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BAMBOO CULTIVATION AND ITS ECONOMIC POTENTIAL IN THE KENYAN CONSTRUCTION SECTOR

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ABSTRACT

For decades, bamboo cultivation has taken place in selected regions in the world such as Latin America and the Far East. It is a fast-growing plant with numerous economic applications in several sectors including the construction industry. Currently, steel and timber are some of the heavily consumed construction materials. While steel production processes contribute to environmental degradation, exploitation of the timber products has led to wonton destructions of forests with grave environmental consequences. The foregoing implies that there is a need to establish alternative construction materials which are both renewable and environmentally sustainable. The study relied on secondary data obtained from critical review of existing literature on bamboo cultivation as well as its economic potential to the construction industry. Content analysis was employed to analyze the data. The findings indicate that while bamboo farming in Latin America and the Far East is large scale, the bamboo cultivation in Africa and Kenya remains scantily exploited. The findings also show that although there exist several applications of bamboo in construction its application in the Kenyan construction industry remains at infancy stage. The recommends that Government provides incentives and sensitization programmes to promote large scale bamboo cultivation. Finally, the Government should put mechanisms in place for the formulation of a code of standards for application of bamboo as a construction material.

KEY WORDS: *Bamboo, Cultivation, Economic potential*

INTRODUCTION

Globally, the construction industry is growing fast especially in developing countries like Kenya and represents a significant Gross Domestic Product (GPD) of world economy. With this growth, the demand for steel has increased tremendously. In some cases, the demand is usually higher than the production and this has lead to increase in prices, hence making construction expensive. Other than the high cost of steel, the production of steel has drawbacks like atmospheric pollution and environmental degradation meaning steel is an environmentally unsustainable construction material *(Vyas, 2020 and Kibwage, 2010)*. Timber just like steel has been in recent years a major raw material in the Kenyan construction industry. The wonton destruction of forests experienced in Kenya in the recent past together with ban on logging has destabilized the supply of timber resulting to the scarcity and escalation of prices of timber products to levels that are unbearable calling for cheaper and sustainable alternative materials *(Mumero, 2020 and Carrere, 2008)*.

The study therefore, involved a critical review of existing literature on the bamboo cultivation and its economic potential in the Kenyan construction sector. The purpose of the study was to explore through existing body of knowledge the extent to which bamboo is cultivated revolving around global, regional and local levels. It also reviewed the potential economic benefits of bamboo cultivation in Kenya with a focus on how it would boost the construction sector. The study further concludes on its findings on the level of bamboo cultivation and its potential benefits to the Kenyan construction sector. It finally makes recommendations on strategies and policies required to enhance the current level of bamboo farming and also how to integrate it with the construction sector to boost economic performance.

BAMBOO CULTIVATION

Bamboo is a perennial grass that grows over a wide range of climates globally. 80% of the world's bamboo production lies in southern tropical region of Asia and 1.4 million ha in Africa with over 1250 species in 75 genera. The main genera in east Africa are; *Oxytenanthera, Arudiniaria and Oreobambos* (K*igomo, 1988*). Bamboo has been used in various forms for decades especially in those locations where it is found in abundance. The global bamboo production in 2016 was valued at 60billion dollars indicating its significant value in the world economies *(Mumero, 2010 and Republic of Kenya, 2019)*. It is estimated that there are over 1200 species of bamboo covering about 14.5 million hectares spread across Asia, Latin America and Africa in order of land coverage *(Kigomo, 1988; Jagadeesh,2014; FAO, 2010 and Essendi, 2017)*. The cultivation is however specifically in abundance in certain regions in the world. The cultivation occurs mostly in China, India and Brazil with China being the leading grower *(Constructor, 2020 and FAO, 2010)*. However according to *Kibwage (2008), Carrere (2008), Kigomo (1988) and Republic of Kenya (2019*), the bamboo cover for Africa is only 1.4 million hectrares which is mostly dominant in East Africa in which Kenya has a share of 150,000 hectares. The foregoing implies bamboo cultivation in Africa and Kenyan is in paltry level compared to the other regions of the world and is not wide spread but limited to specific counties.

Bamboo plant grows in specific regions of Kenya. *Republic of Kenya (2019) and Kibwage (2008)* indicate that bamboo growing in Kenya is concentrated in the Aberdares Ranges, Mau Forest, Mt. Kenya, Mt. Elgon and Cherangany Hills with its presence in a number of counties such as Migori, Vihiga, Homa Bay, Uashin Gishu, Elgeyo Marakwet, Kirinyaga, Laikipia, Nyandarua, Embu and Tharaka Nithi. That bamboo is a useful material prompted some research activities and policy formulation on how it could be best utilized and cultivated. Meaningful research started way back in 1986 when 22 species were introduced by the Kenyan Government and the initiatives were meant to promote growing of bamboo, value addition as an alternative crop, livelihood strategy as well as establishment of potential markets. The 2019 Draft National Bamboo Policy subsequently came into existence. The guiding principles of this policy include; clean and healthy environment, Government led market initiative, bamboo for green growth, increasing farmers income and reducing pressure on forests *(Republic of Kenya, 2019)*. These principles will go along way to boost bamboo farming once the draft policy has been enacted.

Bamboo as a building material is predominantly applied in Southeast Asia and South America where the climate is best suitable for its cultivation. Although the plant is also found in Africa, most African countries have not fully embraced it as a building material. In Kenya, most of the bamboo species exist naturally in the slopes of the Aberdare Ranges and Mt.Kenya (*Kigomo, 1988*). Although it is believed that cultivation of bambusa vulgaris and bambusa tulda could be more prevalent in the central region of Kenya with high to medium rainfall, the species is also available in other parts of the country including western Kenya. Some farmers in Vihiga county have turned to bamboo farming just after realizing the economic potential of this plant. This is mainly attributed to its lucrative nature as well as ability to grow faster and also conserve water compared to other plants making it a more sustainable construction material (Adhiambo, 2018; *Essendi, 2017 and Kibwage, 2010)*. Bamboo farming in Kenya is therefore, still insignificant meaning that the Government has work to provide the requisite incentives and sensitization programmes. Most of the bamboo in Kenya grows in their natural habitats in national forest reserves which are restricted entities.

The ability of bamboo to grow faster than the conventional timber, versatile nature, eco-friendliness and ease within which it can grow enhances its potential in the global economies. Some species can grow up to 3 ft a day and it also grows 3-4 times than other conventional trees such as eucalyptus *(Kibwage, 2008; Bethany, 2010; Kibwage, 2010; Essendi, 2017; Constructor, 2020; Vyas, 2020 and Mumero, 2020*). This is coupled with the fact that it can mature between three to five years depending on species and could be harvested upto 80 – 120 tons with minimal capital investment *(Essendi, 2017; Jagdeesh, 2014 and Fu, 2000)*. It is also interesting to note that mature bamboo trees have lengths of 4 – 12 metres (Limbe,2013). The implication of these characteristics is that bamboo could replace other construction materials such as steel and timber which are costly and also unsustainable environmentally.

Figure 1 below shows a bamboo forest with fast maturing species in Kenya.

Figure 1: Bamboo Trees in Kenya that Can Mature in 3-4 Years

Source: Mumero (2020)

In Vihiga County - Kenya, various species of bamboo such as Bambusa Tulda, Dentrocalamus gigantis, Dentrocalamus asper, bush bamboo and bambusa vulgaris are cultivated *(Adhiambo, 2018).* Local farmers in their individual farms are now growing and harvesting bamboo for making various products for commercialization purposes. Figure 2 below shows a couple processing bamboo in their workshop at Shamakhokho trading centre in Vihiga County, Kenya.

Figure 2: Bamboo Processing Workshop in Shamakhokho, Vihiga County, Kenya
Source: Wachie (2018).

Given the above scenario, bamboo farming by private individuals has its rightful place in the Kenyan the economy and will certainly spur the growth of small and medium enterprises (SMEs). The Government just needs to put in place the requisite strategies and policies for its full potential to be achieved.

THE ECONOMIC POTENTIAL OF BAMBOO PLANT

Globally, bamboo cane because of its unique properties has varied uses and applications ranging from making of tooth picks as household goods to its application as a material in the construction industry. *Swapnil and Smita (2017), Hebel (2015); Fu, 2000 and Vyas (2020)* argue that its various uses and applications are attributed to its versatility, faster growth compared to conventional trees, cost effectiveness as well as being an eco-friendly material. Globally there are over 1500 recorded economic benefits of bamboo plant *(Kibwage, 2010; Esssendi, 2017 and Madhab, 2003)*. On the other hand, in Kenya there are only 48 uses and applications indicating limited exploitation of its potential *(Ongugo et al, 2000; Kibwage, 2010 and Bethany, 2010)*. The limited uses and applications are mainly due to lack of sensitization and restricted logging by the government on timber products *(Carrere, 2008)*. *Gichohi (2014)*, on the other hand, cites lack of exposure of construction industry participants to the varied uses and applications as the key concern for its low economic exploitation in Kenya. Based on the above arguments, it is likely to replace other natural materials such as timber whose exploitation has led to wanton destruction of Kenya's forest cover with dire environmental consequences. Use of bamboo as an alternative resource in Kenya is also supported by the fact the demand for timber products has surpassed supply. According to Mumero (2020) the wood demand in Kenya is 31.4 million square kilometers against a supply equation of 44,130 square kilometers justifying the graveness of the situation.

Historically, bamboo was used in its natural state whereas today, bamboo is also used in engineered form with numerous new uses and applications. In its natural form, bamboo as a construction material is traditionally associated with the cultures of South Asia, East Asia and the South Pacific, to some extent in central and south America, and by extension in the aesthetic of Tiki culture (a 20th century theme used in Polynesian – style restaurants and clubs originally in the United States).

According to *Essendi (2017)* the traditional conventional application of bamboo has been metaphorizing resulting in to engineered construction. Several domestic uses and applications of bamboo plant abound. *Bethany (2010) and Jagadeesh (2014*) cite that tender shoot of bamboo has for decades been used as food in the south-east Asia while *Kibwage et al (2008)* indicates domestic potential benefits of bamboo plant in Kenya as fencing, handcraft goods, props for horticultural and flower plants. Other domestic benefits include medicinal application, soil stabilization, cottage industry, long time biomas, tooth picks, skewers, baskets and match sticks *(Jagdeesh, 2014; Carrere, 2008 and Ongugo et al, 2000)*.

Since historic times, bamboo has been traditionally applied in the construction of shelter by man for millenniums. Traditional use of bamboo in construction of simple shelters started in the South-East Asia and South America where the plant grows abundantly *(The Constructor, 2020)*. According to *Essendi (2017)* the era of traditional bamboo construction existed prior to contemporary interventions by built environment professions such as architecture and engineering. Today there are a variety of applications of bamboo in the construction industry necessitated by its strength and versatility. It is an efficient construction material in the sense that a house that has fully incorporated bamboo products can be erected in a record three weeks while the energy required to produce it is 1/2 that needed for wood, 1/8 for concrete and 1/5 for steel making it an eco-friendly construction material *(Bethany, 2010 and Kibwage, 2010)*. *Mumeru (2020), Constructor (2020), Essendi (2017) and Carrere (2008)* identify major applications of bamboo plant as structural support in the form of columns, beams, roof trusses, bridges and scaffolding. This is in addition to its use as roof cover in the form of tiles and thatch. Traditionally, more so in the far east it has also been applied in the fabrication of house building components such as walls, flooring, ceiling, windows and doors. On the other hand, in Kenya its application in housing building is minimal although research towards this initiative is in place. Sustained research has consequently yielded some demonstration bamboo houses at Maseno University indicating its suitability in the construction sector (INBAR, 2009).

Because of its high strength and cost effectiveness bamboo could be used to construct cheap affordable housing for the low-income earners living in the slums in squalid un-sanitary conditions. Bamboo is three times cheaper than steel and coupled with its moderate strength it could be applied in low-cost housing programmes. *INBAR (2011)* argue that with an urbanization rate of 3.5 % in Africa, slums and squatter settlements have become major features in cities and urban centres implying there is need for concerted efforts towards realization of cheap appropriate alternative construction material for affordable housing. In Kenya, the housing demand in the cities and urban centres is 200,000 units per year against an annual output of 50,000 implying a serious short fall *(Republic of Kenya,2017)*. According to *UN Habitat (2013)* the short fall has led to overcrowding in slums and substandard housing. *Bethany (2010)* contends that over a billion-world population live in some form of bamboo housing but its lack of formal grading and standards unlike conventional timber remains a challenge to its full exploitation as a construction material. The foregoing indicates that the demonstration houses having been built the next item the Government needs to tackle to get things started is promotion of large-scale cultivation and development of a code of standards to guide bamboo construction. To promote concerted exploitation, more efforts in research have been spearheaded to harness the potential of bamboo in the construction of affordable housing. *The Constructor (2020), Essendi (2017), INBAR (2011), Carrere (2008) and Kibwage (2008)* cite the significant role bamboo can play in addressing the question of affordable housing for the vulnerable citizens of the society.

A research study by Clemson Agricultural College on moso specie of bamboo indicates that compressive strength of bamboo is much more than that of steel (*Benitta and Tensing, 2013*). *Candelaria and Hernandez (2019)* contend that the compressive strength of bamboo is impressive and ranges from 63 – 77 N/mm^2 while *Awalludin et al (2017)* believes that the compressive strength of bamboo is higher than that of soft wood but at par with that of hard wood. This

position is supported by *Dixon and Gibson* (2014) who argue that moso bamboo is substantially stronger than the North American construction woods both in flexure and compression. *Rochim et al* (2020) on the other hand indicate the compressive strength of bamboo apus as 34.2 – 60.5 N/mm^2. It can then be stated that the compressive strength of bamboo depends on bamboo type or species. *Ogunbiyi et al (2015) and; Dixon and Gibson (2014)* however argue that bamboo has minimal breaking force given that its tensile strength ranges from 31 – 94 N/mm^2 compared to that of mild steel of the size that ranges from 290 – 509 N/mm^2 making not suitable in heavy structural work. *Mbuge and Gumbe (2022)* on the other hand state that the tensile of bambusa vulgaris bamboo ranges from 94 to 118 N/mm^2 which is equally low. The variation on tensile strengths is mainly equally attributed to bamboo type or species. It is therefore concluded that bamboo is good in compression but poor in tension. In Kenya bamboo is known for various uses but its application as a reinforcement material in reinforced concrete remains unexploited.

In an effort to address the demand gap for steel as a reinforcement bamboo certainly comes in as an alternative structural construction material despite some of its shortcomings. *Chu (2014), Wachie (2018), Limbe (2013) and Steinfied (2001)* however argue that bamboo has other drawbacks that include high volume change, strong water absorption, low resistance to fire, weak bonding with concrete and susceptibility to attack by insects. Most of these setbacks have today been comfortably addressed through concerted research *(Sevalia et al, 2013 and Agarwal et al, 2014)*. *Sonti (1990) and Eshendi (2017)* argue that various preservation methods are available thereby enhancing the durability of bamboo as a construction material. Its faster growth, low cost, lightweight design, better flexibility and toughness coupled with its environmental sustainability enhances its potential as an alternative construction material.

The use of bamboo as reinforcement in Portland cement concrete has been studied extensively by Clemson Agricultural College. The first time a study of bamboo as a reinforcing material was done was in 1964 conducted at the U.S. Army Engineer waterways. Ultimate strength design procedures, modified to take into account the characteristics of the bamboo reinforcement were used to estimate the ultimate load carrying capacity of the precast concrete elements with bamboo reinforcing (*Benitta and Tensing, 2013*). In other countries like China and India bamboo is used as structural material for scaffolding at construction sites and low-cost housing due to its outstanding attributes such as toughness, flexibility, lightweight and cost effectiveness. With advances in research the same scenario should be replicated here in Kenya.

SUMMARY OF FINDINGS

The findings indicate that globally, the bamboo cultivation is 14.5 million hectares covering Asia, Latin America and Africa with the world's largest producer as China. Out of this coverage, 1.4 million hectares is in Africa with Kenya taking her paltry of 150,000 hectares. Most of the bamboo in Kenya are not planted by private farmers but grow naturally in public forest reserves mainly in Arberdares Range, Mau Forest, Mt. Kenya and Cherangany Hills. The findings also show that globally, there are over 1500 uses and applications of bamboo while in Kenya there are only 48 uses and applications. The many uses and applications which are both domestic and construction related makes it a precious cash crop plant. In Kenya, bamboo's use and application is mainly domestic but at a small scale due to the restricted access to the public forest reserves, low cultivation by private individual farmers, marketing challenges and lack of code of standards for bamboo construction. The Government of Kenya has however put in place a draft legislation to promote bamboo cultivation and exploitation. The domestic uses and applications of bamboo in Kenya are mainly fencing, handicraft goods, props for horticultural industry and flower plants. Other major domestic uses and applications include medicinal applications, soil stabilization, cottage industry, biomass, tooth picks, baskets, match sticks and so on. On the other hand, bamboo has good compressive strength but weak tensile strength but could be applied in construction works where structural loading is not too heavy in areas such as low-rise housing, scaffolding, worktops and lintels.

CONCLUSION

As a construction material, bamboo has historically been associated with South Asia, East Asia and South Pacific. In Kenya, bamboo as a construction is still at its infancy stage with demonstration houses having been constructed in the recent past. Application of bamboo as construction materials is also complicated by constrains such as volume change, strong water absorption, low resistance to fire, weak bonding with concrete and susceptibility to attack by insects. Recent research has however revealed appropriate methods for addressing the above constraints. Despite the current low cultivation and the relatively low uptake of bamboo in the Kenyan construction, the future of bamboo application as a construction material is quite bright. Its fast growth, sturdiness, texture, low cost as well as environmental sustainability outweighs its setbacks. The study therefore, recommended that the Government of Kenya provides incentives and sensitizations programmes to promote bamboo cultivation; provides strategies for aggressive marketing of bamboo products and also develops a code of standards to guide application of bamboo as a construction material.

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