Chapter

Recent Advances in Bamboo Research, Product Development and Utilisation in Nigeria

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Abstract

Bamboos are available in all the thirty-six States of the Nigerian Federation, the most common species being *Bambusa vulgaris*. Bamboos are traditionally used for scaffolding in building construction, fencing, staking in farms, handicraft and furniture production, and cooking. Research and development advances in Nigerian universities and research centres in the last twenty years have, however, promoted modern forms of bamboo utilisation in various ways. These include documentation of various properties of locally grown bamboos, development of machines and equipment for bamboo processing, as well as development of modern bamboo products. A few bamboo processing factories have also sprung up in recent years. However, enterprises based on modern bamboo processing techniques are still not common in the country. This Chapter presents a review of the progress made thus far in bamboo processing and product development in Nigeria, discusses the prospects of, and constraints to commercialization of locally developed modern bamboo products, and highlights the way forward.

Keywords: bamboos, bicycle, charcoal, laminated products, roofing tiles, furniture

1. Introduction

Bamboos are some of the fastest-growing plants in the world. Some species grow up to 91 cm within 24 hours, i.e., approximately 4 cm per hour. Different species assume different postures ranging from the erect to the clump forming and the climbing postures. Between the single stemmed and densely clumped forms there are intermediate types with somewhat open clumps [1]. Also, bamboos vary in size from lofty forms with stems up to 23 m high and 23 cm thick, to mere under shrubs [2]. As an engineering material, bamboo has a higher specific compressive strength than wood, brick or concrete and a specific tensile strength that rivals steel [3].

There are over 1000 bamboo species across Asia. However, the five genera commonly found in Africa are *Hiekelia Africana*, *Yushania alpine*, *Oreobambosbuchwaidii*, *Oxytenanthera abyssinica* and *Thannocalamustessellates* [4, 5]. The two main species widely available in Nigeria are *Bambusa vulgaris* and *Oxystenanthera abyssynica*. The former attains a height of between 14 and 20 m at maturity with a girth of about 20 cm, while the later reaches between 8 and 12 m at maturity. The two varieties grow

naturally in the forests below River Niger and in Taraba State, mostly around river courses [5]. A 2004 survey [6] showed that Oyo State was one of the most endowed States with bamboo resources in the country, the other States being Ogun, Osun, Ondo, Edo, Delta, Rivers, Akwa Ibom, Cross River, Abia, Ebonyi, Enugu, Anambra, and Imo States. At least 10% of the natural vegetation in these States was dominated by bamboo and that the most common species was *B. vulgaris*.

It has long been recognised that bamboos have multipurpose uses with about 1500 documented uses by 1987 [7, 8]. By 2002, over 2.5 billion people traded in or used bamboo world-wide [9] and documented uses of bamboo had risen to over 10,000 [10]. The ease with which bamboos can be worked, their versatility, strength, and availability recommend them for industrial utilisation which commenced in the 1990s. Some of the modern bamboo products that have since emerged and are on sale in the global market include bamboo plywood also known as plybamboo, oriented strand board, bamboo fibreboard, medium density fibreboard, and laminated bamboo products employed in producing furniture, doors, floor parquets, windows, frames, and partitions [10]. Apart from these products, bamboo is also being used in biomass-based power generation as well as solid bio- fuels, bio-ethanol ad textile production.

However the documented uses of bamboo in Africa are for less than 100, let alone 1000. In general, less than 30 days old culms of some species that are eaten; 6–9 months old culms are used for basketry, mat making, and binding; while 2–3 years old culms are used for handicraft, furniture and construction works [4]. The major uses of bamboo in Nigeria are still limited largely to making scaffolds for building construction (**Figure 1**), fencing, staking in farms, handicraft, and furniture, and as fuel for cooking [5, 7, 8]. Bamboo handicrafts produced across the country include baskets, poultry cages, trays, packaging materials, flower vase, lampshades, sporting goods, gift items and souvenirs et c. Furniture products include a wide variety of living room (**Figure 2**), bedroom, dinning, occasional, infant and garden furniture items. Many of the properties of bamboos that make them suitable for handicraft and art pieces also make them acceptable for furniture making in substitution for wood and rattans which are now becoming scarce due to



Figure 1.
Bamboo culms used for scaffolding.



Figure 2.
Bamboo furniture items locally made in Nigeria.

over-exploitation. Not only are bamboos still available in large quantities in Nigeria, they are much easier to harvest, and transport [11–13]. Their limitations including non-straightness, roughness, and non-uniformity of stalk diameter are often taken advantage of in furniture constructions. The tendency to splitting when bolts, screws and nails, are inserted is easily addressed with the use of special adhesives and fasteners. The relatively high sugar content that makes them susceptible to rot and pests is also readily mitigated with postharvest treatment processes [5, 6, 11].

Whilst industrial utilisation of bamboo has been on the agenda of the Federal Government of Nigeria for some time, little progress has been made towards its actualisation. Industrial enterprises based on bamboo are not yet playing a major role in employment generation in the country [5, 9, 10]. Only a few factories have sprung up in recent years producing toilet rolls and allied products, toothpick, floor parquets etc. with bamboo. Also, lack of appropriate processing machines remains a barrier to the fuller utilisation of bamboo [4, 5, 13].

The objective of this chapter is to review the progress made thus far in bamboo processing and product development in Nigeria, to discuss the prospects of, and constraints to the commercialisation of locally developed modern bamboo products, and to suggest the way forward.

2. Recent advances in bamboo research and product development in Nigeria

Research and development advances in Nigerian universities and research centres in the last twenty years have promoted modern forms of bamboo utilisation. A few examples will be presented here.

2.1 Documentation of basic properties of locally grown bamboo

Quite a number of researchers have documented basic properties of *Bambusa vulgaris* found in different agro-ecological zones in Nigeria. It has been reported that the culm circumference of air-dry 3–5 year old *B. vulgaris* found in the derived Savannah area of the south-west range between 190 and 245 mm, while the culm thickness varies from 6 to 16 mm. The mean dry density of mature (2–5 year old) and over-mature (> 6 years old) *B. vulgaris* found in the Guinea Savannah area of south-west can be as high as 690 kg/m^3 and 620 kg/m^3 respectively. On the contrary, the mean dry density of 5–6 year old *B. vulgaris* found in the moist forest and derived Savannah zones can range from 666.8 kg/m^3 to 745 kg/m^3 [14, 15]. The mean density

of 2–4 years old *B. vulgaris* found in the rain forest region of south-west varies between 709.6 and 937.9 kg/m^3 along the culm length from base to top [16]. These findings show that the dry density of mature *B. vulgaris* is about 600 kg/m^3.

The fibre length of mature *B. vulgaris* varies from 2.37 mm to 2.92 mm, and its relatively high cellulose content (61–71%) confirms its suitability for paper production. Its gross calorific value (1810.9–4160.60 cal/kg) also confirms its suitability as a fuel product. The species is moderately resistant to decay fungi and permeable to preservatives and quite strong in shear (6.6–13.1 N/mm^2) [14–16].

2.2 Evaluation of the suitability of local bamboo species for water conveyance

Bamboo is a relatively cheap material for water conveyance compared to other piping materials. Hence, bamboo pipes have used in rural communities for many years for irrigation water conveyance. Studies conducted on hydraulic properties of locally grown *oxytenanthera abyssinica* have confirmed its suitability for use as irrigation pipe [17]. The suitability of *B. vulgaris* pipes for irrigation and drainage has also been confirmed, with a relatively low head loss (0.36% - 0.46%) indicative of low resistance to flow of water, and a friction factor of between 0.037 and 0.049. Affordable locally available joint sealants have also been identified [18–20].

2.3 Development of bamboo culm splitter

Many of the problems associated with bamboo utilisation in the natural form can be alleviated by splitting the culm along the length into individual strips which can then be laminated together to create a number of products. Manual splitting of bamboo is tedious, time consuming and hazardous. Also, the splinted culms tend to be imprecise and irregular in shape. Motorised bamboo splitters available on the international market are not affordable to small-scale bamboo processors in Nigeria. To address this challenge, a manually operated splitter shown in **Figure 3** was developed under the author's supervision at the University of Ibadan, Ibadan, Nigeria [21, 22]. The splitter is user friendly and affordable. A one-off version of the



Figure 3.
Bamboo culm splitter developed at the University of Ibadan, Nigeria.

splitter was produced at cost of US$ 60. It is capable of handling dry and wet culms with and without nodes and can produce six pieces of 300 mm long and 35 mm wide bamboo strips (**Figure 4**) for use in bamboo handicraft and furniture workshops, with a splitting efficiency of 80–85%. As shown in **Table 1**, the average splitting time of the machine is 55 seconds. Culms without nodes are split faster than those with nodes. Also, wet culms are split faster than air-dry culms. The dried and planed bamboo strips (**Figure 5**) were laminated and used in the manufacture of a book-shelf (**Figure 6**).

2.4 Domestication of bamboo bicycle production technology

Bicycles have been in existence for centuries and different materials -iron, alloy steels carbon fibre, titanium and other advanced alloys - have been used in making bicycle frames and fork tubes. With the advent of the Green Movement and their calls for environmental sustainability, bamboos are now being promoted for bicycle production. Different species of bamboo have been used bicycle production in a few African countries including Ghana and Zambia and in many cases sold on the international market. In domesticating the production processes in Nigeria, the first set of bicycles produced with locally available bamboo were made in the African University of Science and Technology, Abuja around 2012 (**Figure 7**). The author also supervised the development of processes for bicycle fabrication with *B. vulgaris* at the Department of Wood Products Engineering, University of Ibadan in 2021 [23]. A sample of the bicycle is shown in **Figure 8**.



Figure 4.
Unplanned bamboo strips produced with the bamboo culm splitter.

S/N	Culm Condition	Culm Thickness (mm)	Nodes Present	Splitting Time (sec)
1	Wet	7.29–12.5	Yes	85–117
2	Wet	7.29–10.42	No	45–65
3	Dry	6.25–13.75	Yes	180–356
4	Dry	6.25–12.5	No	65–120

Table 1.
Effects of culm geometry and condition on splitting time.



Figure 5.
The planed bamboo strips.



Figure 6.
Bookshelf produced with the laminated strips.



Figure 7.
Bamboo bicycles produced at the African University of Science and Technology, Abuja, Nigeria.

2.5 Development of bamboo charcoal and charcoal briquette production facilities

Although bamboos in general have relatively high heat values, volatile contents, lower ash and moisture content, they have traditionally not been valued as firewood



Figure 8.
Bamboo bicycle produced at the University of Ibadan, Nigeria.



Figure 9.
a. the bamboo charcoal kiln with retort open. b. the bamboo charcoal kiln with retort closed. c. the furnace stocked with firewood. d. the bamboo charcoal kiln chimney. e. the bamboo charcoal produced.

since they quickly burn to ashes. Unlike firewood, larger volumes of bamboo are needed for meal preparation. Bamboo charcoal offers a cleaner, more consistent alternative to firewood, in terms of higher energy density and steady combustion [4, 12]. The charcoal industry constitutes a viable source of income in Nigeria because of the

relatively low investment cost, simple and adaptable production technology and a ready local market willing to offer competitive prices. Bamboos are easier to process for charcoal making than wood. However, despite the growing concerns about the un-sustainability of wood charcoal production, bamboo charcoal is not yet popular in the country. To facilitate small-scale bamboo charcoal production, a portable kiln was developed and tested by the author (**Figure 9a–e**). The kiln is relatively easy to assemble and simple to use. It consists of two metal barrels and a detachable chimney. The larger barrel serves as the furnace, while the smaller barrel serves as the retort. Evaluation tests have shown that, with the 50 x 60 cm furnace, and 40 x 40 cm retort, 1.5 kg of well-formed lumps of bamboo charcoal can be produced from approximately 6 kg of air-dry *B. vulgaris*. Charring takes about 2 hours, with a cooling time of 2–3 hours. Charcoal production efficiency is about 25%. An experienced operator can operate ten units of the kiln in a day. Its adoption can help to minimise environmental consequences of un-controlled wood charcoal production in the country.

Briquetting is the compaction of particulate materials to highly cohesive fuel products. It is one of the technologies available for converting bamboo into biofuel products. It can also be used to address wastages in bamboo harvesting and processing. For example, branches from clumps, dead poles, the hard and crooked basal parts often discarded during harvesting; trimmings and shavings from furniture makers; and bamboo charcoal fines can all be briquetted. Briquettes are cleaner, easier to package and more convenient to use than firewood and charcoal [12]. They can be produced with manually operated presses or motorised briquetting machines. However, bamboo charcoal briquettes are not yet popular in Nigeria and for small and medium scale operations to succeed in the country, simple, low-cost, manually-operated presses are more appropriate. To address this challenge, the author developed a manual bamboo charcoal briquetting press with throughput capacity of about 50 briquettes per hour (**Figure 10**). The press produces hollow cylindrical fuel briquettes, 10 cm in diameter and 4 cm long, as shown in **Figure 11**). The briquettes are easy to sun-dry and combust in traditional, improved charcoal or purpose-built briquette burning stoves.

If they are conveniently accessible to consumers, bamboo charcoal briquettes could serve as complements to firewood and wood charcoal for domestic cooking and agro-industrial operations. However, for the bamboo charcoal briquetting industry to thrive in Nigeria, the core issues of bamboo cultivation, appropriate product pricing, and awareness creation that would lead to acceptance and wide spread adoption must be addressed. It is likely that consumers might be willing to adopt bamboo charcoal briquettes in replacement for firewood or wood charcoal if the prices are comparable. The natural markets for wood charcoal, i.e., homes, institutional kitchens- schools, prisons, and restaurants- might also be easier to penetrate in promoting the acceptance and adoption of bamboo charcoal briquettes.

2.6 Development of bamboo composite roofing tiles

A roof serves the purpose of protecting a building against sunlight, wind, rain and extreme weather conditions. Different types of roofing materials are available in the global market today, but corrugated zinc roofing sheets remains popular for low-cost building construction in Nigeria. Asbestos-cement roofing sheets have become less popular in the wake of the global campaign against asbestos fibre. Bamboo can be a good substitute for zinc roofing sheets with significant environmental benefits and enormous market potentials. Its suitability for cement-bonded roofing tile production has been acknowledged. The suitability of Nigerian grown *B. vulgaris* fibres for



Figure 10.
The bamboo charcoal briquetting press.



Figure 11.
The bamboo charcoal briquette produced.

the production of durable, relatively strong, and weather-resistant roofing tiles has also been reported [24, 25]. The roofing tiles installed on a building are shown in **Figure 12**.

Another form of bamboo roofing material not yet investigated in Nigeria is the corrugated bamboo roofing sheet typically made from multiple layers of woven bamboo mats impregnated with an adhesive resin (**Figure 13**). The sheets can be produced in a range of sizes to suit particular requirements and can easily be trimmed for special applications. These roofing sheets have the same standard measurements as conventional corrugated roofing sheets and are also potential substitutes to plastic, zinc or corrugated asbestos roofing panels. They are attractive, durable, strong, fire-resistant, and easy to cut and drill. Besides, in comparison with conventional asbestos, zinc and



Figure 12.
Bamboo-cement roofing tiles installation.



Figure 13.
Currugated bamboo roofing sheet.

plastic roofing sheets (**Table 2**), corrugated bamboo roofing sheets tend to be quieter when it is raining and cooler in hot sun given their relatively high thermal resistance, low thermal transmission coefficient, very good noise insulating properties. Although corrugated bamboo roofing tiles are more water absorbent than asbestos roofing sheets, this challenge can be overcome either with the use of appropriate resins for roofing sheet production or by coating the outer layer of the roofing sheets [26].

In general, the use of bamboo for roofing tiles and sheets not only makes commercial sense, but also has potential long term environmental benefits. It also has

Roofing Sheet Material	Density (g/cm^3)	Water absorption (%)	Thermal resistance m^2K/W	Coefficient of thermal transmission W/(m^2K)	Noise obstruction compared with the reference board (dB)	Flexural strength (MPa)	Impact strength (MPa)
Bamboo	0.71	36.7	0.030	5.6	9	39.72	9.93
Zinc	1.56	1.7	0.012	6.2	4	N/A*	N/A*
Plastic	N/A*	N/A*	0.007	6.4	0 (benchmark)	N/A*	N/A*
Asbestos	1.60	21.1	0.019	5.9	15	31.91	2.55

*N/A = Not available.
Source: [26].

Table 2.
Comparison of corrugated bamboo roofing sheet with selected common roofing materials.

Chemical Constituent	Percentage content (%)
CaO	4.43
SiO_2	78.00
Al_2O_3	4.96
MgO	1.02
Fe_2O_3	2.01
K_2O	3.09
MnO_2	0.23
P_2O_5	0.72
TiO_2	0.36

Source: [27].

Table 3.
Chemical constituents of bamboo leaf ash.

potential social impact in terms of boosting income generation people engaged in bamboo cultivation and processing.

2.7 Evaluation of bamboo leaf ash as a pozzolan

Pozzolans are siliceous and aluminous materials that have little or no cementitious properties in themselves but, when finely ground, will chemically react with calcium hydroxide in the presence of water to form compounds that have cementitious properties. In view of global concerns about CO_2 emissions during Portland cement production, efforts have been made over time to identify suitable pozzolans for partial replacement of cement. A well-known pozzolan of organic origin is rice husk ash. However, when properly incinerated, bamboo leaf ash can become pozzolanic. Studies have shown that ashes of Nigerian grown bamboos are pozzolanic since they (i) contain all the main chemical constituents of ordinary Portland cement (**Table 3**). It has been reported that partial replacement of ordinary Portland cement with 10 to 20% of bamboo leaf ash could enhance the workability of concrete [27, 28].

3. Prospects of commercialisation of locally developed modern bamboo products

The prospects of commercialising modern bamboo products in Nigeria are bright for the following reasons:

3.1 Availability of bamboo raw material base

All has not been well with the forestry sector in Nigeria in the last forty years. Nigeria has lost over 60% of its primary forests in the last twenty years and harvesting of at least twenty-six tree species has been banned in different states across the country as far back as 1999 due to their endangered status and concern over their extinction [12]. However, in the midst of the current wood scarcity, bamboos

abound. Unlike most timber, bamboo is self-regenerating; new shoots that appear annually ensure future raw material after mature culms are harvested. With a 10–30% annual increase in biomass compared to 2–5% for woody trees, bamboos create a greater yield of raw materials. Besides, bamboo plantations can remain productive for more than 50 years and investments can be fully recovered within 10 years [2–10]. Also, mature locally grown bamboos in the country are large enough to permit industrial utilisation. The locally grown *B. vulgaris* and *oxytenanthera abyssinica* in particular have been found suitable for making sundry industrial products.

3.2 Growing demand for wood products

With population increase, there is a growing unmet demand for wood products in Nigeria partly due to wood scarcity, infrastructural inadequacies and other factors. The challenge of wood scarcity can be readily addressed by substituting wood with bamboo in furniture, floor parquet, wall siding, match stick, tooth pick, plywood, particleboard, fibreboard, tissue paper, writing paper, and paperboard production. Some of these products can be produced from recycled bamboo scaffold [29–32]. Nigeria needs to borrow from the examples of China, India, Malaysia and other Asian countries where planting and conversion of bamboo into fibreboard, particleboard and laminated products to supplement timber in wood products manufacture continue to be encouraged [12].

3.3 Simplicity and adaptability of the production technology

The production technologies for manufacturing numerous bamboo products are similar to those of wood products manufacturing in many respects. Besides, they are suitable for small-to-medium scale manufacturing, hence their special appeal in Nigeria, where Micro, Small and Medium Enterprises (MSMEs) continue to play a big role in the economy and where energy costs are increasing at an alarming rate. Today, there are officially over 41.5 million MSMEs in Nigeria, contributing about 50% of the Gross Domestic Product (GDP) and providing jobs for about 60 million people (i.e., about 86% of the national workforce). It has been well-established that electricity access tends to have lower positive impact on productivity of micro enterprises largely because such firms do not use electricity-dependent machinery and processes. It is also accepted as a general rule that changes in electricity costs do not significantly affect unit costs and sales price in MSMEs. Materials costs, which can account for 80–90% of total production costs, are also often unaffected by electricity outages [33].

3.4 Availability of local expertise

The processes involved in the conversion of the locally available bamboo species into industrial products are well known in the nation's research and development community. There are several Departments of Forestry, Wood Technology, Chemistry, Agricultural, Civil, Materials, Mechanical, and Wood Products Engineering in the country, many of which have experts engaged in bamboo research. The Forestry Research Institute and the Raw Materials Research and Development Council are also at the fore front of bamboo research. There may, therefore, be no need for expatriate services in setting up manufacturing plants.

3.5 Favourable government policies

The success of any industrial enterprise depends largely on a favourable business environment. There is, at present, a proposed national roadmap with the overall objective of optimally tapping the potentials of Nigeria's bamboo resources for job creation, income generation, biomass energy and environmental protection. The extant government policy also encourages enterprises based on locally-sourced raw materials, preferably non-oil based and export-oriented. These policy initiatives constitute a conducive environment for nurturing a viable bamboo processing industry in Nigeria today.

4. Constraints to commercialisation of bamboo product innovations

Research results, inventions and innovations have value only when they serve useful purposes in the society. As at today, the wide array of innovative bamboo processing equipment and products catalogued above are not available in the Nigerian market. The reasons for non-commercialisation of modest breakthroughs in research and development in general in Nigeria are many and varied. They include minimal institutional support for intellectual property activities, and absence of appropriate reward system for developmental research in Nigerian universities [34]. A major constraint to the commercialisation of innovative bamboo products in particular is the unfavourable societal disposition to bamboo as an engineering material. Bamboo has a poor reputation in many local communities as an invasive weed that is difficult to eliminate. Another constraint is the very low level of awareness in the Nigerian public of the local innovations in bamboo processing and utilisation. For example, in a 2020 survey 17% of 40 respondent undergraduate students of the Faculty of Technology, University of Ibadan, Nigeria, aged 20–29 years and 58% of whom are male, had not heard of, or seen a bamboo bicycle before [23]. There is also the constraint of the absence of local bamboo design codes. For bamboo to be acceptable as building components, appropriate engineering design codes must developed. This has not been the case in Nigeria yet, thus hindering its acceptability by Architects and Structural Engineers. Also, there is the dearth of local entrepreneurs, strategic investors and venture capitalists that are willing to invest in the commercialization of bamboo products.

5. The way forward

One way of enhancing industrial utilisation is securing reliable source of raw material. To date, bamboo is still treated as an 'open-access' resource that can be readily harvested from wild forests. More bamboo plantations have to be established and concerted efforts have to be made to promote local investments in bamboo plantations. Harvesting mature bamboo stems is also a crucial part of appropriate bamboo plantation management as it will influence the sustainable development of the plantation. Hence, standards guiding bamboo harvesting have to be developed for effective control over the maturity of items harvested.

It is also important to deepen awareness about recent local developments in bamboo utilisation. The first step towards change is awareness. The second step is acceptance. For bamboo products to be accepted, the general public has to be informed and educated with the intention of influencing their attitudes, behaviours and beliefs

towards bamboo as an excellent substitute for wood. For effectiveness, awareness has to be deepened among the following categories of stakeholders:

- Users-people who will use the bamboo products Government at local, state and federal levels who are the policy formulators and regulators

- Influencers-professional associations such as Forestry Association of Nigeria, Nigerian Society of Engineers, etc., non-governmental organisations and people who have the power to influence government policies and decisions

- Providers, including banks and other financial institutions that provide financial resources for investments in bamboo-related projects.

Publication of research briefs, extension notes, etc. by universities and research institutes should be encouraged. Annual technology fairs/exhibitions should also be mounted to show-case new process and product innovations; dialogues with key players in the private sector and cognate government ministries, parastatals and agencies [34]. Current bamboo processors in the country have to be empowered through transfer of adaptable innovative processing technologies that meet international standards. The establishment of the National Bamboo and Rattan Growers, Processors and Marketers Association of Nigeria in October 2018 is a step in the right direction. Finally, for the new structural bamboo products already developed locally to be acceptable as building components, appropriate engineering design codes must be developed. This has to be done to promote their acceptability by Engineers and Architects.

Investment in local power generation is also critical. Insecure electricity supply presently constitutes a serious constraint to the development and expansion of local industries in general. The current electric power generation of around 4 GW in the country is insufficient to meet the country's peak demand of 8.25 GW. It is common knowledge that energy insecurity influences investment decisions since power outages and voltage fluctuation often halt production, damage equipment and affect product quality. This is more important since firm competitiveness usually depends on product quality and the ability to meet orders on time, as well as reduce unit cost of production. Since self-generation is generally more expensive than grid electricity, the best solution is to increase the current generating capacity and to find means of reducing transmission and distribution losses. It may, however, be necessary to focus on reducing technical faults in existing transmission and distribution infrastructure as a short-term priority over the long-term necessity to increase generation capacity.

Greater investments in Vocational and Technical Education (VTE) are also necessary because the country is currently in short supply of well-trained artisans and technicians. Not only are vocational training centres too few, there has also been a decline in enrolments over the years. To promote rapid industrialisation in general and for the bamboo processing industry to take off effectively, the overall disinterest in structured VTE, the inadequacy of basic VTE training centres and infrastructure as well as the dearth of experienced VTE instructors must be addressed.

6. Conclusion

The Nigerian forest estate is no longer capable of supplying the quantity and quality of wood required for industrial production of a myriad of wood products on a

sustainable basis. However, there is the possibility of diversification from traditional wood- to bamboo- based products. Bamboo being one of the fastest growing plants makes it a highly attractive natural resource compared to the hardwoods. Several research and development efforts geared towards promoting modern methods of bamboo utilisation in the country have been catalogued. Once the constraints to commercialisation and growth of local industries are removed, the various locally developed modern bamboo products should enjoy good market acceptance in Nigeria as they have done in many other countries across the globe.

Conflict of interest

The author declares no conflict of interest.

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