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Reviving Timber Industries in Kumasi Through the Production of Diversified Wood Products

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Abstract

The timber industry remains a vital contributor to Ghana's economy, providing employment, export earnings, and raw materials for construction and manufacturing. Despite its importance, timber industries in Kumasi have experienced significant decline, with many firms operating far below capacity or shutting down entirely. This study investigates the causes of decline and explores product diversification and waste utilization as strategies for revitalization. Using a mixed-method approach incorporating questionnaires, interviews, observation, and case studies, data were collected from selected timber companies in Kumasi including Logs and Lumber Limited, AG Timbers, and Oakwood Wilhelm Ventures. Findings indicate that challenges such as obsolete machinery, poor management, shortage of raw materials, illegal mining, deforestation, and weak local market structures have contributed significantly to the downturn. Furthermore, waste management practices were rudimentary, with large volumes of waste either burnt or dumped, resulting in environmental degradation. The study demonstrates that diversification into value-added products such as fiberboard, MDF, laminated boards, and wood pellets, combined with zero-waste strategies and technological upgrading, has strong potential to revive the timber industry. The paper recommends policy reform, machinery modernization, workforce training, and afforestation programs as integrated measures to ensure industry sustainability.

Keywords: Timber Industry, Wood Waste, Product Diversification, Sustainability, Kumasi

1. Introduction

1.1 Background

In recent years, there is a growing interest in the role of the timber industry as it has increased in production and timber trade ultimately (Burgess, 1993). In Ghana, where the forest makes about one-third of the country's land and contains roughly 400 different types of wood, lumber is one of the most easily accessible natural resources (Ocloo 1979: Eshun, 2012).

The wood sector has gained an important place in imports to other countries as a result of the considerable contribution of foreign money to Ghana's socioeconomic progress (Baiden et al. 2005). The timber industry also provides income, sustains various local economies and communities, and manufactures

commodities for export (Lebedys 2004, Odoom 2008). According to research, Ghana's third-largest source of foreign exchange profits is the country's timber sector, which accounts for 4.0% of GDP (Sutton and Kpentey, 2012).

The increased need for timber can be attributed to an increase in building demand, according to FAO (1997). According to FAO, in research to establish the stability of the supply of timber into the market for diverse applications, demand for wood and wood products is expected to rise by 30% by 2023 (FAO, 1997).

As the need for timber grows, concerns about supplying that demand arise, as does the need to protect the world's timber resources. According to Eshun et al. (2012), sustainable development has been implemented all over the world to assist reach this aim. Eshun et al. (2012) stated that, effective production of wood products greatly minimizes the amount of waste created throughout the process, resulting in a minimum impact on the environment as well as meeting the rising demand for timber.

Many governments throughout the world have tackled the issue of wood waste in alleviating the problem of timber depletion through management. According to Asamoah et al. (2020), in other parts of the world where wood waste is well managed, wood residue are generally considered to be useless materials rather than goods that may be reused, recovered, or recycled into new products as argued by Sambe and el. (2021).

Many writers, notably Shirek (2007), think that waste from timber processing has no purpose in today's economy and is a loss since it cannot be sold for a profit. The residue has a higher chance of being ignored without value after production, becoming a nuisance.

Several authors have stated that, while wood waste cannot be eliminated completely, it can be minimized at the production stage or turned into other products that are cheaper and compete with imported goods from outside (Falk, 1994: Of et al., 2021) as there is an increase in demand and production of wood in the world.

Despite increasing demand for timber products, production capacities in Kumasi have dropped substantially. Poor waste management, limited technological innovation, declining forest resources, and over-reliance on exports have weakened the local market (Kyereh & Agyeman, n.d.; Baiden et al., 2004). In addition, foreign timber products—mainly from Asia—have flooded the local market with cheaper alternatives (Mensah, 2023).

The primary aim of this study is to revive timber industries in Kumasi through diversification of wood products and waste utilization.

Objectives include:

1. Investigating production processes and output.
2. Evaluating waste management practices.
3. Identifying factors responsible for industrial decline.
4. Proposing innovations to improve sustainability and productivity.

2. LITERATURE REVIEW

2.1 Overview of Timber Processing

Wood production and use have been increasing globally in recent years. This is due to increased demand as a result of population expansion, as well as individual taste and preference (FAO 2009). Ever since timber has been used as a basic material for building, with years due to its uniqueness and versatility in character the scale and ways of usage for construction keep on changing. As a result, wood is seen as one of the attractive building materials among others for building houses and also variety of other constructions and products e.g. furniture, boats and bridges. More recently, the construction of tall buildings from timber, such as the Brock Commons – Tall wood House in Vancouver, indicates a growing interest in the building with wood at a height and scale not previously attainable.

Many researchers have come to conscientious that the use of wood from well-maintained forests is one of the most important solutions for achieving the Sustainable Development Goals (SDGs). The greenhouse gases emitted to produce one tonne of sawn wood are about 13 per cent of what is required for the same weight of concrete, and less than 5 percent of what is required for the same weight of steel. Apart from the low environmental impact of production, construction timber or wood can easily be recycled and turned into fuel for renewable energy production after its useful life span (Ms. Chummy Varaich ,2019).

2.2 Ghanaian Timber Industry Context

The country's forest reserve is divided into a high forest zone in the south, a savannah zone in the north and a transition zone, according to the report aaccording to Tufour, (2012). He further stated that "Ghana's natural forest occupies about 4.94 million hectres which forms about 22% of Ghana's total land area as at the year 2010. About 8.2 million hectres is occupied by the high forest zone and 15.7 million hectres also occupied by the savannah zone with least of 1.1 million hectres of land forming the transition zone. This coincides with Adu (2016) where same figures were reported of the various divisions of land cover. However, a further study by Adu (2016) showed that only 12,000 square kilometres (sq. km) is capable of being used for production. 4500 square kilometres(sqkm) are for reserves whiles 500 square kilometers are used for production. Adu (2016) believes that the forestry sector in Ghana is one of the most important sectors through which the country derives its revenue.

This agrees with Eshun et al (2012) who states that the timber industry has a significant role in the Gross Domestic Product (GDP) as it contributes about 6% of the total whiles also contributing about 11% in the total earnings made from exports. This is affirmed by the Ghana Forestry Commission (GFC), (2018) in their report on the export of timber and wood products where it records about 10.94% of revenue obtained from European exports. A further breakdown shows 5.5% from African exports and 5.78% from American exports (Prince Kafui,2022).

Amoah, (2020) reports that about 50% of the country's forest reserve is either in a bad state or has been depleted. The depletion can be attributed to the efficiency of how harvested timber is being utilized. Dionco-Adetayo, (2001) as cited by Eshun et al (2012) reported that for every cubic metre of tree harvested, about 0.8 cubic metres is generated into waste indicating that only 0.2 cubic metres of the tree is effectively utilised to produce a timber product. Dionco-Adetayo, (2001) further reports that about 50% of the generated waste are in the form of damaged wood residues.

2.3 Wood Waste and Environmental Impact

Eshun, Potting, and Leemans (2012) estimate that 28–64% of raw timber becomes waste in Ghana. Only 20% of this waste is reused (Kolesnikova, 2013). Instead, most is burned, polluting air and water bodies (Akhator et al., 2017).

Ogunjobi et al, (2019) wood residues are left in the forest in the form, of crowns, stumps, offcuts, branches, etc. In terms of lumber, processing substandard timber can result in inaccurate processing into lumber which can cause huge chunks of the timber to be wasted. Both forms of waste however are generated in large quantities and tends to have critical effects on the timber industry.

(Adu, 2016) also classifies timber processing waste into two further categories which are the solid waste component which is made up of slabs, edgings, offcuts, veneer waste and cores, whiles the other category which is the fines waste is made up of sawdust, wood shavings or planer shavings and sander dust.

Akhator et al, (2017) also classify waste produced from sawmills will include bark, trimmings, sawdust, split wood, planer shavings, sander dust, etc. That of the plywood mill also includes lily pads, veneer clippings, panel trim, saner dust.

Table 1: Source and Types of Waste Generation.

Sawmill	
Plywood mill	

Source: Adapted from Akhator et al, (2017)

2.4 Diversification as a Strategy

Adu-sarpong(2017) stated that exporting raw sawn tropical hardwood products to foreign markets from underdeveloped nations, particularly Africa, has long been a standard module of timber trading. This form of primary product with no added value has considerably increased the amount of wood taken with small monetary rewards. As a result, Africa is expected to import wood in the near future (Global Environmental Fund 2013).

It is worth noting that such sawn lumber goes through processing in the destination nations and imported as consumable items back to emerging countries, therefore competing with domestic small-scale firms and creating unemployment. This form of wood production is obviously unsustainable and exposes the timber resource base to depletion and environmental deterioration.

Africa could consider exporting secondary processed wood products (SPWD) rather than raw sawn wood to key wood export destinations such as China and Europe.

This will aid in the upkeep of the local timber sector as well as the remaining natural forest.

Unfortunately, the number of enterprises in Ghana's wood producing industry has been declining in recent years. According to Sutton and Kpentey (2012), the number of wood processing firms that existed and

functioned in the early 1990s has dropped substantially to roughly 100 sawmills producing a variety of products.

The tertiary product sector of the wood industry has the potential to reduce national unemployment, contribute to foreign exchange, and diversify economic activities to improve livelihood. However, this potential is underused. The sector is primarily made up of tiny family-owned businesses that lack the requisite technology and modern equipment to compete in the global market cited by Adu-sarpong(2017). To increase efficiency and productivity, the industry has to change, which includes value addition, improved technology, and equipment. This is crucial because concentrating on tertiary goods with more technological know-how will increase product value while guaranteeing resource efficiency as noted Adu-sarpong(2017).

The consequence of this is limiting the potential benefits that could have been gained from increased export value and secured market share through production and export of high-quality value-added tropical wood product (Acquah & Whyte 1998; Acquah et al. 2014)

The decrease is noticeable in the contribution of tropical wood species to supply on both the global and domestic markets. Many factors might be contributed to this reduction, including resource degradation and an insufficient governance system within the business, as Dadebo and Shinohara (1999) pointed out.

2.5 Ways of timber processing waste utilization

According to Adu (2016), the '4R approach'—reducing, reusing, recycling, and recovery must be used to ensure the efficient exploitation of waste produced throughout the production process. It is also significant to remember that waste is produced throughout the entire process of producing wood. When it comes to minimizing trash, it is possible to do so both before and after it has been produced. By enhancing the production process and efficiently employing the timber logs for production, waste formation can be decreased before it even occurs. When trash has already been produced by the production process, the '4R technique' as proposed by Adu, (2016) is frequently applied. Adu (2016) emphasizes the requirement for finding novel approaches and technology to assist in the in the management of waste.

(Adhikari and Ozarska, 2018), Adu, (2016), and Akhator, et al (2017) all suggested some innovative ways wood waste can be utilized to aid in timber processing waste reduction.

1. The use of wood waste as a source of thermal energy
2. The use of wood as engineered wood products
3. Production of chemicals and medicine
4. Production of insulation materials
5. Exports

2.6 Wood waste as a source of thermal energy

According to Akhator, et al (2017), biomass have different sources with the most common source being wood. Akhator, et al (2017) is of the view that the use of these woody residues can be used to offset fuels such as coal, gasoline, oil, natural gas and others which can help boost the economy.

Adu, (2016) highlighted some forms of energy that wood waste can be used for, these include wood pellets, wood for household use such as charcoal, syngas, ethanol, and briquettes production. To convert wood waste into energy, certain processes such as combustion, gasification and pyrolysis are carried out. Combustion ensures that energy is recovered from the wood waste by burning in a controlled environment. The form of energy produced is in the form of steam and can help in electricity generation. Gasification helps convert wood waste into synthetic gas and can also be used to produce steam for electricity or even serve as fuel for transportation. Pyrolysis on the other hand involve the conversion of waste into biochar or bio-oil.

2.7 Engineered wood products

These are products that are obtained from the binding of small pieces of wood with glue as a binding agent or any other form of binding agent. The procedure involves a mechanical process to press the pieces of wood into a solid mass. These engineered wood products also known as medium density fibreboards (MDF) are generally used for industrial purposes. According to (Tariq, 2013) medium density fibreboards have a wide range of uses ranging from shelving, bookcases, and kitchen counters hence the utilization of wood waste for engineered wood products or help reduce waste in the timber processing industry.

2.7.1. Production of chemicals and medicine

Wood waste search is barks can serve as ingredients in the manufacture of certain chemicals and medicine. Some products that can be obtained include adhesives, antibiotics, and latex. Production of these products also help in the reduction of waste by its utilization.

2.7.2. Production of insulation materials

Wood by nature is a good thermal insulator. In view of this, the usage of wood waste as insulation materials will help ensure the reduction of wood waste generated in the timber processing industries. According to Akhator, et al (2017), the use of wood-based materials for insulation lowers energy consumption whiles also ensuring sustainability of the timber industry and the environment.

3. METHODOLOGY

3.1. Research Design

For this study, a pragmatic worldview or philosophy is used. Because the study is issue-oriented and employs factual evidence gathered through suitable methods for collecting data to solve a problem, this theoretical strategy was chosen. Pragmatism is a strategy for connecting dualisms by focusing on the problem-solving inquiry process. This approach is required for this research as we are looking into methods to revitalize the timber business by diversifying the processes and goods produced at the end. This aims to develop the wood sector and improve exporting in order to raise the country's GDP.

Both qualitative and quantitative methods were used, including:

- Questionnaires (40 respondents)
- Interviews (10 professionals)
- Site observations

- Case studies (AG Timbers, Oakwood Wilhelm Ventures, Logs & Lumber Ltd.)

Sampling was purposive and quota-based. Data was thematically analysed.

3.2 Data Processing and Analysis

For the conduction of case studies, a checklist is used based on literature to collect actual data. Common themes and patterns are drawn in all cases. Conclusions are drawn for all the cases. In analyzing qualitative data, coding and content analysis of themes, text and images was done. coding is the most common process with the use of content analysis either manually or using a computer program (Williamson, 2006).

There is also an in-depth analysis of the manufacturing process using graphical representation to provide an overview of the production line, the technologies used, the current state of the waste, and how it is managed.

The analysis of how much waste can be made into useful products that can be a variation to the wood industry will be clearly established.

4. RESULTS AND DISCUSSION

4.1 Causes of Industry Decline

From the interview conducted the reason why there is decline in the production of timber industries in Kumasi are, there is lack of raw material (Timber Logs), high Management cost, ownership issues, transporting the logs as well as importation of foreign products.

4.1.1. Lack of raw material (Timber Logs)

The inadequate timber logs derived for processing is the leading factor for the

decline in the timber industries.5 of my respondents spoke about the fact that, companies now don't get enough wood as before because of illegal mining and strict restriction on timber harvesting. A related study in Ghana revealed that Ghana's forest timber production area is declining in an increasing manner in both size and productivity due to unethical logging practices and overuse of the traditional timber species (Solomon-Ayeh, 2004; Ayarkwa, 1998). Hence, Authorities placed tight regulations in place as a result of the extensive forest exploitation, which finally resulted in a decrease in the amount of lumber for production (Solomon-Ayeh, 2004; Ayarkwa, 1998).

4.1.2. High Management cost

This sub theme gained 6 responses which spoke of high managerial expenses such as paying of electrical bills, water bills and other operational cost such as fuel affect the overall production. One of the respondents said '*electricity bills, fuel and water bills are so high nowadays that we sometimes cannot pay and run at a loss when we do.* This goes a long way to the number of machineries operated in a day so as to say cost.

4.1.3. Ownership issues

The issue of ownership and operations is one of the reasons why many timber industries and sawmills are collapsing nowadays. 'Most of the companies are mostly solely owned by the white people who manage the whole process thoroughly. If any case of relocation of the white managers out of the country, the companies come crushing down' reported by one of the respondents.

4.1.4. Transporting the logs

When trees are fell in the forest, they are mostly transported in logs to machine centers in timber industries where the processes of sawing, planning, edging and others occur. Transporting the logs from their source which is the forest in rural areas to machine centers which are in the urban centers has always been a problem to timber contractors '*The cost in transporting the logs here is very expensive and sometimes becomes the cost of the contractor if in a concession agreement. This has cause many timber loggers sell to nearby factories other than ones in the urban centers'*,responded by one interviewee. Because of the distance of the log to the n

4.1.5. Importation of foreign products

Rating 7 frequency among the 10 interviews conducted, this is the most intriguing factors affecting the progress and contributing massively to the collapse and decline in the production of local timber industries. There is intense competition from the Far East Asian countries whose designs serves as a substitute filling most showrooms of many large and famous furniture companies leaving our local market unattended to and unpurchased (Kyereh and Agyeman, no date). *The foreign timber products are mostly cheaper and nicer. They have the current trending styles and*

4.2 Waste Management Practices

Only sawdust and bark were found to be regularly reused. Other forms were incinerated or dumped. Most companies lacked quantification systems for waste, resulting in inefficiencies and environmental harm.

4.2.1. Waste Collection

The results indicate the efficiency and usefulness in dealing with the timber processing waste generated. As stated by Chan et al (2019), the efficient management of waste is important in the production process and hence strategies and procedures to ensure this efficient management needs to be implemented. The survey identified that the factories mostly make use of the mechanical means to dispose of the waste that have been generated. The various factories employed the use of different forms of mechanical equipment to dispose of the generated waste. These include the use of trucks/ tractors, air extractors and forklift to transport the generated waste from the production hall to the dump sites or recovery sites. The study also identified the application of manual means of waste collection which included the use of bags and wheelbarrows. The report from the study shows that trucks/ tractors are mostly used to transport mainly solid wastes from the production hall to the dump sites

The manual form of waste collection is the least preferred option since this form of waste collection is only identified in two of the studied factories. This method of waste collection included bagging and the use of wheelbarrows to eliminate the generated waste from the production hall.

. Means of Collecting Wood Waste (Source: Author's Construct,2023)

4.2.2. Waste utilization

Studies by Bonsi et al (2011) ; Adu-Boahene et al (2014); Asamoah et al (2020), showed that most waste generated from industries are dumped forcibly instead of utilization due to lack of technology. The waste is disposed by open burning, composting or sometimes selling to secondary customers. However, the frequency of selling to secondary consumers is rare and so most of these waste finds its way back to the dumping sites or gets burnt in the end. The secondary users buy the wood sawdust, shavings, grinding dust which are actively used in agriculture as an additive to fertilizers for heavy soils, in animal husbandry – for the underlying layer(Of *et al.*, 2021).Studies from Adhikari and Ozarska (2018), Eshun et al (2012) and Ramasamy et al (2015) shows that the mode of disposal associated with dumping and burning has impacted the environment negatively.

Waste is disposed inappropriately without utilization

The result however shows that majority of the waste produced are not properly utilized and further assesses the extent of the utilization of timber processing waste and the impact it has on the environment. This

shows that the absence of technology needed to reduce the amount of timber processing waste through its utilization leads to uncontrolled amounts of waste being generated in the production process.

Heap of fine waste (Source: Author's Construct,2023)

However, the fine waste such as saw dust is used as a fuel and burnt to heat up the boiler house. In the broiler house, there are steel pipe with water that are heated up with the heat from the burnt saw dust and the steam is channeled into the Kiln where the wood is seasoned. A study by (Eshun et al. 2012) as cited by (Adhikari and Ozarska, 2018) stated that large amount of wasted wood is often used in the steam production boiler for drying wood products. These practices contribute to environmental impacts through wood waste and at the same time lead to depletion of timber resources.

Waste as a fuel for the Boiler House(Source: Author's Construct,2023)

The bark as waste is sent to secondary end users in Sokoban Wood Village for further processing into boards and planks such as 2 by 2 wood and 2 by 4 smaller wood for people to buy.

In order part of the Africa, specifically Nigeria, effort has been made by the forestry Institute of Nigeria (FRIN) to research into wood waste utilization and has led to the floor tile, ceiling board and ultimately

.Bark waste sent to secondary users

(Source:Author's Construct,2023)

Wood Bark waste is converted to these planks for sales(Source: Author's Construct,2023)

SP- panels (Ogunsanwo, 2001).The SP- panels are made of sawdust ,veneer and cement board This is aiming at producing value added wood products. This enables optimal utilization of logs and provides a better wood waste(Council, 2014).

4.3 Diversification Potential

Respondents identified MDF, HDF, railway beams, and laminated boards as high-demand products not adequately produced locally (Adu-Sarpong, 2017). Firms lacking product diversity were losing customers.

4.3.1 Practicing of zero waste strategy at our timber industries

With the view of the worldwide rally towards sustainability, it is important that waste is effectively managed at the production level to reduce wastage. Too much wastage of wood ultimately affects the forest resource in general. Amoah, (2020) reports that about 50% of the country's forest reserve that is depleted is to the efficiency of how harvested timber is being utilized. This can be addressed by improving on the technologies and machineries in the production of wood. From one respondents from the interview stated that ' *Our machineries are very old and are over twenty years her, they tend not to be so effective. We need new machines.* There is also the need to train operators and workers on new emerging trends and styles to improve production and remain relevant. This is critical because focusing on greater technological know-how will raise product value while also ensuring resource efficiency(Adu-sarpong, 2017).

4.3.2 Production of diversified products

The timber industries in Kumasi primarily focuses on exporting their products in the raw form without value addition which attracts little monetary value(Adu-sarpong, 2017). These countries refined these raw

materials and bring it back as consumable products to us, competition heavily with our local market. There is the need to add value to the primary product to enhance productivity, sales and economic value of products. There is the need to produce varying products to match clients' taste,add more economic value and compete with the foreign market. One respondent raised the issue that '*a lot of people come here requesting for products such as MDF, chipboards, railway beams, laminated mats, fiberboards, and HDF which we don't have. We are losing customers because we don't have variety of products for them to choose from*'

4.3.3 Afforestation

Notwithstanding the Government Authorities to solve issues of Ghana's forest wood depletion which is decreased in both size and productivity as a result of unethical logging methods and misuse of traditional timber species (Solomon-Ayeh, 2004; Ayarkwa, 1998), there is a huge deficies. There has been strict enforced limitations however, that is not enough. More trees should be planted to replace depleted ones and ensure sustainability in the wood production.

4.4 Technology Gaps

Most equipment exceeded 20 years in age (Oduro, 2010). Modern machinery such as drum chippers, defibrators, and ring flakers were unavailable (Mensah, 2023).

Feasibility of Application of technology

SWOT Analysis of possibility of wood waste processes adapted from(Of et al., 2021)

STRENGTH	WEAKNESS
• Accessibility of skilled workers • Convenient factory location near roads • Availability of suppliers and customers	• The use of outdated technology • High product costs • Weak marketing strategies • The existence of strong competition
OPPORTUNITIES	**THREATS**
• High demand for products from woodworking waste • Application of new technologies for the production of products from waste • Release of quality products • Entering other sales markets	Unstable financial situation Low profitability of the plant Threat of bankruptcy

5. CONCLUSION

The decline of Kumasi's timber industry is driven by outdated technology, environmental neglect, resource scarcity, and weak market positioning. However, significant opportunity exists through:

Conclusions on Objective 1:

To investigate into the various wood production processes and products of timber industries in Kumasi.

From literature, the timber production undergoes four stages which is still practiced by most timber industry which is not meeting its maximum production due to obsolete technology in production activities. The common products that were produced by most timber industries are the plywood, veneer, boards and planks. Even though, these products are in demand however, the Medium Density Fiber (MDF) which is in higher demand and can equally compete with the foreign market. Adding value to the timber products like the MDF can increase the sales of products on a daily basis.In producing these products, the Edger, Extractor, Bandmill, Trimmer, Cold and Hot dryer, Kiln dryer were used.

Conclusions on Objective 2:

To investigate into how waste is managed during and after production in the timber industries in Kumasi

The findings shows that even though most of the timber industries don't know the exact amount of timber waste generated after every production which can be suicidal to the production of most timber industries. More waste is generated at the machine centers due to the use of outdated machineries and production processes in the timber industries which affects the environment at large. In managing the waste generated, only two types of the waste identified which was the bark and sawdust. All the other waste types were either dumped or burnt. It was also identified that the waste generated decreases as it gets to the end of the production line. The waste generated however is not utilized to its maximum due to lack of innovate ideas, lack of capital and equipment as well as lack of expertise

Conclusions on Objective 3:

To investigate into the contributing factors in the decline in production of timber industries in Kumasi

From the findings, the timber industries are not doing so well and some have collapsed with their operations. They are faced with low production due to the use of old and faulty machineries, issues of management and legal issues of illegal mining. Their inability to pay their workers well have led to laying off of workers leading to reduction in labour force. There are issues of shortage of raw materials, high management cost, competition from foreign market as well as ownership issues. This has led to the low productivity of most timber industries in Kumasi.

Objective 4:

To investigate into technologies and innovations that can be applied in improving production and reviving the timber industries in Kumasi

From the findings, suggestions to revive the dying timber industries in Kumasi were practicing zero waste strategy to reduce the waste produced at the industries ultimately. Also, more trees can be planted to increase the number of logs used for production.

Production of diversified products was also other ways of reviving the timber industries and matching up with the foreign market who act as a big competitor against the local market. They have many timber products with varying properties and characteristics that make them more favorable to use. These diversified products can be made from either waste from production or entirely new raw materials for them. Machineries needed for the production of the diversified wood product are Drum chipper, defibrator, knife-ring flaker, chip screen, sanding machine

6. RECOMMENDATIONS

Based on the findings relating to the first objective, it is recommended that timber industries in Kumasi diversify their product range by incorporating high-demand wood products such as chipboards, railway beams, laminated mats, fibreboards, and high-density fibreboards (HDF). This diversification should be supported by the acquisition of modern machinery and advanced production technologies capable of handling multiple product types efficiently. Additionally, industries should invest in improving infrastructure and reorganising production layouts to enhance workflow, increase production capacity, and significantly reduce material waste along the value chain.

With regards to waste management practices, the study recommends that fine wood waste such as sawdust and shavings be processed into refined products to increase their economic value and usability. Waste materials that cannot be repurposed into products should be channelled into biomass energy systems to generate electricity, thereby reducing environmental pollution and improving energy efficiency within the industry. Furthermore, regular training programmes should be organised to equip workers with current knowledge and skills in waste recycling technologies and sustainable production methods to maximise resource recovery and productivity.

To address the factors contributing to the decline in timber production, manufacturers are encouraged to adopt modern technologies to improve operational efficiency, enhance output, and enable the production of value-added products. At the policy level, the Forest Commission and metropolitan authorities should regulate the importation of foreign wood products to protect local industries from unfair competition. In addition, stricter enforcement of forestry and environmental regulations is necessary to curb illegal logging and deforestation, which continue to threaten the industry's long-term sustainability.

In terms of innovation and technological advancement, timber industries should develop workshops, exhibition spaces, and showrooms for the production and promotion of secondary wood products to boost market visibility and consumer engagement. Production facilities and factory layouts should also be critically redesigned to accommodate emerging product types and advanced manufacturing systems. These

improvements will encourage innovation, improve production efficiency, and enhance the overall competitiveness of the timber industry in Kumasi.

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