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Predicament for the sustainability of wood-based industries in the Lake Zone, Tanzania

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Abstract

Wood-based industries make significant contribution to the utilization of forest products in terms of value addition. However, there is limited scientific evidence on the current development status of wood-based industries in the Lake Zone, which comprises Mwanza, Geita, Kagera, Shinyanga, Simiyu, and Mara regions. This study assessed the status of these industries and their optimal productivity level, types of raw materials used, their sources and quantity, trends of consumption of raw materials for wood-based industries, and the capacity of forest resources to sustain raw materials demands. Data collection methods involve desk review, interviews, field observation, and satellite image classification for plantation types and other land covers. The Lake Zone has 198 registered primary wood-based industries, which comprise only Sawmills. Most of these industries sourced wood raw materials from forest plantations as well as woodlots. Planted area of the plantations and woodlots in the zone is about 50,646.82 ha, with *Pinus* species covering 33,622.56 ha (66.39%) and *Eucalyptus* covering 17,024.26 ha (33.61%), yielding a total allowable cut of 67,988 m^3 (22%). The annual demand, however, stands at 315,800 m^3, resulting in a deficit of 247,812 m^3 for the industries to operate at a normal state. The major challenges affecting the sustainability of forest plantations in the Lake Zone include the rapid expansion of primary wood-based industries focused mainly on sawmilling, uncontrolled livestock grazing, frequent fire outbreaks, and the use of poor-quality planting materials. To sustain the primary wood-based industries, more efforts are needed to establish more tree woodlots and plantations and improve their management. Despite the low supply of wood raw materials that focus on only sawmill technologies, the zone has the opportunity of the availability of wood residues emanating from the sawmills. Investment in appropriate Engineered Wood Products technologies, which could utilize the vast wood residues, is recommended.

Key words: *Forest plantations; forest resources; Lake Zone; primary wood-based industries; sawmills; woodlots*

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Introduction

Wood-based industries in Tanzania play a major role in the conversion of forest products into various end uses (Kilongo, 2018). Various studies on wood-based industries in the country have shown the sub-sector to be based on primary processing as the core value addition activity in Tanzania's commercial forest sector, dominated mainly by sawmilling, which produces structural timber used in construction, transmission poles for electricity, and telecommunication distribution. The limited number of wood processing value chains has resulted in reduced economic gains, including economic development, industrialization, employment creation, and fiscal revenue generation (URT, 2021a).

The study on the development of wood-based industries in Sub-Saharan Africa by Asumadu (2004) tried to show the predicament nature of the industry in the region. The study described the regions' colonial past as having a role in influencing the development, nature, and ownership structure of its forest and wood products industry, including the wood processing sector. Although the study mainly delved deep into the nature of the industry in West and Central Africa, the characteristics of the sector, such as dominance by small to medium enterprises (SMEs), most of which operate in the informal sector; dominance of obsolete equipment and low recovery rates; and high excess capacity in the sawmilling sector, are widely shared. While problems such as low level of investment in processing activities, low volumes per hectare log production which increases the unit cost of production; negative perception in some of their traditional markets, particularly Europe, about unsustainable forest management practices resulting in increased deforestation and a diminishing resource base; weak economic structures, including small domestic markets (Balama *et al.*, 2016; Abdallah and Masaka, 2018; Mhando *et al.*, 2022) and, production inefficiencies (Kilongo, 2018) caused by obsolete equipment and unskilled workforce continue to downscale performance of the sector in Tanzania.

The study on availability of forest products to support industries in Tanzania: challenges and opportunities by Kilongo (2018) covering seven zones of forest management and 23 forest plantations under the Tanzania Forest Services Agency (TFS) jurisdiction indicated that Wood-based industries were either active (44%) or inactive (45%) with small proportions (11%) being dormant and their actual installed, annual wood demand and utilized capacities were 2,541,918 m^3, 1,559,332 m^3 and 554,752 m^3, respectively. The total annual wood allocated for all primary wood-based industries increases yearly due to the growing market demand of wood for construction purposes or other development activities (Chenga and Mgaza, 2016).

Understanding the predicament nature of the sector, the Ministry of Natural Resources and Tourism, through Tanzania Forestry Research Institute (TAFORI), realized the need to conduct a detailed study of the country's commercial forest sector. The study provides an understanding of wood-based industries' demand and supply chains. Specifically, the study aimed at establishing information on the status of the wood-based industries and their optimal productivity level, types of raw materials used, their sources and quantity, trends of consumption of raw materials for wood-based industries, and the capacity of forest resources to sustain raw materials demands for the industries. This information is crucial to ensuring the challenges facing the sector are addressed to ensure sustainable development is reached. The study also informs policy and decision makers on the implementation of the National Forest Policy (URT, 1998), through its Implementation Strategy that covers the period from 2021 to 2031. The National Forest Policy Implementation Strategy (2021 to 2031) has targeted a total of 1,500 wood-based industries by 2031 (URT, 2021b).

Materials and methods

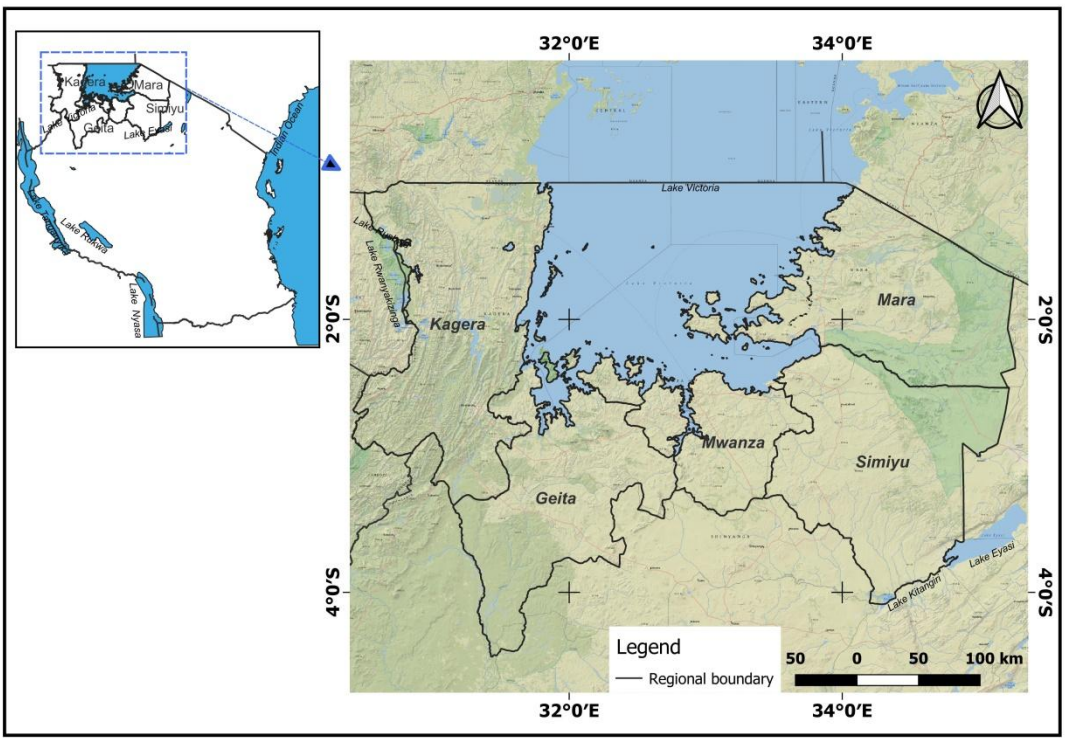
Study area

The study was conducted in the Lake Zone regions of Tanzania. The zone comprises five regions, including Geita, Kagera, Mwanza, Mara, and Simiyu (Figure 1). All these regions surround and share Lake Victoria on the Tanzanian side. The area, with the exception of Simiyu Region, receives bimodal rainfalls from January- May and October – December, making the area wetter and more conducive for plantation forest. The Lake Zone was selected because of having substantial number of wood-based industries due to presence

of sources of wood raw materials from both natural (in unreserved forest lands in Mbogwe and Bukombe districts in Geita Region) and plantation forests (Rubare (Kagera Region), Buhindi and Rubya (Mwanza Region).

Figure 1

Map Showing Study Areas in the Lake Zone regions in Tanzania



Data collection

Data was collected in January - March 2024 using an array of methods, including desk review, interviews, field observation, and satellite image classification for plantation types and other land covers. A desk review was carried out to gather information from online platforms, management plans for various forest reserves, and different official reports from the stakeholders encountered during the study. A structured questionnaire interview with 46 owners/persons in charge of the wood-based industries using a structured questionnaire captured essential data on the status of wood-based Industries, such as: location, type, and size/category, source of raw materials for the industry types, amount of raw materials, and trends of consumption of these raw materials. Further, the number of personnel, as well as their level of training and working skills, were recorded. In this study, the wood-based industries were categorized into three categories: Small, medium, and large with an annual capacity of < 5,000 m^3, 5,000 - 10,000 m^3> 10,000 m^3, respectively.

Moreover, Key Informant's interview with District Forest Conservators, District Forest Officer, some wood-based industries owners/those in charge, and tree growers was also conducted using a checklist. The checklist was also applied during focus group discussions with stakeholders on wood-based industries. In all cases, data on wood-based Industries available in the area, types and sources of raw materials for industries, amount of raw materials, and trends of consumption of these raw materials, and industries' sustainability and raw materials.

Field observation was also conducted to comprehend the information collected through interviews with different stakeholders.

Observations revealed that all field operations were carried out with the availability and quality of raw materials for the wood-based industries. Furthermore, satellite image classification for plantation types and other land covers through cloud-free Sentinel 2 satellite images between the months of July and August was used in the area in Google Earth Engine (GEE) to genera a level to produce thematic maps of forest plantations/woodlots.

Data analysis

Content analysis was used to analyze the data collected through desk reviews, Key informant interviews, Focus Group discussions, and field observation to get meaningful insights about wood-based industries in the area. Descriptive analysis was employed for quantitative data collected through a structured questionnaire.

Google Earth Engine (GEE) was used to classify the satellite images to produce the forest plantation map. The produced map was fine-tuned to 90% overall user accuracy. QGIS software was used to further synthesize the data from the produced thematic maps to understand area coverage (ha) for each genus, i.e., *Eucalyptus* spp. and *Pinus* spp., for each administrative unit (Regions and Districts).

Results

Status of the wood-based industries

A total of 198 wood-based industries were observed in the Lake Zone regions of Tanzania (Table 1). The industries were only distributed in Mwanza and Kagera regions (Figure 2). However, Mwanza had a high concentration of industries (sawmills) compared to the Kagera Region due to the availability of wood raw materials from forest plantations, especially Buhindi (Sengerema District) and Rubya (Ukerewe District) forest plantations. In Mwanza, a high concentration of wood-based industries (sawmills) was at Sabasaba Timber Yard, located at Butuja Street – Sabasaba, Ilemela Ward, Ilemela District, Mwanza Region. The yard comprised 11 medium-sized and different wood value chain activities, including sawing of timber from cants imported from different regions and nearby countries, including the Democratic Republic of Congo (DRC). In Kagera, high concentrations of sawmills were around Rubare Forest Plantation. Other regions in the Zone did not have primary wood-based industries rather wood works.

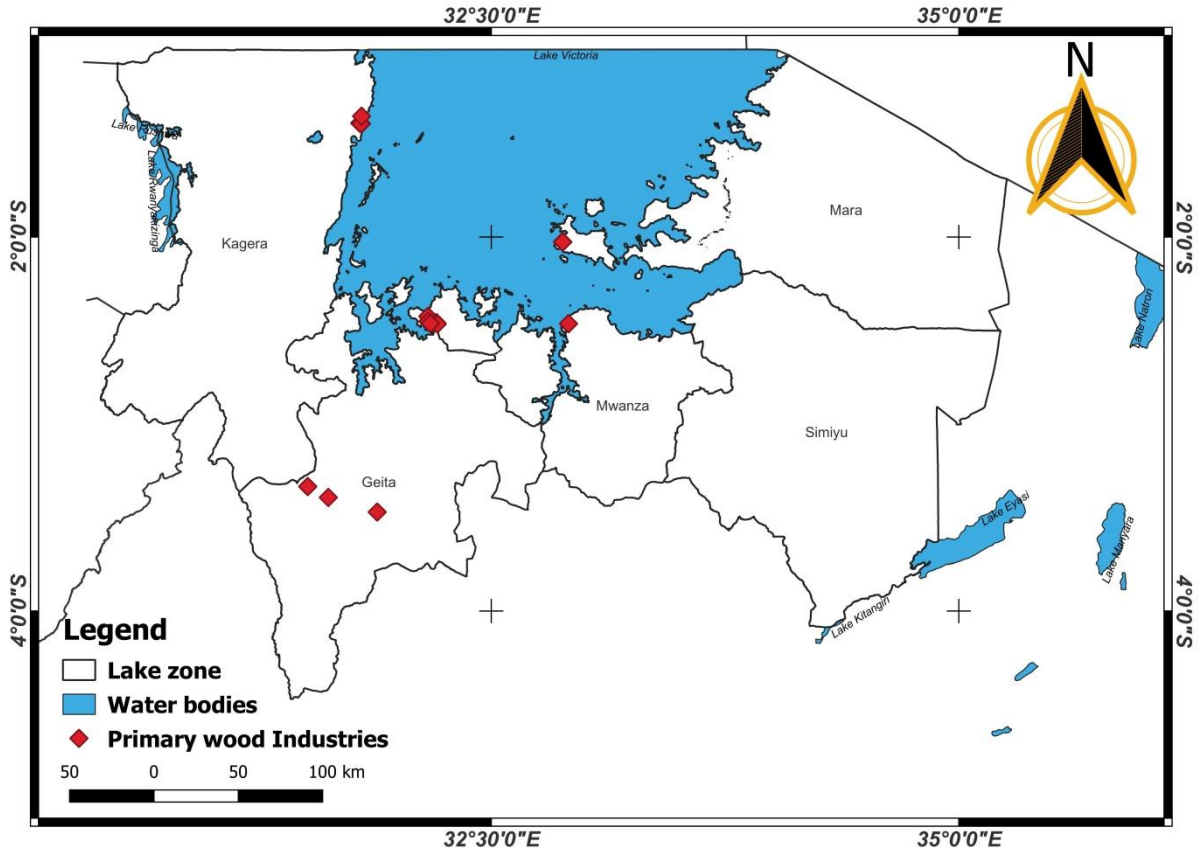
Table 1

Number of Wood-Based Industries in the Lake Zone regions in Tanzania

Region	District	Number of wood-based industries (Sawmills)
Mwanza		151
	Ilemela	11
	Sengerema	88
	Ukerewe	52
Kagera		19
	Bukoba	19
Geita		28
	Geita	3
	Chato	3
	Bukombe	6
	Mbogwe	16
Total		198

Figure 2

Map Showing the Distribution of the Wood-Based Industries in Lake Zone regions in Tanzania



Productivity level of wood-based industries in Lake Zone of Tanzania

About 72% of sawmills were found to operate under medium capacity. Most of which are characterized by either circular or band saw technologies, with a recovery rate of about 30% and 40% for the circular and band saw technologies, respectively. In Kagera region, circular saws motored using diesel engines with a small bench for log carriage were predominant as they can be easily transported from one place to another in seek of raw materials. This situation was quite different from that observed in some places, like Buhindi and the Rubya forest plantation, where sawmills were large and stationary. Sawmills using band saw technology were of medium scale and few in number.

Sawmills with band technology were observed in Geita and Mwanza regions and were used in processing hardwood tree species, mainly those harvested from natural forests. Apart from Wood materials obtained from natural forests surrounding these regions, some are brought from neighboring countries like the DRC. Therefore, circular saw technology was mostly used in areas with softwood tree species, while band saw technology was used in processing hardwood tree species. Challenges such as unmanaged pileups of wood residues, in particular sawdust, were observed. The wide use of circular saws tends to exacerbate the problem as they saw wider kerf compared to their counterparts, indicating the need for prompt intervention to reduce the residues and increase productivity. There was no investment in technologies that could consume wood residues in the zone.

The results further indicated that the annual demand of the industries ranged from 1,000 m^3 to 5,000 m^3 for small and medium-sized wood-based industries, respectively. Total annual wood

allocation in the three public forest plantations (Rubare, Buhindi, and Rubya) ranged from 4,000 m^3 to 35,000 m^3. During the financial year 2023/24, the total allowable cut from the three forest plantations was 67,988 m^3 (Table 2), while the total annual demand was found to be 315,800 $m^{3,}$ making a deficit of 247,812 $m^{3,}$ for the primary wood industries to operate at an optimal state. Some proportion of the noted deficit was reported to be sourced from individual woodlots and on-farm trees, though the wood obtained was reported to be of low quality compared to that from public forest plantations. Furthermore, the study has revealed that annual consumption of wood from public plantations ranged from 500 m^3 to 1,000 m^3 for small and medium-sized wood-based industries, respectively, and such an amount of wood was just processed within one month.

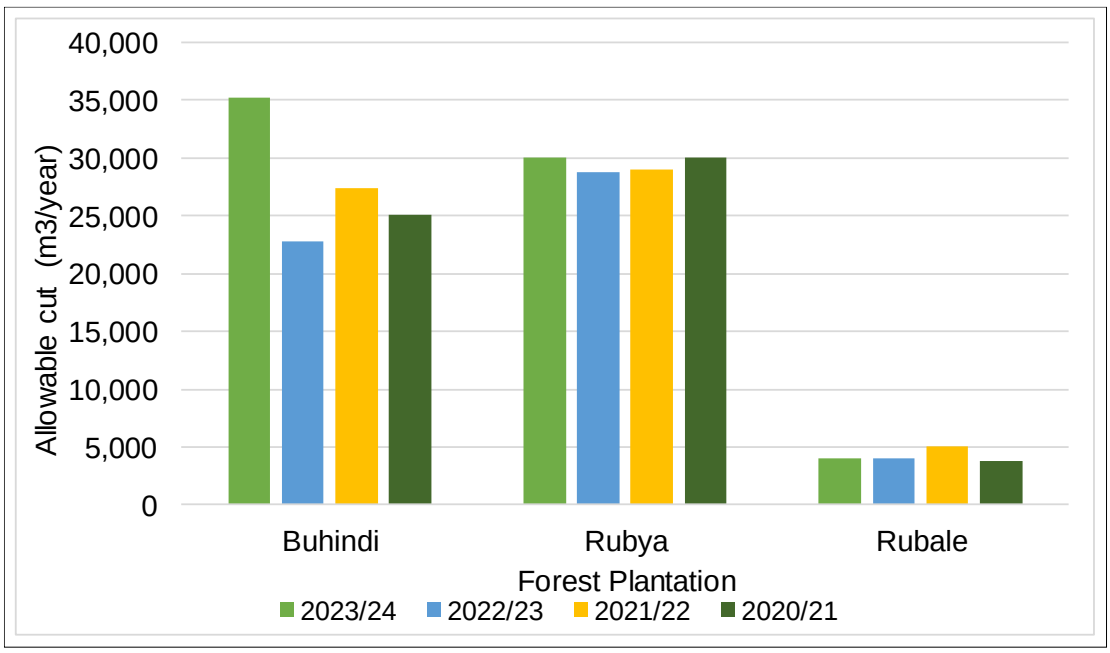
Table 2

Total Annual Wood Allocation in the Public Forest Plantations for Wood-Based Industries in the Lake Zone regions in Tanzania

S/N	Financial Year	Allowable Cut (m^3)	Amount requested (m^3) (Actual Demand)	Unmet Demand (m^3)
		Buhindi		
1	2023/24	35,166	227,800	192,634
2	2022/23	22,830	121,000	98,170
3	2021/22	27,344	153,000	125,656
4	2020/21	25,140	152,900	127,760
5	2019/20	23,586	198,500	174,914
6	2018/19	20,000	124,800	104,800
		Rubale		
1	2022/23	4,007	16,000	11,993
2	2021/22	5,048	15,000	9,952
3	2020/21	3,740	18,000	14,260
4	2019/20	4,100	22,000	17,900
5	2018/19	4,430	28,000	23,570
		Rubya		
1	2022/23	28,815	72,000	43,185
2	2021/22	29,056	200,000	170,944
3	2020/21	30,000	68,000	38,000
4	2019/20	27,983	39,000	11,017
5	2018/19	15,500	47,000	31,500

Figure 3

Wood Allocation in Public Forest Plantation in the Lake Zone regions in Tanzania



Work staff involved in the wood-based industries

The average number of work staff in the primary wood-based industries in the Lake Zone regions was between 12 and 25 people for small and medium-sized wood-based industries, respectively. The staff comprised both permanent and temporary employees. About 99% of the staff were male. This might be due to the nature of the work, which was termed masculine work. The few female staff employed were cooking food for other workers and marketing the wood products. The average number of permanent staff ranged from 1 to 2 for small and medium wood-based industries, respectively. On average, the ratio between males and females among the permanent staff was two (2) to one (1), whereas for temporary staff, it was 16 to 1. The permanent staff were machine operators or supervisors, and or both for small and medium-sized wood-based industries, respectively. The majority of the workers did not have safety gear, thus putting them at high risk of accidents. This situation calls for awareness creation in the workforce so that accidents and unhealthy preventive measures are prevented. Owners of these industries also need to be part of this process to ensure workers' safety.

Types of raw materials used, their sources, and quantity

Wood-based industries in the lake zone consumed both hardwood and softwood tree species. Softwood species accounted for about 83% of the raw materials consumed and were obtained from Forest Plantations of Rubare, Buhindi, and Rubya, as well as private woodlots and trees on farms. Large woodlots were observed in Kagera, Geita, and Mwanza regions, being planted with *Pinus caribaea* and *P. tecunumanii*. While the former remain the most prominent tree species found in forest plantations in the area, the latter is showing prospects as it has begun to fetch acceptance from tree growers in recent years, perhaps because it has wood that is perceived to be of good quality compared to *P. caribaea*. Most hardwood timber was sourced from forests found in general land (especially in Mbogwe and Bukombe districts in Geita Region); with some fetched from neighboring countries, particularly the DRC.

The following timber species were traded: *Pericopsis angolensis* (Mbanga), *Pterocarpus angolensis* (Mninga), *Brachystegia spiciformis* (Mtundu), *Pterocarpus tinctorius* (Mkurungu), *Burkea africana* (Mgando), and *Afzelia quanzensis* (Mkongo). The latter timber species was imported

from DRC. On-farm timber species include: *Gmelina arborea* (*Majani mapana*), *Maesopsis eminii* (Mhumula/Msila) (Plate 7), *Grevillea robusta* (Mgivilea), *Cedrela odorata* (Mti kunuka), *Leucaena leucocephala* (Mlusina), *Syzygium quanzensis* (Mzambarau), *Senna siamea* (Mjoholo), *Mangifera indica* (Mwembe), and *Melia azedarach* (Muboyo). In some other areas, wood materials were either sourced from on-farm trees or nearby districts with the resource.

The raw materials fetched from government plantations have been reported to provide materials of higher quality compared to those fetched from privately owned plantations/woodlots. This can be attributed to the fact that trees grown from government plantations receive well-silvicultural treatment compared to the majority of those fetched from other sources.

Capacity of forest resources (natural and plantation) to sustain raw materials demands for the industries

The raw materials for the wood-based industries is sourced from both natural and plantation forests. However, most of the wood is from forest plantations. The study has shown that the available forest resources cannot certainly sustain the demand of the wood-based industries, as some of the industries consuming the raw materials are not registered. However, the extent of sustainability varies between natural and plantation forests.

Natural forests

Most of the natural forests in the Lake Zone regions are not productive (Table 3) as they have been protected for either catchment or biodiversity conservation purposes. Other forests found on general lands, mostly in Mbogwe and Bukombe districts in Geita Region, succumb to overharvesting and land use changes due to a lack of management, making them unreliable.

Table 3

Distribution of Some Forest Reserves in the Lake Zone regions in Tanzania

Region	District	Forest Reserve	Size (ha)	Management Category		Status
				Productive	Protective	
Geita	Mbwogwe	Mkweni Hills	15,740		√	
		Kigosi	700,000		√	
	Bukombe	Biharamulo Kahama	14,000		√	
	Geita	Geita	50,186		√	
		Lwamugasa	28,160		√	
		Usindakwe	450		√	
		Ruande	15,550		√	
Kagera	Biharamulo	Biharamulo Kahama	70,000		√	
		Nyantakale	29,000		√	
	Bukoba	Mlema Kiaga Luasina	NA		√	
		Kyamawa	15		√	
		Kyau	20		√	
Mwanza	Sengerema	Kome	2,467		√	
		Maisome	9,319		√	
	Ilemela	Medical Research			√	These are
		Elekalo			√	community

Region	District	Forest Reserve	Size (ha)	Management Category		Status
				Productive	Protective	
		Kasumwa			√	forest reserves
		Nyashimba			√	
		Kawekamo			√	
		Kabusungu			√	
Mara	Butiama	Kyarano	175		√	
		Kyanyari	2752		√	
	Bunda	Kwirwirwi	1,995		√	
		Mlima Balili			√	
		Mlima Chamulilo			√	
		Mlima Boma			√	

Forest plantation coverage and distribution

This study found that the Lake Zone has approximately 50,646.82 hectares of forest plantations. *Pinus* species were found to cover 33,622.56 ha (66.39%) and *Eucalyptus* 17,024.26 ha (33.61%) (Table 4). Again, Kagera was found to harbour 19,878.31 ha, followed by Mwanza, Geita, and Mara with plantation coverage of 15,968.71 ha, 9,963.40 ha, and 4,836.40 ha, respectively. The Simiyu region was found not to harbour forest plantations of commercial significance.

In this zone, apart from *Pinus* (*P. caribaea and P. tecunumanii*) and *Eucalyptus* (mainly *E. saligna*) species, other tree species of commercial importance were observed to be planted in different places, although in very small quantities, in a manner that is not possible or logical to map their distribution. These species include *Maesopsis eminii, Grevillea robusta, Gmelina arborea, Melia azedarach, Markhamia lutea, Acrocarpus fraxinifolius, Cedrela odorata,* and *Khaya anthotheca.*

Table 4

Forest Plantation Coverage in ha by Genera in the Lake Zone regions in Tanzania

District	Woodlot Area (Ha)			Percentage (%)	
	Pinus	Eucalyptus	Total	% Regional	% Total
Bukombe	254.62	0.32	254.94	2.56	0.50
Chato	2,568.50	21.08	2,589.58	25.99	5.11
Geita	6,800.68	29.90	6,83058	68.56	13.49
Mbogwe	175.42	0.05	175.47	1.76	0.35
Nyang'wale	107.99	4.84	112.83	1.13	0.22
Geita	**9,907.20**	**56.20**	**9,963.40**	**100.00**	**19.67**
Biharamulo	402.53	7.23	409.76	2.06	0.81
Ngara	566.61	326.06	892.67	4.49	1.76
Muleba	2,513.82	2,475.62	4,989.44	25.10	9.85
Kyerwa	429.04	2,924.97	3,354.01	16.87	6.62
Karagwe	356.58	2,457.36	2,813.94	14.16	5.56
Bukoba	236.75	215.81	452.56	2.28	0.89
Bukoba	2,240.72	2,156.60	4,397.32	22.12	8.68
Misenyi	1,080.20	1,488.41	2,568.61	12.92	5.07
Kagera	**7,826.25**	**12,052.06**	**19,878.31**	**100.00**	**39.25**

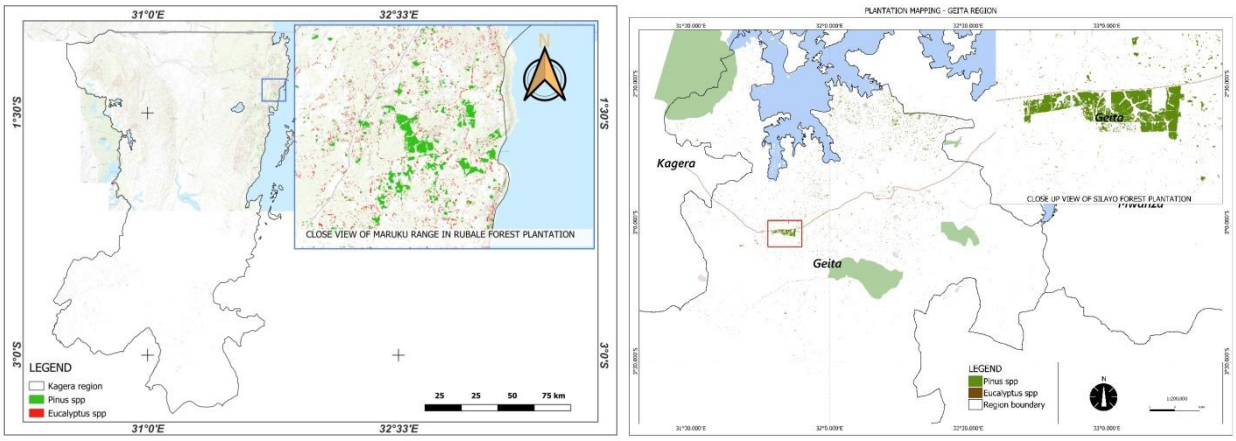
District	Woodlot Area (Ha)			Percentage (%)	
	Pinus	**Eucalyptus**	**Total**	**% Regional**	**% Total**
Rorya	-	344.62	344.62	7.13	0.68
Tarime	-	3,401.94	3,401.94	70.34	6.72
Mara	-	803.85	803.85	16.62	1.59
Butiama	-	138.29	138.29	2.86	0.27
Bunda	-	79.80	79.80	1.65	0.16
Musoma	-	67.9	67.9	1.4	0.13
Mara	**-**	**4,836.40**	**4,836.40**	**100.00**	**9.55**
Ukerewe	3,942.56	13.54	3,956.10	24.77	7.81
Sengerema	11,815.43	63.30	11,878.72	74.39	23.45
Misungwi	79.63	0.61	80.23	0.50	0.16
Magu	38.64	2.16	40.80	0.26	0.08
Kwimba	12.86	-	12.86	0.08	0.03
Mwanza	**15,889.11**	**79.60**	**15,968.71**	**100.00**	**31.53**
Total	**33,622.56**	**17,024.26**	**50,646.82**	**NA**	**100.00**

Kagera region was found to have about 19,878.31 ha of forest plantations, which account for 39.25% of all forest plantations in the studied area. *Eucalyptus* spp. were found to be the main tree genus planted in the region, with a total of 12,052.06 ha, followed by *Pinus* spp., which is estimated to be 7,826.25 ha (Table 4). *Eucalyptus* spp. were mostly found in Kyerwa, Bukoba, Karagwe, and Muleba Districts, each harbouring over 2,100 ha, which is estimated to be 83% of all eucalyptus plantations in the region or 58% of all eucalyptus plantations in the Lake zone. Most of the *Eucalyptus* are harvested to provide poles for the mining industry in Geita, Kagera, and other nearby areas. Pine plantations are mainly found in Muleba and Bukoba districts and are mainly used to meet timber needs in the region and other nearby towns (Table 4).

Furthermore, Geita Region was found to have a total of 9,963.40 ha (19%), of which 9,907.20 ha was *Pinus* spp, and the remaining portion was *Eucalyptus* spp. The majority of these plantations were found in Geita District, which accounted for over 68% of all forest plantations in the region (Table 4). This region has so much potential for the growth of the sector, mainly due to the presence of Silayo Forest Plantation, which is the second plantation (total area of 69,756 ha), of which 4,210 ha have been planted, and the plantable area of 43,062 ha yet to be planted. Figure 6 below shows the distribution of forest plantations in the region.

Figure 4

Plantation Forest Distribution in Kagera and Geita regions in Tanzania

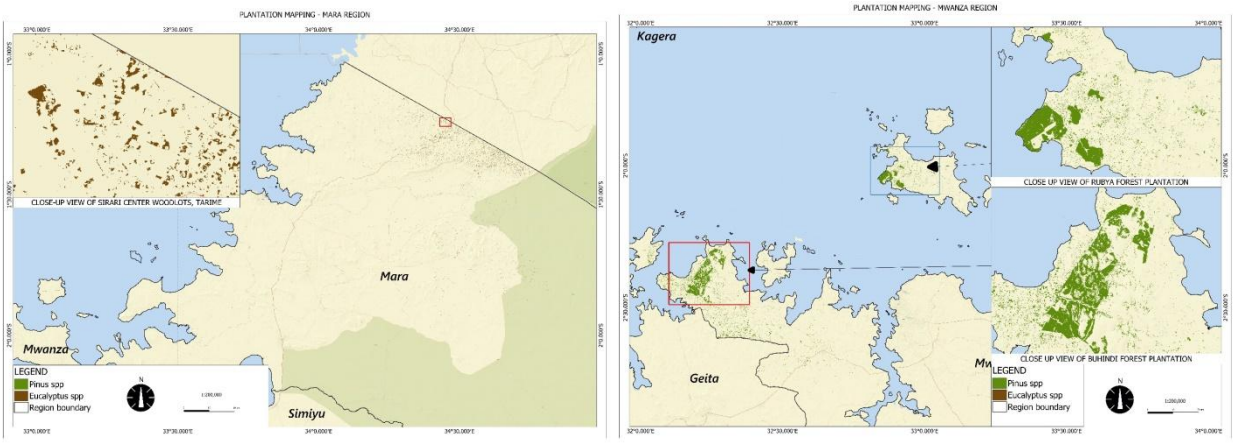


Mwanza Region was found to be the second region with the most forest plantation in the zone, planted with about 15,968.71 ha of forest plantations. *Pinus* spp. accounts for 99% of all forest plantations in the region with a total plantation area of 15,889.11 ha. Forest plantation in the region is mainly contributed by the presence of government forest plantations of Rubya (Ukerewe District) and Buhindi (Sengerema District) under TFS, which account for over 75% of all forest plantations in the region. Again, over 74% of all forest plantations are found in Sengerema District, while Ukerewe accounts for 24.77% with the remaining proportion found in Misungwi, Magu, and Kwimba districts (Table 4). See also Figure 5. Eucalyptus plantations are few and sparsely distributed in the region.

Mara Region was found to have a total of 4,836.40 ha of forest plantations, all being of the *Eucalyptus* genus, with more than 70% of all the plantations in the region found in Tarime District alone, followed by Mara District by 16% (Figure 5). The remaining portion was found in Rorya, Butiama, Bunda, and Musoma in small quantities (Table 4). Figure 5 below shows the distribution of forest plantations in the region. Small and medium-scale tree growers are the key players in this region and own almost all forest plantations. The *Eucalyptus* trees are mostly preferred in the area as there is high demand for poles in North Mara Gold mine and other mining areas in the region. Although very few Pine woodlots were observed along the way, they could not be mapped as most are still young and not within detectable range, pausing signature confusion, and are not of any potential for Industrial Investment.

Figure 5

Plantation Forest Distribution in Mara and Mwanza regions in Tanzania



Discussion

The study has shown the number of wood-based industries in the Lake Zone regions to be 198, with most of them being situated in Mwanza and Kagera regions. A similar study by Kilongo (2018) recorded 83 primary wood-based industries in the Lake Zone regions, implying that the number of industries has increased by 138% since then. Despite this increase in the number of wood industries, the industry is still dominated by sawmills.

Furthermore, the current study has found that about 72% of the primary wood sawmill industries were found to operate under medium capacity. Most of which are characterized by either circular or band saw technologies, with a recovery rate of about 30% and 40% for the circular and band saw technologies, respectively. Furthermore, a deficit of 247,812 m^3 for the primary wood industries to operate at an optimal state was revealed during this study. All these findings concur well with Asumadu (2004), who characterized the industry in Sub-Saharan Africa to be (i) dominated by small to medium enterprises (SMEs), most of which operate in the informal sector; (ii) dominated by obsolete equipment and low recovery rates; and (iii) high excess capacity in the sawmilling sector.

Wood-based industries in the Lake Zone consumed both hardwood and softwood tree species, with softwood species accounting for about 83% of the raw materials consumed. Furthermore, the zone was found to harbour approximately 50,646.82 hectares of forest plantations. *Pinus* species were found to cover 33,622.56 ha (66.39%) and *Eucalyptus* 17,024.26 ha (33.61%). The planted area is not only for public forest plantations but also from communities/individual woodlots. Mwamakimbullah (2016), Held *et al.* (2017), and Pima *et al.* (2021) revealed commercial forestry sector in the country was in transition from large public and private plantations towards small and medium tree growers who invested in woodlots. With small and medium tree growers set to be among the key players in the sector, there is therefore a vital need to ensure continued focus on driving higher productivity and quality in their woodlots.

The scenario was also observed by Mhando *et al.* (2022) in the Southern Highlands of Tanzania, in particular Njombe, Makete and Mufindi districts as were quite profound on issues related to tree plant as communities did not require any more sensitization regarding tree planting. They already knew the importance of trees as they contribute highly to the economy of individuals and to the districts at large. Despite awareness in place on tree planting, Mwamakimbullah (2016) recommended a need to address challenges facing the private forestry sector in particular, that related to proper forest management for improved wood productivity and quality.

Never the less; despite the growth of commercial forest plantations in Tanzania, there are

roadblocks facing the sustainability of forest plantations and wood-based industries included, low supply of wood raw materials, pest and disease, fire outbreaks, the influx of primary wood-based industries that focused only on sawmills technology, and poor plantation/ woodlot management, poor site species matching and presence of poor planting materials, harvesting of trees of immature age from on-farms and woodlots. Despite the study by Laswai *et al.* (2018) and the Technical Order Number One of 2021 (URT, 2021c) revising the rotation age for Pinus species from 25 to 18 years, most of the woodlots are still harvested at an immature age, thus negatively affecting wood recovery. Most of the wood sourced from on-farms and woodlots was of small diameter, which indicates poor quality of timber produced, as the proportion of sapwood is large.

Despite all these roadblocks, Ngaga (20211) predicted an increased demand for wood from forest plantations by about 2,200,000 m^3 by the year 2030 due to increasing population and urbanization. In line with that, Chenga and Mgaza (2016) noted a rapid increase in demand for timber due to population and economic growth, which led to the shift in the use of valuable and less valuable timber species, hardwood and softwood, plantations versus natural forest timber. On the other hand, the Technical Order Number One of 2021 (URT, 2021c) has recommended planting of non-monoculture plantations/woodlots in order to minimize the risk of pest and disease outbreaks. Balama *et al.* (2023) observed on-farm planting of tree species other than common exotic timber species for income generation in the Mpwapwa District.

Moreover, a study by Abdallah and Masaka (2018) and the African Natural Resources Management and Investment Centre (2022) recommended the need for increasing the production of quality wood-based products by increasing industrial investment for exportation purposes. This avenue could be promoted by appropriate means of operationalisation of the National Engineered Wood Sector Development Framework (2021-2031) (URT, 2021a) as well as its Action Plan (2021-2031) (URT, 2021d) by increasing investment in technologies that could utilize wood residues, e.g. wood panel board industries.

Conclusion

The study has revealed an influx of sawmill wood-based industries' investment in the Lake Zone, which has led to a wood raw material deficit of 247,812 m^3 to operate at a normal state. The raw materials for the wood industries were sourced from forest plantations and woodlots dominated by *Pinus* and *Eucalyptus* species. The major roadblocks for facing the sustainability of wood-based industries in the Lake zone were mainly: low supply of wood raw materials, investment skewness to only sawmills, harvesting of immature wood, fire outbreaks, pest and disease, and planting materials of poor quality. Despite the low supply of wood raw materials that focus on only sawmill technologies, the zone has the opportunity of the availability of wood residues emanating from the sawmills.

Recommendations

In order to sustain the primary wood-based industries, more efforts are needed to establish more tree woodlots and plantations and improve their management. Also, challenges such as poor plantation/woodlot management, poor site species matching, and the presence of poor planting materials need to be addressed promptly in a comprehensive manner to reduce the observed deficit. With regard to the vast wood residues coming out from the sawmills, investment in appropriate Engineered Wood Products (EWP) technologies, which could utilize the vast wood residues, is recommended.

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