles is another commonly used material for flooring and its prices range from Ksh. 600- Ksh. 8,200 per square meter depending on the quality and origin. 87% of the research participants, which is a majority, agree that bamboo is a relatively cheap product.

Table 4.9.2 Bamboo products are relatively inexpensive

Response	Proportion of response %
Agree	87
Disagree	0
Neutral	13
TOTAL	100

4.9.3 Durable

There are certain types of bamboo that can be extremely strong, hard, and durable. Natural, un-carbonized bamboo that was properly harvested and manufactured can be as durable as red oak. Strand woven bamboo can be manufactured even harder than that. A majority of the respondents (87%) agree that bamboo is a durable construction material.

Table 4.9.3 Durability of Bamboo

Response	Proportion of response %
Agree	87
Disagree	0
Neutral	13
TOTAL	100

4.9.4 Ease of Installation and Aesthetically Pleasant

Bamboo flooring can be installed over numerous types of sub-floors such as: wood, sheathing grade plywood, vinyl tile, concrete, or Oriented Strand Board and has pretty simple process of installation i.e. can be nailed, glued, or set as a floating floor. Bamboo is a trendy flooring material that can elevate the elegance of a space almost instantly. It has an appearance and a feel that is similar to hardwood and yet, is still distinct and different. This can add an ineffable quality and worth to a room. 65.2% of the respondents agree to these two advantages of Bamboo of being easy to install and aesthetically pleasing.

Table 4.9.4 Bamboo is easy to install and aesthetically pleasant

Response	Proportion of response %
Agree	65.2
Disagree	0
Neutral	34.8
TOTAL	100

4.9.5 Sustainable

Bamboo is made from natural vegetation. The bamboo plant is a highly renewable resource that is able to grow to maturity in as little as three to five years. This is much faster than hardwood trees which can take upwards of twenty years or more to reach maturity. The use of natural materials is an important trend in the construction industry right now. As people are becoming more ecologically conscious they are demanding products that reflect these values. The entire population of respondents agrees that Bamboo is a sustainable construction material as shown in table 4.9.5.

Table 4.9.5 Bamboo is a sustainable construction material

Response	Proportion of response %
Agree	100
Disagree	0
Neutral	0
TOTAL	100

A Summary of the perceptions of the respondents towards advantages of bamboo flooring over other construction materials is given in table 4.9.6 below:

Table 4.9.6 Perceptions of respondents towards Advantages of Bamboo over other Construction Materials in Kenya

Factors	Strongly Disagree %	Disagree %	Neutral	Agree %	Strongly Agree %
Ease of Maintenance	0	0	26.1	47.8	26.1
Relatively Inexpensive	0	0	13	39.1	47.9
Durable	0	0	13	30.4	56.6
Sustainability	0	0	0	26.1	73.9
Ease of installation & Aesthetically Pleasant	0	0	34.7	30.4	34.9

4.9.7 Descriptive analysis of Perceptions of respondents towards Advantages of Bamboo over other Flooring Construction Materials in Kenya (using the means and standard deviation)

Here descriptive tools like the means and standard deviation were used; the variable or the factor with the greatest mean and least standard deviation was ranked the most influential advantage of bamboo over other flooring construction materials as shown in the table 4.9.7 below.

Table 4.9.7 Output of the descriptive analysis

Factors	Proportion (%)	Mean	Standard deviation
Ease of Maintenance	73.9	4.00	0.72
Relatively Inexpensive	87	4.35	0.70
Durable	87	4.43	0.71
Ease of installation & Aesthetically Pleasant	65.3	4.00	0.83
Sustainable	100	4.70	0.46

From the table above, Sustainability emerged to be the highest ranked advantage of bamboo with a proportion of 100%, a mean of 4.7 on the 5-point Likert Scale and the standard deviation of 0.46 which is the lowest.

4.10 Importance of research on Bamboo for Construction in Kenya

With ranking from 1 to 7, where 1 is “not useful” and 7 is “very useful”, the response indicated that there is need for research to be conducted covering Bamboo use in construction in Kenya, with 13% ranking 5, 21.7% ranking 6, and 65.3% ranking 7. I aspire to take this research to completion and put to action my findings as we continue to build our country and take construction to levels achieved by international platforms.

Table 4.10 Importance of research on Bamboo for construction in Kenya

Response	Proportion of response %
Useful	100
Not Useful	0
TOTAL	100

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter reports the findings and highlights various discussions of the influence of Bamboo as a construction material in Kenya: A Case of Garden City Project. The data presented shows the results obtained and recommendations for practice/improvement and for further studies.

5.2 Summary of the findings

The primary purpose of this study is to look at the influence of Bamboo as a construction material in Kenya and in particular the influence of the use of bamboo in the Garden City Project in Nairobi County, Kenya. The data presented is based on responses to various items in the questionnaires. The presented data discusses information based on personal characteristics of the respondents. The data presentation was done according to the objectives of the study. The results obtained from the questionnaire were analyzed via basic statistical tools such as proportions and means. This is particularly useful in evaluating the factors that influence the choice of construction materials and the advantages of using Bamboo in construction as captured on the 4-point and 5-point Likert scales respectively.

Based on the results, it is clear that majority of the respondents have worked for the construction industry for more than 5 years this represented by 53.2% whereas 47.8% have worked for a period between one and five years. The entire project population was at that time actively involved in the Garden City project. All of the respondents are either college, university graduates or post graduates; this implies that they have knowledge of major operations and their work.

The results of the study indicated the various factors considered when purchasing or ordering for flooring construction materials vis a vis the importance of each factor. The factors included cost, availability, aesthetics, sustainability and durability/ strength. A four point Likert was used to rank these and Durability/ Strength ranked first with 3.78 points average, followed by

sustainability with 3.61 points average, followed by availability with 3.57 points average, followed by cost with 3.48 points average and finally but equally important, aesthetics with 2.996 points average.

Majority of the respondents, 61.1%, agreed that there exist problems related to bamboo products in construction with regard to its availability locally. The respondents pointed out that fitting is not well done at times when it comes to bamboo flooring, end-product-bamboo is not locally available and is highly priced due to importation costs, there are few suppliers in Kenya for bamboo used in construction and many people are unaware that these products that are available locally. All these affect the adoption of bamboo in construction in Kenya greatly. To deal with these problems facing adoption of bamboo in construction in Kenya, there is need for clear communication and advertisement between the supplier and the industry with shared goals of achieving high quality bamboo products and proper installation of the materials; the industry should deal with qualified suppliers, expand the bamboo farming in Kenya and set up local industries to produce bamboo-end-product to avoid import taxes and extra costs incurred on importation, specifications for use of bamboo in construction should be promoted and with that ensure a continuous supply of high quality bamboo products.

From the study, it was determined that the scale used to cost bamboo is cost per square feet or square meters which is on average Ksh.3200 per square meter. In Garden City Project, approximately 24,000 square meters are being used for the residential component of the project. 60.9% of the respondents consider this to be cheaper as compared to other flooring materials used in the same capacity, and this is related to the advantages bamboo has over these other materials.

The advantages of bamboo flooring over other construction materials were ranked using the five-Point Likert Scale. Sustainability came first with an average of 4.7 points, followed by durability with an average of 4.45 points, followed by bamboo being relatively inexpensive with 4.35 points average and finally the ease of installation, ease of maintenance and it being aesthetically pleasing all with an average of 4.0 points. Majority of the respondents agree that

bamboo is environmentally friendly because it comes from a rapidly renewable resource, this as well as it is durable, relatively inexpensive, attractive and more resistant to expansion and contraction than solid hard wood. There are numerous advantages that bamboo flooring has over other construction materials but it also has its pitfalls.

It is shown in the research that all respondents indicated that there is need for further information research of bamboo in the construction industry and not just as flooring but adopted for other uses as well. The richness and depth of this research can be enhanced by use of interviews and observations. The study is limited to the extent that its focus is on the use of questionnaires and the researcher's observation to gather relevant information as well as a specific construction project, Garden City Thika Road Nairobi.

5.3 Discussion of Findings

From the data collected, it is evident that selection of construction materials is an important process in construction and in relation, various factors that are necessary to consider. Bamboo flooring meets these factor-requirements that include cost, availability, style and décor, sustainability, durability and strength.

Choosing a construction material is subject to preferences and from the research, some of the reasons project participants would not choose bamboo locally is because they do not like the product, are not willing to pay for it or cannot afford it and some are generally satisfied with products currently in the market. Majority of the participants in the Garden City Project were highly satisfied with their experience with bamboo and would recommend it in their further projects.

Bamboo is locally available but for construction it is fully on import basis which heightens the price due to importation charges that escalate its final cost. Otherwise, bamboo is a relatively cheaper material as compared to other hardwoods. This cost can further be lowered by setting up manufacture of ready-made bamboo materials for use in construction. On the lower range of the

scale, bamboo provides a less expensive alternative to hardwood, while still achieving a certain look and style, (Bamboo Flooring).

Bamboo has various advantages over competing flooring materials in construction. In our study we examined five of these which include its durability and strength, relative inexpensive products, pleasant aesthetically, sustainable and easy to install and maintain. These are broken down to be explained further by ranking how highly the respondents agree with these advantages from their experience with bamboo and all these were accepted. Bamboo flooring is a quality product that can be used widely and has a large, global consumer market. It has certain advantages over wooden floors due to its smoothness, brightness, stability, high resistance, insulation qualities and flexibility. Bamboo flooring has a soft natural luster and maintains the natural gloss and elegance of bamboo fiber. This flooring is attractive to the demanding markets in Europe, Japan and North America. The estimated annual production of bamboo flooring in China was 17.5 million m² in 2004. Exports account for some 65 percent of total production (Customs General Administration of China, 2004).

We assumed that bamboo is a viable product to carry out research on for the benefit of the Kenyan construction industry; it meets the requirements for construction materials and has potential for expansive use within the construction industry. The empirical research has also proved it to be the correct assumption. Decades of research by bamboo practitioners has validated that, when treated and used properly, bamboo is a sound structural and engineering material, which, due to its strength, flexibility and versatility, is a suitable material for use in housing, (Kibwage et al, 2011). The research was able to demonstrate statistically significant links between the durability of bamboo, its sustainability and availability or lack thereof within the country. We found that the cost is directly connected to its unavailability regardless of its great performance in terms of strength and positive sustainability.

5.4 Conclusions

In conclusion, the research indicated that bamboo for construction is locally available but not many participants in the construction industry are exposed to its numerous uses and advantages

which determined from the study are that it is a sustainable material, it is durable and meets the strength requirements in construction, it is relatively inexpensive as compared to hardwood and is aesthetically pleasant as well as easy to maintain and install.

An important extension of this study is to replicate this research to other construction projects, and more importantly conduct comparative organization studies. In addition, given the changes that are taking place globally and enactment of rules and laws, on corporate governance, it would be necessary to carry out research on ways in which the government and private sector can come in to assist in set up of manufacturing industries for locally available bamboo produce for construction since conditions are favorable for the growth of bamboo in Kenya. The findings are useful to further refine the already existing internationally conducted research with respect to the use of bamboo in construction. The problem the industry has with bamboo is that at times the fitting is not well done when it comes to bamboo flooring, end-product-bamboo is not locally available and is highly priced due to importation costs, there are few suppliers in Kenya for construction bamboo and many are unaware of these products availability locally. Strategies that can be set up to deal with these problems indicated are proper marketing from suppliers to participants in the industry, proper installation of the materials; the industry should deal with qualified suppliers, expand the bamboo farming in Kenya and set up local industries to produce bamboo end-products to avoid taxes plus extra costs incurred on importation, promote conditions for use of bamboo in construction and with that ensure a continuous supply of high quality bamboo products.

The respondents also found out that there is need for further research on construction materials in Kenya to bridge the gap of finding a locally available material that is sustainable, durable, cost friendly as well as aesthetically pleasant to increase market and value of construction projects. Material selection is a complex and delicate task determined by the immense number of building material options. Likewise, multiple factors are often considered when evaluating the various categories of building materials. Consultants usually need to identify and prioritize the relevant criteria to effectively and accurately evaluate the trade-offs between technical, environmental, economic and performance issues during the material evaluation and selection processes.

5.5 Recommendations

1. There has been relatively little research effort made to promote conditions for use of bamboo in the construction industry and not only as a flooring material but in other areas. More research should be done and deeper analysis into finding proper farming practices that can increase bamboo yield in Kenya that can in turn necessitate set up of local manufacturing industries that will reduce the overall cost of bamboo and enable consumers to enjoy all the other benefits bamboo has to offer in construction.
2. Substantial efforts need to be directed to consumer awareness of bamboo as a construction material as well as a sustainable building material.
3. The government agencies should be approached to assist in pushing for building laws and regulations/policies that emphasize on sustainable construction methods, setting up of new technology subsidies for the private sector who wish to pursue industrial manufacture of bamboo and other sustainable materials and mass campaign on sustainable construction methods.

5.6 Suggestions for further studies

1. There is an existing gap between the awareness and implementation of sustainable practices in the selection of local and recycled building materials in the design-decision making process, this can be elaborated further by research
2. Locally-sourced and sustainable building materials are yet to become main features or resemble a regime in mainstream construction, these materials should be looked into further to encourage adoption of materials that will not harm the environment
3. Nature, cost and factors influencing the technology required for bamboo production in Kenya.

REFERENCES

Alex Carrere (2008), "*Materials: Bamboo in Kenya.*" Brown University: Rhode Island.

Auberbach, C. F. and Silverstein, L. B. (2003) *Qualitative Data: An Introduction to Coding and Analysis*. New York: New York University Press.

B. Darko Obiri and A. A. Oteng-Amoako (2007), *Towards a Sustainable Development Of The Bamboo Industry In Ghana*

Bamboo Flooring, Retrieved on 12th October 2014 from <http://www.ifloor.com/bamboo-flooring>

Begley, C. M. (1996). *Using triangulation in nursing research*. *Journal of Advanced Nursing*, 24(1), 122-128.

Bethany Albert, (2011) *Village Volunteers*

Bernard N. Kigomo(2007), *Guidelines for Growing Bamboo, KEFRI Guideline Series: No. 4 - April*

Brewer, M. (2000). *Research Design and Issues of Validity*. In Reis, H. & Judd, C. (eds) *Handbook of Research Methods in Social and Personality Psychology*. Cambridge: Cambridge University Press.

Coolican, H. (1994). *Research methods and statistics in psychology (2nd edn.)*. London: Hodder & Stoughton

Chen Xuhe (2003), *Promotion of bamboo for poverty alleviation and economic development*

Customs General Administration of China, 2004, *China customs statistics yearbook*, Beijing: CGAC Publishing

Creswell, J. W. (2002), *Educational Research, Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, University of Netvaska : Merrill Prentice Hall,

David Farrelly (1984), *The book of bamboo*

Denzin, N. K. (1970), *The Research Act in Sociology*. Chicago: Aldine.

Eugene Nelson (2008), *Materials- Bamboo in Kenya*

FAO. (2010). *Global Forests Resource Assessment Country Report: Ethiopia*.
<http://www.fao.org/docrep/013/a1501E/a1501e.pdf>

Frank Angwa (May 2014) “Choosing your Flooring Alternatives” newsletter retrieved from
<http://www.homeskenya.com/homeskenya/index.php/b3>

Froeschle, L.M. (1999), *Environmental Assessment and Specification of Green Building Materials. The Construction Specifier. October 1999: 53-57*

Isabelle de Muysers-Boucher , Graham Saunders , Elizabeth Babister (2009), *A guide to the planning, use, procurement and logistics of timber as a construction material in humanitarian relief*

Jacob K. Kibwage, Oliver B. Frith And Shyam Krishna Paudel (2011), *Bamboo as a building material for meeting East Africa's housing needs: a value chain case study from Ethiopia*

John D. Anderson (2006), *Qualitative and Quantitative research*

Joseph Abuje (2014), *Kenya invests Sh120m in Bamboo Project*, Retrieved from:
<https://www.google.co.ke/#q=Kenya+invests+Sh120m+in+Bamboo+Project>

Karl Krämer Verlag Stuttgart (1992), *Bamboo as a building material: IL31 Bambus*,

Kathleen M. Eisenhardt (1989), *Building Theories from Case Study Research*

Kenya Forestry Research Institute (2007), *Guidelines for Growing Bamboo*. KEFRI: Nairobi

Kibwage, J. K.; Netondo, G. W.; Kapiyo, R. A.; Nyatika, D.; Momanyi, G. M., Odindo, A., (2005)., *Final Technical Proceedings Report on Workshop on the Diversification of Household Livelihood Strategies for Tobacco Small-holder Farmers*, (South NyanzaRegion, Kenya): IDRC, Canada.

Kibwage, J. K., (2007), *Diversification of Household Livelihood Strategies for Tobacco Smallholder Farmers: A Case Study of Introducing Bamboo in the South Nyanza Region, Kenya*.

L. R. Gay (1987), *Educational Research: Competencies for Analysis and Application, 3rd ed.*, Columbus, Ohio: Merrill Publishing Company

Lee Wallender (May 2014), “*Bamboo Flooring Durability*”, retrieved from
<http://www.homerenovations.about.com>

Liese, W. (1980). *Preservation of bamboo. In: Bamboo Research in Asia*, Bamboo Workshop, Singapore: IDRC, Ottawa, Canada.

Liese, W. (1987). “*Research on bamboo.*” *Wood Sci. Technol.*, 21(3), 189–209.

Liese, W. (1992). "The structure of bamboo in relation to its properties and utilization." *Proc., Int. Symposium on Industrial Use of Bamboo, Int. Tropical Timber Org. and Chinese Academy of Forestry.*

M. Mahdavi; P. L. Clouston, A.M.ASCE; and S. R. Arwade, A.M.ASCE (2011), *Development of Laminated Bamboo Lumber: Review of Processing, Performance, and Economical Considerations*

M. N Muchiri*and M. O. Muga (2013), *A Preliminary Yield Model for Natural Yushania Alpina Bamboo in Kenya*

Miles, M. B. & Huberman, A. M. (1994). *Qualitative Data Analysis*. Thousand Oaks, CA: Sage.

Mohamad Monkiz Khasreen, Phillip F.G. Banfill and Gillian F. Menzies (2009), *Life-Cycle Assessment and the Environmental Impact of Buildings: A Review*

P.O Ongugo, G. O. Sigu, J. G. Kariuki, A. M Luvanda and B.N. Kigomo (2000), *Production-to-Consumption Systems: A Case Study of the Bamboo Sector in Kenya*

Paul J. Lavrakas (2008), *Encyclopedia of Survey Research Methods*

Pedhazur, E. J. & Pedhazur-Schmelkin, L. (1991), *Measurement, Design, and Analysis: An Integrated Approach*. Hillsdale, NJ: Lawrence Erlbaum.

Peréz Zeledón (2014), *Bamboo construction*

Properties of Bamboo, retrieved 4th September 2014 from http://www.bikebamboo.com/bamboo_properties.php

Sengupta Nilanjan, Roy Souvanic (2013), *Study of Appropriateness of Cost-Effective Building Construction Technologies in Housing Sector in India*

Shyam Paudel (2011), *Development and Promotion of Bamboo Housing Technology in East Africa*

Silverman, D. (1997). *Qualitative Research: Theory, Method and Practice*. London: Sage.

T. Oberthur, L. Aliguma, B. Biryahwaho, D. Kuria, A. Jarvis, S.G. Anyona, R. Njeri, S. Kamau, N. Kinyanjui (2009), *Markets for Eco-agriculture in East Africa, with Focus on Kijabe, Kayunga and Kisoro Landscapes*

Trieste (2008), International Centre For Science And High Technology, *Available technologies for local building materials*

TV Cumberbatch (2004), *Research methods: Data analysis*,

Webb, E. J., Campbell, D. T., Schwartz, R. D., and Sechrest, L. (1966), *Unobtrusive Measures: Nonreactive Measures in the Social Sciences*. Chicago: Rand McNally

WCED (1987), *Our Common Future*. World Commission on Environment and Development. Oxford University Press, Oxford.

Yan Xiao, Bo Shan, Guo Chen, Quan Zhou, Liyong She, Ruizhen Yang (2010, 2009) *Modern Bamboo Construction as An Alternative for Sustainable Development*

Yan Xiao, Masafumi Inoue, Shyam K. Paudel (2008), *Modern Bamboo Structures: Proceedings of the First International Conference*

Yin, R.K. (1994) *Case study research: design and methods*. 2nd edition. Thousand Oaks, CA: Sage.

APPENDICES

APPENDIX 1: TRANSMITTAL LETTER



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Dear Sir/Madam,

**RE: THE INFLUENCE OF BAMBOO AS A CONSTRUCTION MATERIAL IN KENYA: A
CASE OF GARDEN CITY PROJECT –NAIROBI COUNTY, KENYA.**

I am a Postgraduate student undertaking a Master of Arts (MA) degree at the Department of Extramural Studies, University Of Nairobi. I am currently carrying out a research on the influence of bamboo as a flooring construction material in Kenya, a case study of Garden City Residential Project. This is a requirement to complete my MA course project at the University.

My approach to this survey is to be consultative but ensure that it is non-disruptive to your day to day schedule of activities. I kindly request you to provide the required information by responding to the questions in the questionnaire. The information required is purely for academic purposes and will be treated with confidentiality. Your name will not be mentioned in this research.

A copy of this research project will be made available to you upon request. I will appreciate your cooperation in this academic exercise. Thank you in advance.

Yours faithfully,

Robert N. Gichohi

APPENDIX 2: QUESTIONNAIRE

Dear respondent,

I am a student at Nairobi University undertaking a master's degree course in Project management. I am carrying out a research project entitled "**Factors Influencing the use of Bamboo as a Flooring Construction Material in Kenya: A Case of Garden City Project– Nairobi County, Kenya**". The project is a partial requirement by the institution for the award of Masters' Degree. Below are some questions addressed to you on the subject given above, kindly answer them as genuinely as possible. Your cooperation in ensuring that the questionnaire is answered will be highly appreciated. Please note that the information you will give will be highly confidential and will be used for academic purposes only.

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (X) THE RELEVANT BLOCK OR WRITING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

EXAMPLE of how to complete this questionnaire:	
Your gender?	
If you are female:	
Male	1
Female	2

Section A– Background information

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your cooperation is appreciated.

1. What is your age?

21 – 30 years	1
31 – 40 years	2
41 – 50 years	3
50 years and above	4

2. What is your gender?

Male	1
Female	2

3.Nationality

Kenyan	1
Non-Kenyan	2

Other (Specify).....

4. What is your level of education?

Primary School	1
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Secondary School	2
College	3
University Undergraduate	4
University Post Graduate	5

Other (Specify).....

5. How long have you worked in the construction industry?

1-5 Years	1
6-10 Years	2
11-15 Years	3
Above 15 Years	4

Other (Specify).....

6. What is your Profession?

Residential Construction Developer	1
Contractor	2

Architect	3
Engineer	4
Quantity Surveyor	5
Green Consultant	6
Project Manager	7
Bamboo Supplier	8

Other (Specify).....

7. Is your project with our company currently active, or has it been completed?

Currently active	1
Completed	2

Section B

This section of the questionnaire explores your preferences, if any, with regard to the use of bamboo as a construction material in Kenya.

8. How important is each of the following to you when purchasing/ordering for flooring construction materials? Please indicate your answer using the following 4-point scale where:

- 1 = Totally unimportant
- 2 = Unimportant
- 3 = Important
- 4 = Very important

	Totally unimportant	Unimportant	Important	Very important
Cost implications	1	2	3	4
Availability of materials	1	2	3	4
Style and Décor	1	2	3	4
Sustainability	1	2	3	4
Durability and Strength	1	2	3	4

9. Outline the problems related with bamboo products in construction with regard to its availability locally.

- a.....
- b.
- c.....

10. If you are not likely to use bamboo product available locally, why not?

Do not want a product like this	1
Satisfied with competing products currently available	2
Cannot afford to pay for a product like this	3
Not willing to pay for a product like this	4

11. What scale do you use to cost the bamboo used in Garden city for flooring, and how much is it?

12. Would you consider this cost of bamboo flooring to be cheap as compared to other flooring materials used in construction in Kenya?

Yes	1
No	2

Explain _____

Section C

This section explores your attitude and perceptions regarding bamboo in construction that is rapidly becoming one of the most popular types of flooring.

13. To what extent do you agree with each of the following statements? Please indicate your answer using the following 5-point scale where:

1. = Strongly disagree

2. = Disagree

3. = Neutral

4. = Agree

5. = Strongly Agree

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Bamboo floors are easy to clean.	1	2	3	4	5
Bamboo floors are ideal for allergy sufferers as they do not promote dust or harbor dust mites.	1	2	3	4	5
Bamboo flooring is an inexpensive alternative to hardwood flooring, usually costing 25% to 50% less than hardwood.	1	2	3	4	5
Bamboo flooring is long-lasting.	1	2	3	4	5
Bamboo flooring can be installed over numerous types of sub-floors	1	2	3	4	5

such as: wood, sheathing grade plywood, vinyl tile, concrete, or Oriented Strand Board.					
Bamboo floors are environmentally friendly. They use a quickly renewable crop. If they are made with safe resins, they have extremely low formaldehyde emissions and make excellent floors for healthy homes.	1	2	3	4	5

14. Bamboo is considered to be environmentally friendly because it comes from a rapidly renewable resource. Bamboo flooring is durable, attractive, and sourced from a renewable resource. It is more resistant to expansion and contraction than solid wood, and is also insect and mildew resistant.

No, I strongly disagree	1
No, I disagree just a little	2
I'm not sure about this	3
Yes, I agree quite a lot	4
Yes, I strongly agree	5

15. Do you think that further information on bamboo as a flooring construction material in Kenya would be useful for you?

Not at all Useful	1	2	3	4	5	6	7	Very Useful
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Thank you for your co-operation in completing this questionnaire. Kindly return the questionnaire as specified in the transmittal letter.

APPENDIX 3: PICTURES FOR GARDEN CITY SHOW HOUSE

A show house is a completed unit intended to show what the whole is like. It is furnished and decorated to be shown to prospective buyers. The pictures below show the finished bamboo floors in the show house.

Bamboo floor finish



Kitchen Bamboo Floor finish



Lounge



APPENDIX 4: PICTURES FOR TYPES OF BAMBOO FLOORING

The images below are the different types of bamboo flooring which are solid, engineered and strand woven bamboo. The type used in Garden City Project is Solid bamboo flooring.

