Journal of Ecosystem & Ecography
ISSN: 2157-7625
Nyamoga et al., J Ecosys Ecograph 2(
10.4172/2157-7625.S5-
Research Article
Open Acces

Keywords Substitution e ects; Sawnwood consumption; Income elasticity; Elasticity of demand; Construction sector; Building industry; Forest sector; Environmental conservation

Introduction

ere is an increasing global awareness and discourses on the contribution of building designs and materials in global warming and greenhouses gases emissions [1,2]. e tastes, preferences and choices of building material should therefore consider these global interests, resource bases and the environmental e ects for extracting and processing these resources [3]. Wood is one of the world's main construction materials which are widely used in housing and construction activities. It can be sawn longitudinally, with or without its natural rounded surface but also with or without bark to produce sawnwood [4]. e use of wood-based panels and other wood products in construction and building works have shown an increasing trend [5]. e increase use of these materials therefore gives a clear relationship between forest industries, building sector, global warming and climate change globally. e e ects of wood products and alternative construction materials to the changing global climates are not well studied and examined. It is therefore important to understand the rates

residential and none residential buildings, roads, bridges and land improvement activities.

e rapid expansion of towns as results of high rate of urbanization and commercial activities indicate an imbalance between the amount of wood products supplied to consumers and the actual requirements [9]. Similarly, the emerging competition between wood products in the building and construction works with substitute materials like concrete, steel, plastic and aluminium may result into dwindling of wood markets [10]. High quality reconstituted wood based panels such as particle board, Medium Density Fiberboard (MDF) and Oriented Strand Board (OSB) are predicted to reduce the consumption of locally made wood materials from traditional forest industries due to di erences in tastes, preferences and quality [10]. Forecasting the consumption of wood products under di erent driving forces is inevitable since many decisions for future development of the forestry sector will depend on the forces that in uence the demand and supply of these wood products. e substitution of wood with none wood materials or with di erent species causes a shi ing demand of these building materials. Replacement of wood framed ground oor system by concrete stab foundation and applications of roof trusses replacing sawnwood, plywood substituting sawnwood in roof sheathing and sub ooring are currently becoming common practices [11,12]. On the other hands, metal poles are replacing premature poles used in the formwork while aluminium is replacing timber in door and window frames. Consumers are also shi ing into diverse species comprising of so wood and lesser-known hardwood species that were previously underutilized and ignored [13-15].

e increase in demand for sawnwood in building industry depends on the e ciency of the wood industry and its ability to face competition from substitute materials. Despite the importance of the building sector in Tanzania, scanty information is available on future demand for wood products and its associated environmental consequences resulting from substitution by other materials. is information is useful to di erent stakeholders such as tree growers, timber traders, policy and decision makers at national and international levels. On the other hand, the understanding of substitute building materials may stimulate trades, promote local industries, contribute to environmental and forest conservation in the country. erefore, the general objective of the study was to investigate substitution of wood products and forecast its consumption in the building industry in Dar es Salaam city, Tanzania. Speci cally it aimed to estimate the present consumption of sawnwood products by the building industry, identify the types of sawnwood products and areas being substituted and the level of substitution in the building industry, identify factors underlying substitution of sawnwood products by other materials in the building industry, forecast future consumption of wood products by the building industry.e ndings are expected to serve as a basis for promoting the use of wood products by construction companies, architects, designers and builders.

Methodology

Study area

Dar es Salaam Region is located between latitudes 6°36' and 7° South and longitudes 33°33' and 39° East. It is bordered by the Indian Ocean on the East and by the Coast Region on the other sides. Administratively, Dar es Salaam is divided into 3 municipalities, Ilala, Kinondoni and Temeke

building category with 4 or more storeys consumed about 5.6 m^3

Building Category	Building units surveyed	Sawnwood consumption (m^3)	Sawnwood weighted m^3/building unit	Aluminium consumption(m^2)	Aluminium weighted m^2/ building unit
Lower(none Storey)	653	1756.6	2.7	16 170.1	24.8
Medium(1-3 Storeys)	43	131.6	3.1	2965.1	69.0
+ L J K • 6 W R U H \ V	36	190.2	5.3	4830.0	134.2
Total	732	2078.6	2.8	23,965.3	32.7
Source: Field Data (2012)					

Table 1: Consumption of sawnwood and substitute building materials in different building categories.

Building category		2009		2010		2012	
	Sawnwood m^3/ unit	Building units	Sawn wood m^3/year	Building units	Sawnwood m^3/year	Building units	Sawnwood m^3/year
Lower	2.7	1815	4882.3	1580	4250.3	1439	3870.9
Medium	3.1	790	2417.4	964	2949.8	1245	3809.7
High	5.3	121	640.1	86	454.9	194	1026.3
Total		2726	7939.8	2630	7655.0	2878	8706.9
Population		3,040,118		3,118,132		3,194,903	
Consumption(m^3) per capita (1000)			2.6		2.5		2.7
Source: Field Data (2012) Note: Municipalities have indicated that between 30% -70% of buildings are in unsurveyed areas therefore no building permits were solicited. A correction factor of 50% was used to get the correct number.							

Table 2: Per capita consumption of sawnwood in building units from 2009 - 2012.

DESCRIPTION	BUILDING		2009				2010				2012		
	MATERIAL	ILL	TMK	KNDN	TOTAL	ILL	TMK	KNDN	TOTAL	ILL	TMK	KNDN	TOTAL
Population		775,125	940,167	1,324,826	3,040,118	795,209	964,913	1358,004	3,118,126	815,313	988,809	1390,781	3,194,903
Total consumption	SW(m^3)	2913.5	1918	3108.3	7939.8	2860.1	1748.4	3046.5	7655	3026.3	2006.3	3674.3	8706.9
Percentage (%)		36.7	24.2	39.1	100.0	37.4	22.8	39.8	100.0	34.8	23.0	42.2	100.0
Per1000 capita													
consumption	SW(m^3)	3.8	2.0	2.3		3.6	1.8	2.2		3.7	2.0	2.6	
Total consumption	AL(m^2)	45,194.5	26,512.3	43,945.6	11,5652	48,889.3	22,190.6	46,056.9	117137	61,686.2	27,220.2	58,607.5	147,513.9
Percentage (%)		39.1	22.9	38.0	100.0	41.7	18.9	39.3	100.0	41.8	18.5	39.7	100.0
Per1000 capita													
consumption	AL(m^2)	58.3	28.2	33.2		61.5	23.0	33.9		75.7	27.5	42.1	
Source: Field Data (2012) Note: ILL = Ilala, TMK = Temeke, KNDN = Kinondoni, AL = Aluminium, SW = Sawnwood													

Table 3: Consumption of Sawnwood and6.175 0 Td

medium buildings category (1-3 storeys), 90.1% of the doors consumed sawnwood and the rest (9.9%) consumed aluminium materials. Most of the windows (72.6%) in medium category consumed aluminium materials while 27.4% consumed sawnwood. On the other hand sawnwood consumption in the highest building category covered 90.0% of doors with aluminium covering the remaining 10.0%. About 78% of windows consumed aluminium materials while 22% consumed sawnwood materials. Surveys revealed that aluminium materials are currently popular in the building industry compared to Poly Vinyl Chloride (PVC) as most of the substituted sawnwood doors and window frames in new dwellings and renovated buildings were made of aluminium. Steel were also observed during assessment but its abundance and substitution was low compared to aluminium materials. Sawnwood is being replaced by aluminium, steel, PVC and other materials depending on the intended use and location of doors and windows (Figure 1). Aluminium has taken the largest share (61%) in substituting sawnwood materials in the building and construction industry followed by steel -24% (Figure 2). Poly Vinyl Chloride (PVC) materials are described as one of the best and most appropriate materials for windows and doors and is economically cheaper than both sawnwood and aluminium.

Building contractors, architects and house builders revealed that aluminium is mostly preferred for windows followed by doors and partitions (Figure 2). Majority of the respondents (52%) mentioned that aluminium is preferred and mostly substituted in windows and some few in doors indicating that aluminium materials are mostly used to replace sawnwood in windows compared to doors and partitioning works. Only 4% of the respondents said that aluminium materials are being used to replace sawnwood sections other than windows, doors and partition. e substitution of these materials is directly linked to many factors including price, quality, availability and durability. It is therefore important for traders to ensure good quality products to guarantee the market for sawnwood products in the country.

About 46% of the respondents revealed that the rate of substitution in doors ranges between 0-25% meaning that aluminium was less preferred in doors while about 38% asserted that substitution ranges from 26-50% and 17% stated gave the highest range (Table 5). e highest substitution percentage range estimates in windows was 52% followed by 26% implying that aluminium was mostly preferred in windows compared to other parts. It is also revealed that, aluminium materials are less preferred for partitioning as few respondents mentioned this during interviews. About 35% of the assessed windows in buildings consumed aluminium while only 3% of the assessed doors consumed aluminium. is support the narration by some key informants that more than 50% of the people prefer aluminium materials for windows compared to doors and partitioning. Furthermore, majority (70%) of the people had the opinion that availability of aluminium was abundant in Ilala, Kinondoni and Temeke municipalities and only 26% mentioned that the materials are scarce.

Experience from the eld indicate that the availability of aluminium in Dar es Salaam market is high but the future supply may be uncertain due to high demand and extension of market and number of customers in other regions but is not evident to what extent the upcountry market for aluminium will grow in future. e report provided by construction registration board in 2011 indicated that among 2635 building contractors country wide, about 1040 (nearly 40%) building contractors are based in Dar es Salaam. Moreover, more than 300 commercial and residential construction projects each with a value of more than 2.1 billion TAS (Tanzanian Shillings) were implemented in the same nancial year in Dar es Salaam. e largest project in this city was a commercial building by the Public Services Pension Fund (PSPF), worth more than 100 billion TAS (pers. comm). Field observation showed that many projects were implemented at the city center and mostly being commercial multi-storey buildings made by none wood materials including aluminium and glasses.

For residential buildings, 64.3% of the interviewees revealed that the rate of substitution ranged between 0-20% implying that in residential buildings sawnwood are still being used in large quantities compared to commercial and o ce buildings (Table 6). In commercial buildings, 42% of those interviewed stated that sawnwood substitution range between 61-80% while 27% thought that the rate of substitution was about 41-60%. On the other hand, about 54% of the interviewee showed that sawnwood substitution in o ce buildings is low compared to commercial buildings but a bit high when compared to residential buildings (range between 21-40%). e extent of sawnwood substitution in commercial, residential and o ce buildings also di er depending on the regulations and the use of the building. e corresponding responses from building contractors, architects and house builders on what type of buildings will sawnwood substitution likely to occur showed that commercial buildings were leading in sawnwood substitution by high percentage range compared to residential and o ce buildings. In order to assess sawnwood substitution in di erent building categories respondents estimated their percentage ranges of substitution to the three categories of buildings which aimed to provide a general picture of what is happening in the building industry with regard to sawnwood substitution by other building materials.

e majority of respondents (93%) revealed that substitution of

Citation: Nyamoga GZ, Mgana JE, Ngaga YM (2016) Sawnwood Substitution in Dar es Salaam, Tanzania and its Linkage to Environmental Conservation. J Ecosys Ecograph S5: 006. doi:

which is an increase of about 11% compared to the previous period. e real prices for *Afzelia africana* rose by 36% from 2004-2008 and by about 58% from 2008-2012 which is about 15% more compared to *Pterocarpus angolensis* in the nancial years 2008-2012 indicating that the value and uses of *Afzelia africana* and *Pterocarpus angolensis* in the building industry has risen signi cantly in recent years. During site visits, it was revealed that most of the building contractors used *Afzelia africana* species for doors compared to *Pterocarpus angolensis* with the reason that the former is o en available in the market than the later. According to the data from the Bank of Tanzania, the in ation rates for the year 2004, 2008 and 2012 in the country were 4.1%, 6.7% and 12.7% respectively (pers. comm). e comparison of price index showed a slight di erence between real and market prices of the sawnwood species.

e sharp increase of prices of sawn hardwood may be attributed by the increase in the logging costs, transport and the high in ation rates experienced in the country. e interviewed registered timber traders and end users mentioned that the prices of sawnwood are not stable, it may rise or fall within short period of time. Apart from availability, the uctuation of sawnwood prices in recent years has been accelerated by in ation which raised the transportation costs of goods due to increased prices of fuel and spare parts. Anecdotal evidence shows that, most of the sawn hardwoods are imported from Mozambique. e government royalty fee per m^3 of timber doubled to 256000 TAS thus making it di cult for small scale carpentry factories to invest in timber trading. Some traders revealed that sawnwoods in Mozambique are being charged in dollars therefore the in ation of the Tanzanian shilling resulted into high sawnwood prices in Dar es Salaam.

Both timber traders and end users revealed that the instability in sawnwood prices is mainly due to the rise in prices of fuel and logs since transportation is associated with fuels (Table 11). ey also claimed that frequent instability of prices are caused by distances from which sawnwood are being produced especially a er banning logs production in Ru ji, Kilwa and Liwale districts. ese arguments are in line with those given by other previous research ndings [22,23].

2011 per 1000 capita sawnwood consumption	Population growth per year (%)	GDP growth per year (%)	GDP growth rate per year (per capita) %	Income elasticity (EID)	Per 1000 capita increase in consumption	Estimator	2012 (per 1000 capita) m^3	2016 (per 1000 capita) m^3	2021 (per 1000 capita) m^3	2026 (per 1000 capita) m^3
2.73	4.3	6.0	1.7	1.2	2.04	(1.02)	2.78	3.01	3.33	3.67
Source: Field Data (2012)										

Table 14: Sawnwood consumption forecast in building and construction industry for Dar es Salaam from 2012 - 2026.

2011 (Per capita consumption m^2)	Population growth per year (%)	GDP growth per year (%)	GDP growth rate per year (per capita) %	Income elasticity	Per 1000 capita increase in consumption	Estimator	2012 (per 1000 capita) m^2	2016 (per 1000 capita) m^2	2021 (per 1000 capita) m^2	2026 (per 1000 capita) m^2
46.17	4.30	6.00	1.70	2.50	4.25	1.043	48.2	57.0	70.3	86.8

Conclusions and Recommendations

Sawnwood is considered environmentally friendly and better alternative for construction purposes in Tanzania. Its extraction however is directly linked to environmental damages and degradation due to increased pressure to forest resources. In the construction and building industry, sawnwood is much consumed in none storey buildings and its consumption per building unit is minimal in the high storey buildings. For both none storey and storey buildings, sawnwood consumption is high in doors than in window frames. Sawnwood substitution is greatly taking place in storey buildings compared to none storey buildings with more substitution in window frames than doors. Durable sawnwood species are becoming more scarce, hence predicting high substitution rates in the future. e uctuation of sawnwood prices, dwindling availability of sawnwood products especially for hardwood species, emergence of new technologies, quality and durability of the substitute materials are among the factors enhancing the substitution of these materials. e consumption of sawnwood in Dar es Salaam will keep increasing with aluminium being a dominant substitute building materials. However, the environmental e ects of these aluminium materials have not been established especially at this era where the impact of global warming and climate changes are enormous.

Durable timber species takes long to mature, the promotion of commercially unknown and underutilized sawnwood species in order to meet the existing demand of sawnwood in the country is recommended. More research on strength properties, resistance to weather and durability on lesser-known species are required. Researchers should also provide this information to architects, building contractors and other consumers for future consumption. Promoting substitute-building materials is important for conservation purposes and reducing pressure on the existing forests as results of a high demand of sawnwood. is study covered sawnwood consumption and substitution in windows and doors and its link to environmental conservation in Dar es Salaam city only, more researches on sawnwood consumption, substitution and the e ect to the environment in the entire building and construction sector is necessary for future development of forest sector in Tanzania.

Acknowledgement

The authors would like to thank the research sponsors – the Belgium JRYHUQPHQW WKURXJK %7& ZKR VSRQVRUHG WKH ¿HOG ZRUNV 6RNRLQH 8QLYHUVLW\ RI $JULFXOWXUH DOO UHVSRQGHQWV JRYHUQPHQW RI¿FLDOV DW GLVWULFW UHJLRQDO DQG QDWLRQDO levels in Dar es Salaam for their willingness to provide valuable information which made this study successful. The authors would also like to thank different reviewers for their comprehensive comments at the early stages of preparing this paper. It is not possible to mention everyone here but we assure you that all the contributions were valuable and appreciated.

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