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EVALUATION OF EFFICIENCY OF IN THE SAWN TIMBER VALUE CHAIN IN KENYA



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Evaluation of Efficiency of the Sawn Timber Value Chain in Kenya

Joshua K. Cheboiwo, Anthony Macharia and Jonah Kiprop

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ACRONYMS AND ABBREVIATIONS

AFF	African Forest Forum
CENAREMA	Centre for Natural Resource Management
CFAs	Community Forest Associations
DEA	Data Envelopment Analysis
DMU's	Decision Making Units
EMCA	Environmental Management and Co-ordination Act
FAO	Food and Agriculture Organization of the United Nations
FCMA	Forest Conservation and Management Act 2016
FFPOs	Forest and Farm Producer Associations
FFSPAK	Farm Forestry Small Producers Association of Kenya
FGD	Focus Group Discussions
GoK	Government of Kenya
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KIIs	Key Informant Interviews
MECCF	Ministry of Environment Climate Change and Forestry
MENWR	Ministry of Environment Water and Natural Resources
NFP	National Forest Programme
NGOs	Non-Governmental Organizations
NPOs	Non-Profit Organizations
PFM	Participatory Forest Management
SCP	Structure Conduct Performance
SDF	State Department of Forestry
SEA	Strategic Environmental Assessment
Sida	Swedish International Development Co-operation Agency
UN	United Nations

EXECUTIVE SUMMARY

The sawn timber value chain is an important subsector within the forestry sector that provides sawn timber to the construction industry and provision of employment opportunities, among other benefits. Despite its critical role, the sawn timber value chain has faced numerous challenges including use of poor-quality germplasm resulting in low productivity, wrong species to site matching, poor silvicultural management practices, poor management of public plantations, high transaction costs, poor infrastructure in tree growing areas, use of inefficient processing technologies, and low investments across the value chain. These challenges have led to increased losses and wastage of forestry resources.

This study, funded by the Swedish International Development Co-operation Agency (Sida) and implemented by the African Forest Forum (AFF) assessed the efficiency of the sawn timber value chain in Kenya. Specifically, the study focussed on understanding the sawn timber value chain, assessing efficiency across the value chain, analysis of industrial roundwood material availability and how to improve sustainability of supply, assessment of governance structures, as well as other factors influencing the value chain. A mixed method approach was applied in the study. Data was collected from various sawn timber value chain actors who were categorized into seed and seedling producers; tree growers; harvesters; transporters; sawmillers and traders. The study used market surveys, Key Informant Interviews (KIIs), and Focus Group Discussions (FGDs) to obtain requisite information and data from the actors. Additional information was gathered through literature review. Data Envelopment Analysis (DEA) approach was used to assess efficiency of the various operations across the value chain.

Findings indicate that commercial tree seed collection, processing, and packaging was mainly done by the Kenya Forest Research Institute (KEFRI), with a few local seed collectors operating at low scale, mainly for propagation of indigenous tree species. In respect to access to tree seed and germplasm, 70% of the sampled nursery operators obtained their seed from KEFRI, 25% from local collectors, and 3% got them from other tree seed sources. A few large scale private roundwood producers imported high yielding commercial species germplasm such as Eucalyptus from South Africa. For instance, imported eucalyptus germplasm from South Africa by private companies have realized productivity of up to 400 m^3/ ha as compared to an average productivity of approximately 100m^3/ha realized by local actors.

Tree seedling production was mainly undertaken by Kenya Forest Service (KFS), KEFRI, in addition to over 300 registered tree nurseries spread across the country. Roundwood production for sawn timber was mainly undertaken in public forest plantations by KFS with plantations covering over 135,000 ha, private companies in mainly tea estates, small and large-scale tree growers with land forests covering over 100,000 ha. The most preferred commercial tree species grown for sawn timber by sampled tree growers was eucalyptus (28.57%), cypress (14.29%), grevillea and pine (4.76% each). The tree growers also grew more than one species in their farms, with a mix of eucalyptus and cypress accounting for 23.81%, eucalyptus and grevillea (9.52%) while farmers who planted eucalyptus, cypress and grevillea together were approximately 6%.

Efficiency analysis of sawn timber production using DEA indicates that large scale tree growers had higher efficiency than the smallholder tree growers. This is attributed to economies of scale and adoption of improved technologies for establishment and management of their enterprises. Roundwood harvesting on smallholder farms was mainly done by hired powersaw operators. Large companies and sawmillers on the other hand had invested in their own power saws,

haulage, and transportation trucks to reduce on the cost of harvesting and haulage. Efficiency assessment on the sawmills revealed that large scale sawmillers were more efficient as compared to the smaller ones. This was attributed to their investment in modern efficient equipment such as twin band saws and wood mizers as compared to the small and medium scale operators that mainly relied on powersaws and bench saws that have a relatively lower recovery rates.

Assessment of roundwood availability and sustainability indicated that the country mainly relies on public plantations, supply from private companies and farmlands, as well as imports from East and Central Africa to meet its timber demands. The governance arrangement in the sawn timber value chain revolves around public entities and private sector players. Kenya Forest Service (KFS) is the public agency mandated to manage forestry operations in the country such as registration of sawmillers and issuance of felling and movement permits for forestry products. Kenya Forestry Research Institute is mandated undertake research on forestry and allied natural resources, collect, process, and package tree seeds and develop superior germplasm for improved tree productivity in the country. The county governments are mandated to coordinate forestry operations within their counties such as offering extension services and forest products movement permits within the county borders. They are also in charge of managing community forests held in trust by the counties. There also exists several cooperatives and associations such as the Farm Forestry Smallholder Producers Association of Kenya (FF SPAK) that aggregate farmers, train them, as well as offer linkages to technologies, advisory and finance services.

In conclusion, efficiency along the sawn timber value chain was generally low, driven by use of low recovery rate equipment such as the power saws and bench saws to process timber. Farmers also did not apply appropriate silvicultural management practices when setting up their commercial forestry plantations. Aggregating smallholder tree growers into associations and capacity building them on tree production for sawn timber, appropriate species for the different agro ecological zones, access to finance and technologies to harvest, process, and season timber are some of the interventions that could be adopted to improve efficiency across the value chain as well secure environmental sustainability due to prudent use of forestry resources.

1. INTRODUCTION

1.1 Background Information

Forestry is an important sector that contributes to Kenya's economic, environmental, and sociocultural development (CENAREMA, KFS & FAO, 2020). It plays a critical role in the provision of primary raw materials for industry, employment creation, as well as provision of ecosystem services (Kenya Forest Service, 2020). The sector contributes approximately 3.6% to Gross Domestic Product (GDP) through revenue generation, wealth creation, and direct subsistence use, excluding provision of ecosystem services in the country (FAO, 2016; GoK, 2015). This sector employs over 50,000 people directly and another 300,000 indirectly (Cheboiwo et al., 2018; Kenya Forest Service, 2020) while also supporting over 530,000 people in forest dependent communities for cultivation, grazing, fishing, fuel, food, honey, herbal medicines, water, and other benefits (Kenya Forest Service, 2020). The forestry sector also supports other productive sectors such as agriculture, fisheries, livestock, energy, water, construction, tourism, and trade which are key sectors of the economy (GoK, 2015).

Forestry activities in Kenya revolve around public, community, and private forests covering up to 4.18 million ha (KFS, 2013). Public forests encompass both plantation and natural forests. Public plantations cover over 120,000 ha. They are managed by the Kenya Forest Service (KFS) exclusively for domestic supply of wood materials. The main commercial species grown in public plantations are cypress which occupy approximately 55% of the total land area, followed by pines (22%), eucalyptus (14%) and other species (7%) (MENWR 2013). The natural forests on the other hand are maintained for biodiversity conservation and provision of environmental services.

Private and community forests cover approximately 3.04 million ha. They are managed by private landowners and other entities for aesthetic and commercial purposes . These forests are mainly managed for the provision of wood products, mainly transmission and construction poles, fuelwood, and sawn timber (UN Environment, 2017). The main tree species grown in these forests are those of eucalyptus, Grevillea robusta, cypress, pines, casuarina, Acacia mearnsii (Black wattle) and many indigenous species both planted and naturally growing. The distribution of different forest types in Kenya is as in Table 1.

Table 1: Forest types in Kenya (in hectares)

Type of forest	Public (gazetted)	Private and community-owned	Total
Natural forests	905,000	2,945,000	3,850,000
Plantations	120,000	72,000	192,000
Bamboo forests	71,000	15,000	86,000
Mangrove forests	1,000	9,000	10,000
Total	1,097,000	3,041,000	4,138,000

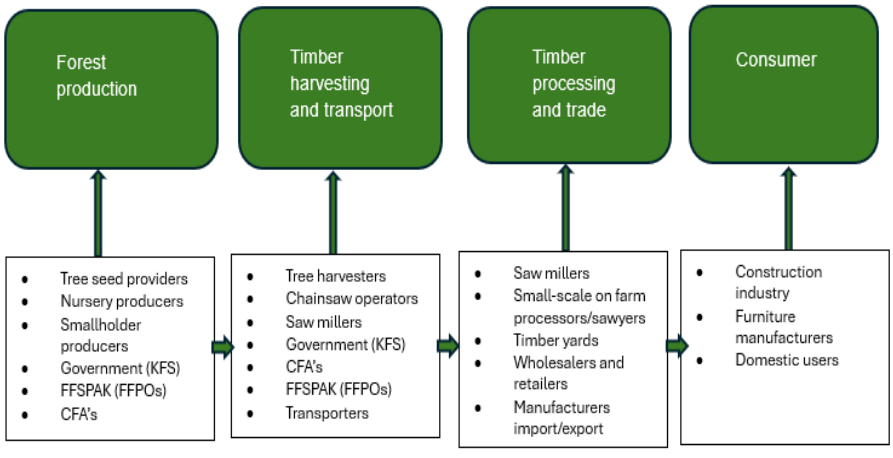
(Source: Kenya Forest Service, 2013)

Over time however, forestry resources in Kenya have continued to face increased pressure from human induced activities including urbanization, agriculture expansion, and infrastructural development (FAO, 2016; UN Environment, 2017). The Kenyan population is expected grow at a rate of over 2% per year over the next two decades, this may lead to increased conversion of forested lands to support production of food commodities as well as provide accommodation spaces (GoK, 2020). Similarly, the demand for forestry products such as timber for construction and other uses is also expected to increase to support the construction industry. The ongoing timber harvesting moratorium imposed on public plantations in 2018 has also increased harvesting of trees on farms as well as imports from neighbouring countries to meet the deficit. An assessment of wood demand and supply by the Ministry of Environment in 2013 indicated that the country had a wood supply potential of 31.4 million m^3 against a national demand of 41.7 million m^3 with the deficit expected to increase gradually over the next 20 years (GoK, 2015).

The forest sector in Kenya is characterized by inadequate financing, use of low-quality germplasm, inappropriate species to site matching, poor silvicultural management practices, inefficient processing technologies, as well as use of old and obsolete machinery, all of which combine to affect realization of optimal returns. These handicaps have a knockoff effect on the timber/wood industry and sawn timber value chain, hence the need for increased initiatives that support increased productivity, improved silvicultural management practices, efficient harvesting and processing technologies, as well as improved marketing conditions.

1.2 Sawn timber value chain in Kenya

Sawn timber production in Kenya is undertaken in public forest plantations, farmlands, and community forests. The major sawn timber species in the country are cypress, pine, eucalyptus, and grevillea. The sawn timber value chain involves various actors engaged in forest production, timber harvesting, haulage, timber processing, trade, and consumption of finished products. The relationship between the actors is as depicted in Figure 1.



Source (Author's conceptualization).

Figure 1: Sawn timber value chain in Kenya

1.3 Project overview

This study on evaluation of efficiency of the sawn timber value chain in Kenya is part of a wider continental study under the project “Strengthening management and use of forest ecosystems for sustainable development in Africa” implemented by the African Forest Forum (AFF) through funding from the Swedish International Development Co-operation Agency (Sida). The overall goal of the project is “to generate and share knowledge and information through partnerships in ways that provide inputs into policy and decision-making options and capacity building, for improved forest management that better addresses poverty eradication and environmental protection in Africa”.

One of the key project objectives is to enhance the capacity of key stakeholders to sustainably manage the forest resource base in ways that enhance the supply of ecosystem goods and services, including through approaches and technologies that increase efficiency in the use of forest and tree resources.

1.4 Purpose of assignment

This study assessed the sawn timber value chain, with the aim of identifying how to improve efficiencies at its various levels, including the necessary capacity building requirements for key actors in the value chain. Recommendations from this study will contribute to designing strategies for improving efficiency of the sector as well as securing sustainable industrial roundwood production for the country.

1.4.1 The specific tasks for the assignment were as follows:

a) Map the sawn timber value chain from industrial roundwood raw material base, through harvesting/logging, processing, drying, to sale as sawn timber sourced from selected forests, including identifying the range of actors at the various levels in the value chain.
b) Undertake efficiency studies on various operations in the value chain including, harvesting/logging, log transport, sawmilling operations, sorting, and drying of sawn timber, marketing and trade in sawn timber: detailing the product flows, productivity, technologies used and transaction costs at each step from logging to sale of sawn timber.
c) Assess the industrial roundwood material availability and ways to make it meet demand for sawn timber on a sustainable basis.
d) Identify the governance structures at each level of the sawn timber value chain, how they operate and how they can be made more efficient.
e) Explore other determining factors and approaches (institutional, financial, policy, and others) that constrain efficiency and/or could be employed for increased efficiency at various levels of the sawn timber value chain.
f) Provide recommendations for improving the sawn timber value chain in ways that are environmentally, socially and gender inclusive.

2.0 LITERATURE REVIEW

2.1 Sawn timber value chain in Kenya

As far back as 1930's forest experts had initiated trial establishment and piloting of exotic plantation species due to the inability of natural forests to sustainability supply sawn timber in the long run. However, the country continued to rely on timber extracted from natural forests until the 1970's on maturity of industrial plantations. In 1986, the country banned harvesting in natural forests, making 90% of industrial wood to be sourced from industrial plantations, thus natural forests were left to be strictly for provision of ecosystem services. Plantation forest area in the 1980's peaked at 174,000 ha, that has since fallen to approximately 120,000 ha by 2020, exclusively managed for domestic supply of wood materials (KFS, 2013). The management of public plantations in Kenya has however witnessed its fair share of challenges, key among them being their mismanagement and unsustainable harvesting.

These have led to government interventions from time to time through imposition of timber harvesting moratoriums (2002-2012 and 2018 to present) to prevent decline in the country's forest cover. To bridge the supply gap, private forest plantations, now estimated to cover over 100,000 hectares spread across the country have emerged as major source to complement the supply of sawn timber in the country.

The sawn timber value chain activities include roundwood production, harvesting, transportation, processing, and marketing. The production component was for a long time dominated by Kenya Forest Service (KFS), at almost 80%, with the rest being supplied by large scale individual tree growers, smallholder tree growers, private companies, and cooperatives. However, the frequent imposition of bans and moratoriums in harvesting in public plantations has increased the roles of the private sector players and imports of timber from Tanzania, Democratic Republic of Congo (DRC), and other countries (Kagombe, *et al*., 2020, Cheboiwo *et. al.,*2018; Lukumbuzya & Sianga, 2017;).

Harvesting of roundwood for sawn timber is mainly undertaken by crews of power saw operators hired by sawmillers and tree growers (Muthike *et al.*, 2010); All Africa, 2022). Most of the haulage operations are undertaken by large scale sawmillers who transport the logs to their sawmills often located far from the harvesting sites, whereas small scale operators deploy portable power saws and tractor drawn bench saws for on farm sawing thus saving on haulage and transportation costs. Haulage by large-scale sawmillers is mainly done by skidders, haulage trucks and associated machinery, mostly owned by the companies or sometimes contracted from individual providers. Small-scale operators mainly rely on manual labour and small farm machinery for skidding and loading and use general purpose trucks for transporting roundwood and timber to their premises (UN Environment, 2017).

Sawmillers in the country were categorized into large, medium, and small scale based on KFS classification. Large scale sawmillers have a sawn timber production capacity of over 20 m^3/day. Medium scale sawmillers have a capacity of between 10 and 20 m^3/day while

the small scale sawmillers have a sawn timber production capacity of less than 10 m^3/day (Muthike & Githiomi, 2017). Roundwood processing in the country is mainly done by sawmillers on large scale. By 2018 there were 712 sawmills registered in the country of which (40 large, 168 medium and 504 small) were prequalified by the KFS (Cheboiwo, 2016). In addition, there are thousands of power saws and hundreds of bench saw operators scattered across the country processing logs mostly from farms. Bench saws are common in areas where roundwood is available in large quantities and readily available. However, most of these sawing systems have been found to be inefficient thus indirectly contributing to low recovery and wastage (Muthike *et al.*, 2010). Large established timber processing sawmillers use gang or band saws and wood mizers which have relatively high recovery rates.

Transportation of timber depends on distance; for shorter distances it is usually done by tractors and animal drawn carts, whereas for longer distances lorries and large trucks are hired to deliver to various urban towns. Sawn timber transportation is mainly done by truckers who are hired per kilometre or per load for their services. According to the Kenya forests harvesting rules of 2009, revised in 2012, timber transportation requires a movement permit and certificate of origin issued by Kenya Forest Service, (GoK, 2009). Most sawn timber is delivered by merchants to timber wholesalers and retailers mostly located in urban areas. Sawn timber distribution channels are influenced by various factors, including types of marketers, volume of trade, and modes of transport (Cheboiwo *et al.*, 2017). An example is that small quantities of sawn timber are directly purchased from timber merchants while large quantities are purchased from large millers. Large sawn timber wholesalers are mostly located in urban areas where demand for sawn timber is high. Table 2 provides a summary of the key actors in the sawn timber value chain in Kenya.

Table 2: Key actors in the sawn timber value chain in Kenya.

Value chain activity	Main actors
Input suppliers	Agro dealers (fertilizer, fungicides, herbicides etc.), tree seed suppliers, nursery operators
Roundwood production	Kenya Forest Service, private sector companies, tree grower associations, and individual tree growers
Harvesting and transportation	Forest owners, contract harvesters, timber merchants, machine operators, transporters
Roundwood processing	Sawmillers, power saw operators, bench saw operators
Marketing	Distribution merchants, retailers, wholesalers, and brokers
Consumption	Construction contractors, furniture makers, individual users
Regulators and facilitators	National and county governments, KFS, KEFRI, research organizations, NGOs, financial institutions

2.2 Efficiency of the sawn timber value chain

Efficiency of the sawn timber value chain is influenced by various factors including quality of seedlings planted, land site index, species to site matching, silvicultural management practices, harvesting/ logging technologies, sawmilling technologies, integrated utilization, and manpower skills (UN Environment, 2017). The use of certified quality seeds and seedlings appropriately matched to sites coupled with the recommended silvicultural management has a direct positive effect of tree productivity (Njuguna, *et al.,* 2021). Proper harvesting and hauling technologies influence the quantity and quality of sawn timber (Acar, *et al.*, 2003). Adoption of efficient sawmilling technologies improves the recovery rates and quality of timber (UN Environment, 2017).

Proper technical/ vocational, as well as business management skills to both the staff and management of sawmillers improves on the quality of work, recovery rate of the machinery, reduces time wastage while also contributing to the safety of workers. Value addition and preservation of sawn timber through seasoning and treatment improves longevity and the value of the timber. Utilization of by products such as sawdust and wood shavings for other productive activities such as drying of sawn timber, or bioenergy production increases the revenue of the business as well as value of the timber (Rominiyi, *et al.,* 2017). All these factors jointly contribute to improving efficiency along the sawn timber value chain through their effect on recovery rates, time and cost saved, increasing the duration and value of sawn timber, improving safety of workers among others.

Sawmilling in Kenya is done using different methods with varying efficiencies. Timber processing in the country is mainly done using bench saws, circular saws, multi band saws, power saws as well as wood mizers (Kagombe, *et al*., 2020; MoEW&NR, 2013). Several studies on recovery efficiency indicate that power saws on average result in 20% timber recovery rate, tractor mounted saws (29.5%), two-man pit sawing (39.9%), circular saws (40.1%) and band saws (46.1%), (Muthike *et al*. (2009), Cheboiwo & Githiomi, 2012; Ototo & Vlosky, 2018).

Wood Mizer equipment have better recovery rates ranging from 50-55% (Cedamon, Herbohn, & Harrison, 2009). Other innovations include KEFRI modified framed chain saw and multi blades technologies that can improve recovery up to 50% especially on small diameter logs which are prevalent among smallholder tree growers (Muthike and Githiomi, 2017; Marfo, 2010). Investment in efficient wood harvesting and processing technologies is essential in the sector through its effects recovery rates and output from the limited roundwood available in the country.

2.3 Industrial roundwood material availability and sustainability

For the last 50 years most of the industrial roundwood in Kenya was sourced from public plantations. However, frequent moratoriums have locked out sawmillers from state forests leading to scaling down or closure thereby opening opportunities for private forest product suppliers and imports into the country.

Currently most sawmills face roundwood supply related challenges including increased distances to the tree sources, decreasing volumes, high delivery costs, and poor quality (Muthike & Githiomi, 2017).

To fill the national timber deficit, Kenya has increased imports of both exotic and hardwood timber from East and Central Africa. Estimated annual sawn wood demand is 420,000 m^3 (Lukumbuzya and Sianga, 2017). Between 2009 and 2013, Kenya imported approximately 83,729 m^3 of hardwood timber from DRC and 192,279 m^3 of softwood timber from Tanzania (Cheboiwo, 2015).

Imports of both hardwood and exotics from Tanzania, DRC, Uganda, and other COMESA countries has been increasing over the years due to reduced cost of importation. Kenya has been exporting value added manufactured wood products such as plywood, block-boards, hard-boards, chipboards, carvings, paper tissues and furniture components to countries in East and Central Africa.

2.4 Governance structure of the sawn timber value chain

The Kenya government has continued to improve the policy, legal, and institutional frameworks to support forestry sector development in Kenya (Cheboiwo, 2018). Key among them are the Forest Conservation and Management Act (FCMA 2016) that outlines some economic incentives, provides for establishment of forest fund for promotion of conservation and commercial forestry, among others. The Public Private Partnership Act (2013) provides guidelines for public-private partnerships including forest concessioning. The Community Land Act 2012 outlines procedures for investment in natural resources on community lands. Further, a draft Forests Policy 2020, the Agriculture Act 1986 revised 2012 and the Farm Forestry Rules 2009 place some obligations to landowners on attainment and maintenance at least 10% tree cover in all agricultural landscapes in the country.

The timber value chain that includes harvesting, processing, and transportation of forestry products is well articulated in the Forest Conservation and Management Act 2016 (FCMA 2016). This Act established the Kenya Forest Services that is mandated, among other things, to conserve, protect, and manage all public forests in Kenya; prepare and implement management plans for all public forests, as well as community and private forests in consultation with landowners and county governments.

FCMA 2016 allows for co-management of public forests by KFS, and Community Forest Associations (CFAs) participation in forest governance through legally recognized community forest associations registered through the KFS. There are 670 Community Forestry Associations adjacent to forest stations across the country. KFS is responsible for issuing harvesting and movement permits for roundwood and sawn timber in the country (GoK, 2009). The county governments are responsible for issuing trading licenses to sawmillers and sawn timber merchants, as well as providing extension services to various forest owners (Gachanja and Mwaniki, 2021).

2.5 Other factors influencing the sawn timber value chain in Kenya.

The forest resource extraction is highly regulated in Kenya and is characterised by high level of interference and rent seeking that has hampered attracting and maintaining investors in the sector. Several checks, including interceptions of vehicles transporting forest products, result in increased transaction costs to actors who in turn load the same to consumers, thus making the sector less competitive. The sector also attracts less funding from government and donors, hence cannot fully implement key policies and legislations such as the National Forest Programme (NFP) and the FCMA 2016.

Further, county governments experience financial constraints to employ forestry professionals to undertake devolved forestry functions such as forest extension, licensing, and supervision of forest industries and traders (Muthike & Githiomi, 2017). Other factors include inadequate guide standardization measures used in commercial harvesting and sale of trees on farm that make it difficult to standardize valuation of trees (Anyonge *et al.*, 2011). There is also information asymentry among actors where traders have more information on prices, quality and volumes of timber as compared to producers thus disadvantaging them during the negotiation process (Carsan & Holding, 2006).

2.6 Conceptual framework

This study adopted a combination of the New Institution Economics (NIE) and Structure Conduct Performance (SCP) frameworks which allow for a comprehensive analysis of the incentive structure embedded in social, physical, and institutional environment in which the value chain actors operate and the relationship between them as depicted in Figure 2. The value chain actors were categorized into three levels, Macro (influencers), Meso (supporters) and Micro (players).

There is also direct interrelationship between resource allocation for value chain activities, conduct, governance, and value chain performance. The micro level actors receive value chain support from the Meso level actors (information, extension, training, mentorship, research and development and technology provision) which are critical to value chain performance. The macro level environment (institutional and policy) offers strategic guidance to the other components of the value chain. The framework was adopted to understand the value chain actors, their interactions/ relationships and how they influence the sawn timber value chain performance in the country.

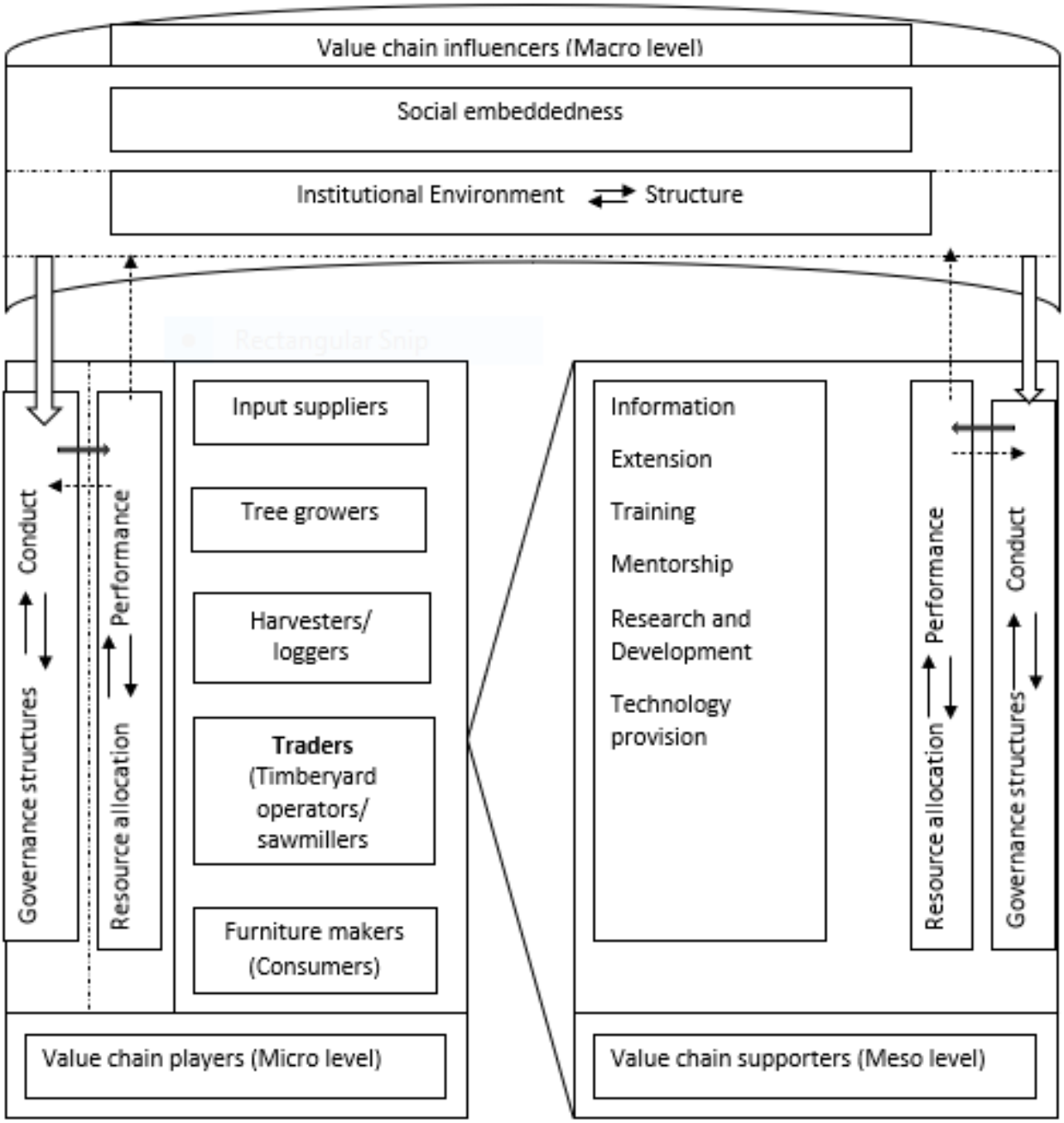


Figure 2: Conceptual framework for the sawn timber value chain in Kenya
Source: Adopted from (Jordaan *et al.*, 2014)

3. METHODOLOGY

3.1 Data collection and description of study sites

Predesigned and tested questionnaires were used for primary data collection. Data was collected from 128 actors across the sawn timber value chain as shown in Table 3. The study was undertaken in seven regions of Kenya (Nairobi, Central, Eastern, Rift Valley, Western, Lake Basin and the Coastal region) where production and consumption of sawn timber forest products is highly concentrated. Data was collected from various actors across the sawn timber value chain including roundwood producers, producer associations, loggers/harvesters, transporters, traders/ merchants, and sawmillers.

Key informants interviewed included representatives of farmer producer organizations including Nyandarua and Kwale tree growers' associations, county government officials, national government officials (KEFRI and KFS), and cooperatives involved in commercial forestry. Data collected focused on understanding the structure of the value chain, and this included information on main species grown for sawn timber, quantities harvested, production technologies used, pricing and marketing of roundwood, harvesting and haulage technologies, wood processing technologies, supply and demand of sawn timber products, governance structures, constraints, and opportunities to value chain upscaling in the country.

Secondary data was collected through desktop review of literature from published articles, periodicals, and reports. Key informant interviews with representatives of the value chain actors were undertaken to further corroborate findings from survey and to understand the key issues affecting the performance of the sector. Finally, two focus group discussions were conducted in Central and Rift Valley regions with all representatives of value chain actors to understand cross cutting issues across the sawn timber value chain.

Table 3: Number of respondents interviewed.

Region	Towns	Roundwood producers/ Tree growers	Tree Producer organizations	Sawmillers	Sawn wood traders/ merchants	Total
Nairobi	Nairobi	-	-	-	3	
Coast	Kwale	-	1	-	-	
	Mombasa	-	-		6	
Lake Basin	Kisumu	-	-	-	3	
Western	Bungoma	-	-	-	1	
Rift Valley	Uasin-Gishu	20	-	10	3	
	Nakuru	15	-	8	4	
Central	Nyandarua	25	1	3	3	
	Kiambu	15	-	-	2	

Region	Towns	Roundwood producers/ Tree growers	Tree Producer organizations	Sawmillers	Sawn wood traders/ merchants	Total
Eastern	Machakos	-	-	-	3	
	Kitui	-	-	-	2	
Sub Totals		75	2	21	30	128

3.2 Data Analysis

A combination of different methods was used for data analysis where joint stakeholder mapping was used to list all the value chain actors, their locations, roles in the value chain and relationships among them. The Data Envelopment Analysis (DEA) was used to assess efficiency of the sawn timber value chain among growers, sawmillers, and traders. This information was enriched through observation and descriptive statistics on the various technologies used to conduct different value chain operations (production, harvesting, processing, and marketing). Review of industry reports, policies, and initiatives that promote commercial forestry in the country was used to understand and document industrial roundwood material availability and ways to make it meet future sawn timber demand on a sustainable basis. Qualitative analysis techniques such as participatory ranking were used to identify the governance structures, determine how they operate, and how to make them more efficient, as well as identification of other factors that constrain efficiency across the sawn timber value chain and ways to improve them.

3.2.1 Description of the Data Envelopment Analysis (DEA) model

The DEA is a non-parametric method used to measure the efficiency of Decision-Making Units (DMUs) using multiple inputs to outputs configurations. The model estimates an efficiency frontier by comparing the best performance observation (extreme points) which "envelop" the remaining observations using linear programming techniques. Efficiency can thus be defined as the ratio of produced outputs to the used inputs.

$$\boldsymbol{Efficiency} = \frac{\boldsymbol{Outputs}}{\boldsymbol{Inputs}}$$

An inefficient unit can become efficient by expanding products (outputs) keeping the same level of used resources, or by reducing the used resources while maintaining the same production levels (Charles & Kumar, 2013).

We split the model into three classes (tree growers), sawmillers, and traders. For tree growers, inputs used in the DEA model were the cost of plantation establishment and management per hectare (KES) while output was timber yield (m^3/ ha). Sawmillers were categorized into small, medium, and large-scale categories. Inputs for the sawmillers were the cost of sawlogs at the mill (USD/m^3), annual running and maintenance cost of equipment (USD) and the cost of labour (USD) while the output was sawn timber output in m^3/day. Inputs for sawn timber merchants were price of sawn timber (USD/m^3), cost of transportation per cubic meter of logs, and the cost of doing business (permits/ licenses, rents etc). The inputs and outputs were computed and fed to the DEAP model where efficiency scores for tree growers, sawmillers, and traders (timber merchants) were computed.

4. RESULTS AND DISCUSSION

4.1 Sawn timber value chain in Kenya

The sawn timber value chain in Kenya is composed of various actors who undertake different activities across the value chain. These actors include seed producers, seedling producers, tree growers, loggers, transporters, millers, and traders. Specific roles played by the various actors across the value chain is as elaborated in the following sections.

4.1.1 Tree seed production

KEFRI is the dominant agency in tree seed production, processing, packaging, and distribution for certified and general tree seed through its centres spread across the country. KEFRI also trains tree seed collectors across the country to enhance their skills on quality control, processing, and marketing of the seeds. The institute has established tree seed orchards and tree seed stands for production of high-quality tree seeds for the market. The other small holder tree seed producers complement supply of general tree seed mostly to small-scale nurseries. According to the survey, 70% of the sampled nursery operators obtained their tree seeds from KEFRI, another 25% got tree seeds from local collectors, with 3% getting tree seeds from other sources such as importation from overseas suppliers, mostly South Africa and India (Figure 3).

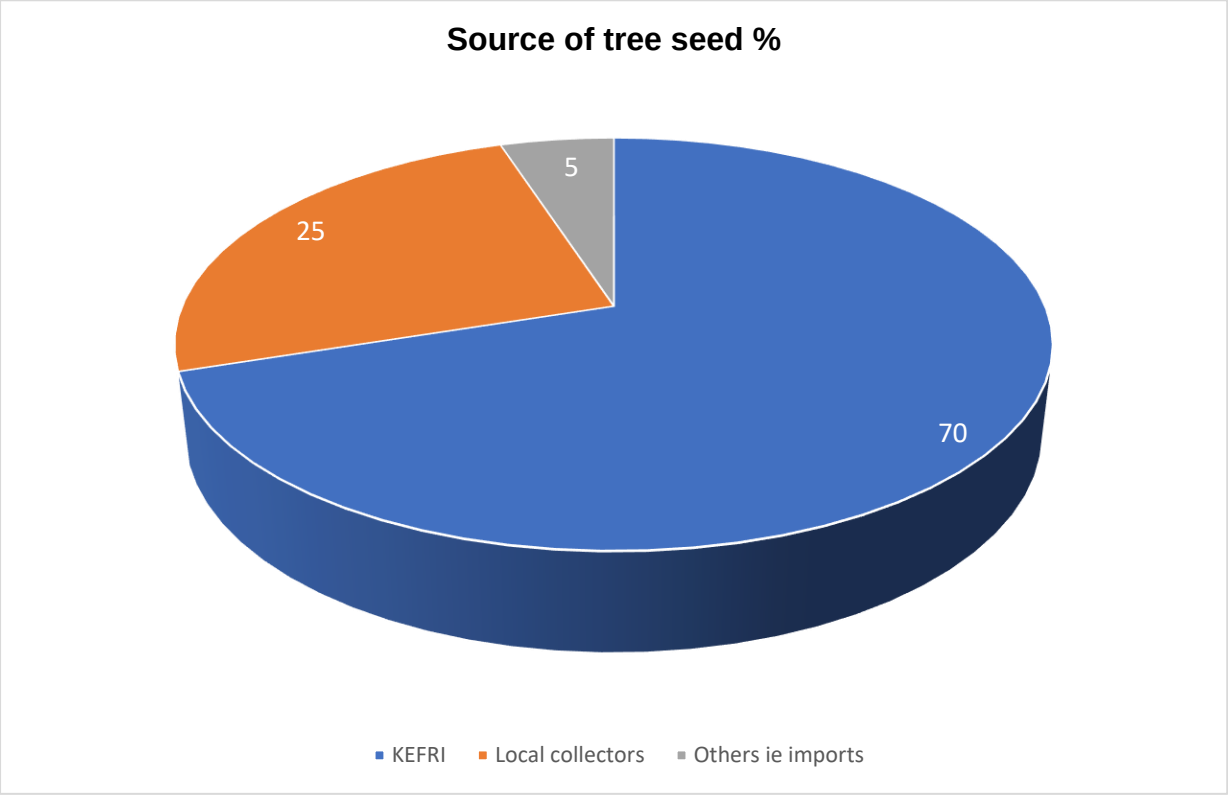


Figure 3: Sources of tree seeds

Photo 1: A commercial tree nursery at KEFRI headquarters Muguga, Kenya

4.1.2 Tree seedling production

The Kenya Forest Service (KFS) and Kenya Forestry Research Institute are the main public institutions involved in mass tree seedlings production for commercial purposes. Other actors in tree seedling production include public institutions such as Kenya prisons service, schools, and colleges. Private small-scale nurseries were the dominant actors for tree seedling production both in urban and rural areas for various purposes. Based on tree grower survey, most of the growers (30%) obtained their seedlings from private tree nursery operators, followed by KFS (25%) and KEFRI (20%).

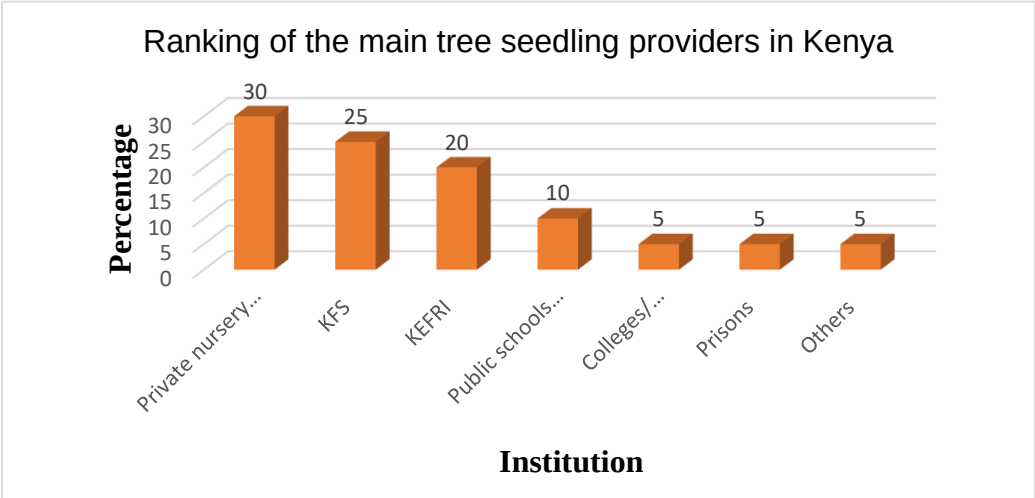


Figure 4: Major tree seedling providers in Kenya

Kenya Forest Service database has 300 tree nurseries spread across the country which produce seedlings for restocking of harvested and/or degraded gazetted forests and for sale to the local communities. KEFRI is in the process of certifying tree nurseries across the country to ensure they conform to required standards in terms of seed sources, quality, and hygiene.

4.1.3 Roundwood production in Kenya

The study revealed that the main commercial tree species grown for timber were those of eucalyptus (28.57%), cypress (14.29%), grevillea and pine (4.76% each). Smallholder farmers grew more than one species in their farms with a mix of eucalyptus and cypress accounting for 23.81%, eucalyptus and grevillea (9.52%) while farmers who planted eucalyptus, cypress and grevillea together were approximately 6% (Table 4).

Table 4: Commercial tree species grown by farmers.

Species	Frequency	%
Eucalyptus	18.00	28.57
Combination of eucalyptus and cypress	15.00	23.81
Cypress	9.00	14.29
Combination of eucalyptus and grevillea	6.00	9.52
Grevillea	3.00	4.76
Pine	3.00	4.76
Combination of eucalyptus, cypress, and grevillea	4.00	6.34
Others	5.00	7.95
Total	63	100

The main players in roundwood production are KFS, private companies, individual large scale tree growers, and smallholder tree growers. The Kenya Forest Service (KFS) is the dominant player in roundwood production through its extensive forest plantations, estimated at 135,000 ha located in various parts of the country (GoK, 2020). It is the major roundwood supplier to large mills in Kenya such as RaiPly, PrimePly, Comply, Timsales, and the over 600 medium and small saw millers spread across the country. It is estimated that there are approximately 100,000 ha of private forest plantations and woodlots in Kenya (KFS, 2014) owned by members of tree producer associations such as FFSPAK, Kenya Forest Growers Association (KEFGA), among others (Cheboiwo, 2018). The private sector is projected to expand the area under commercial forestry by an additional 200,000 ha by 2035 (Gatsby Africa, 2020).

4.1.4 Logging and transportation

The results revealed that large-scale sawmills own a wide range of logging machinery and equipment such as power saws, skidders, loaders, and logging trucks for logging and transportation. Their logging operations are also more organized with specialized teams undertaking the different activities and use digital technology to monitor operations.

Medium and small-scale sawmillers mostly use portable power saws, and farm machinery such as multipurpose trucks and tractors for logging and haulage activities. Most smallholder operators do not have specialized logging and transportation equipment at their disposal. Most of the large and medium operators prefer to invest in their own transportation equipment such as trucks and tractors to reduce costs, as well as improve efficiency in terms of time taken to transport industrial roundwood from the field to sawmills and sawn timber from the sawmills to their client premises. Further, most small-scale operators undertake their saw log conversion activities at/or near roundwood production sites to minimize log haulage costs. The strategy not only cuts costs but maximizes returns through value addition of logs at the farm gate. Logging and log transportation was one of the most expensive operations in the value chain with the cost accounting for between 30 and 40% of the total value (Gatsby Africa, 2020).

4.1.5 Sawmilling

The sawmilling industry consists of over 712 registered mills (Kagombe *et.al.,*2020). The mills deploy a wide range of equipment such as power saws and bench saws with large sawmills equipped with gang saws, band saws and wood-mizers. The saw milling operations annual output was estimated at about 400,000 m^3 (EPZ, 2010), which is equivalent 1,300,000 m^3 of roundwood, out of this, 507,000 m^3 was supplied by public forests with the remainder coming from private and community forests. The high dependence of the sawmilling sector on sawlogs from public plantations led to the collapse of most sawmills during the 1999 – 2012 and 2018 to 2023 logging bans and moratoriums. Currently, most sawmills are operating below capacity since 2018 due to the timber harvesting moratorium. Further, the sector lacks competent and skilled manpower for efficient operations (Cheboiwo, 2012). Despite the current state, most of the sawmills can be rehabilitated into full scale operations, provided there is guaranteed supply of roundwood material in the country.

4.1.6 Wholesaling and retailing of sawn timber.

Wholesalers and retailers are the final actors in the sawn timber value chain who connect the entire value chain to consumers. At the wholesaling and retailing level, actors have the option of selling rough sawn wood or value-added products to spread the income streams and while diversifying risk. Value addition services offered by sawn timber merchants included planning (72%), grooving (67%), moulding (64%), door frame making (58%), door making (45%), timber seasoning/ drying before sale (28%); as well as furniture making (21%) such as tables, chairs, and seats. Other value addition services offered by timber merchants include making of picture rails and scatting services that was undertaken by approximately 12% of the respondents.

4.1.7 Timber value chain support services.

Key agencies and institutions supporting the sawn timber value chain activities in Kenya were KEFRI, KFS, county governments and KEPHIS. KFS licenses all sawmillers for purposes of allocation of public forest plantations, and enforces rules and regulations governing importation, exportation, and trade in forest produce. Through its extension services, the service supports private and individual forests owners through provision of training and technical advisory services on establishment and management of commercial

tree species for sawn timber. KEFRI supports value chain activities through supply of quality tree seed and introduction of new tree germplasm for purposes of commercial species diversification. The institute also develops standards for timber treatment, testing, and grading. The Kenya Plant Health Inspectorate Service (KEPHIS) is responsible for maintaining phytosanitary standards across borders on imports and exports of sawn timber and related forest products to prevent transboundary transfer of pests and diseases. The service is also responsible for certifying tree seeds before they are released to the public. The county governments support the sawn timber value chain through issuance of trading licenses for sawmillers and timber traders operating within the county. A visual representation of the sawn timber value chain in Kenya is as shown in Figure 3. Key actors in the sawn timber value chain are as shown in Table 5.

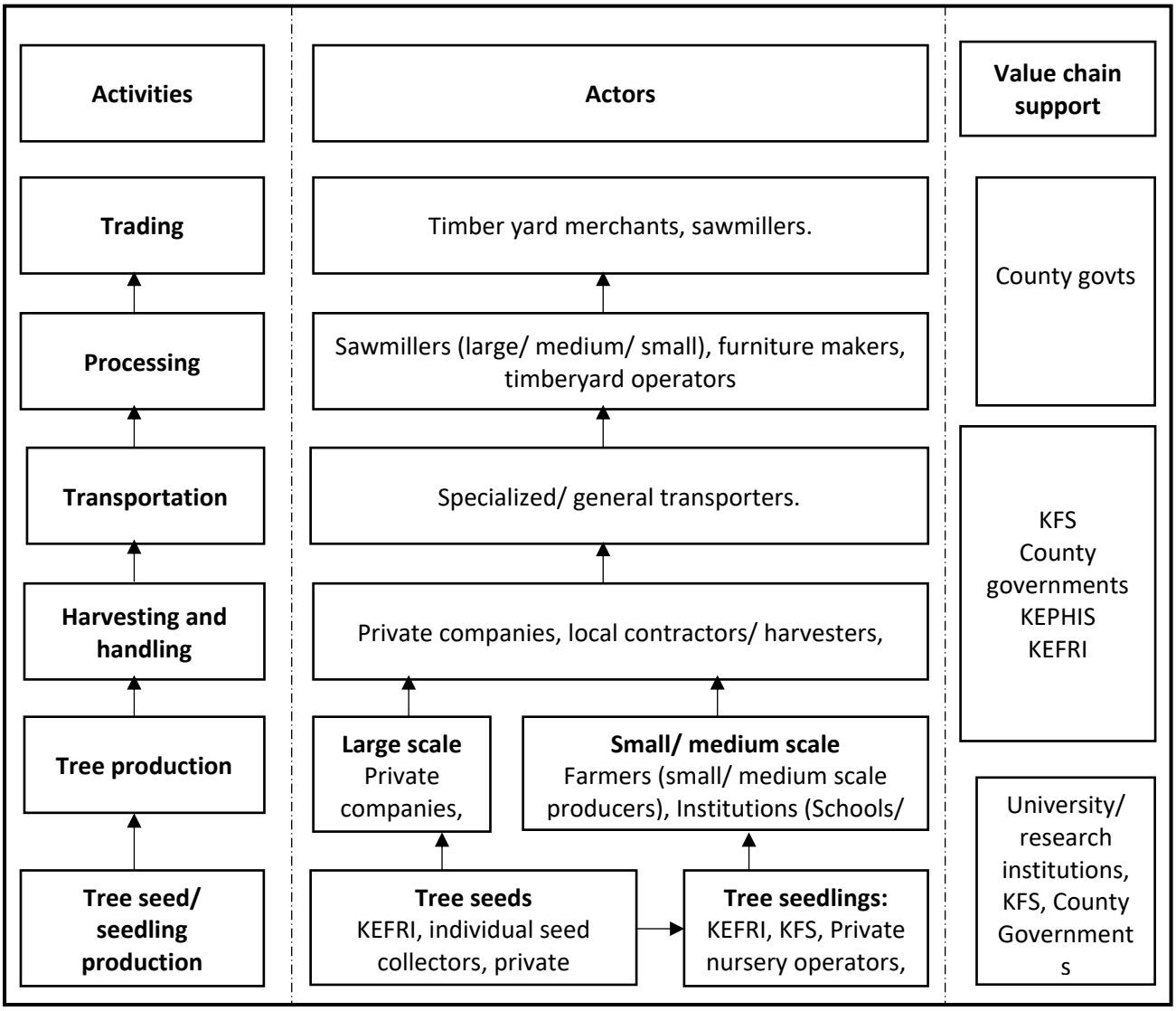


Figure 5:Sawn timber value chain in Kenya

Table 5: Key actors in the sawn timber value chain

Key actor	Roles and responsibility
Input providers	
KEFRI	Provision of high-quality tree seeds and germplasm for sawn timber species Provision of tree seedlings Conduct research on forestry for sawn timber production
Agro input dealers	Provision of agro inputs including fertilizers and chemicals for tree production
Nursery operators	Provision of tree seedlings for commercial forestry
Roundwood production	
KFS	Management and protection of public owned commercial plantations for production of roundwood Prequalification and registration of sawmillers and other forest product-based traders Provision of licenses (movement permits and certificate of origin) Provision of forestry extension services to value chain actors
Smallholder tree growers	Roundwood production for sawn timber
Private companies	Roundwood production for sawn timber
Tree grower associations and cooperatives (KFGAs, FF SPAK, FFPOs)	Roundwood production Capacity building tree growers Lobbying for roundwood producer issues
Harvesting and transportation	
Forest owners (roundwood producers)	Own harvesting of roundwood
Harvesters/ loggers	Offer logging/ harvesting services
Transporters	Offer transportation of roundwood and sawn timber
Local administration (chiefs)	Monitor tree harvesting practices within their locality
County governments	Issue trading licenses for value chain actors Offer forestry extension services to value chain actors
Roundwood processing	
Machinery and equipment suppliers	Supply of machinery for sawn timber processing
Sawmillers	Processing of roundwood to sawn timber Sale of sawn timber Timber processing and value addition services
Kenya Timber Manufacturers Association	Awareness creation among sawmillers on recommended sawmilling practices Lobbying for interests of sawmillers
Social and philanthropic investors (KOMAZA, Gatsby Africa, Better Globe Forestry, etc.)	Training on value chain efficiency Providing improved technology to roundwood producers Financing value chain actors

Key actor	Roles and responsibility
Sawn timber marketing	
Timber yard merchants	Sale of sawn timber Value addition of sawn timber
Cross cutting	
MECCF	Development and implementing policies to support the sawn timber value chain in Kenya
KEFRI	Conduct research on forestry operations including tree establishment, management, and marketing operations
KFS, County governments, universities/ colleges, associations and cooperatives and private entities	Extension services

4.2 Efficiency of the sawn timber value chain in Kenya

Assessment of efficiency of the sawn timber value chain was undertaken using the Data Envelopment Analysis (DEA) for various activities across the sawn timber value chain. Value chain actors were divided into three categories (large, medium, and small scale) to understand how efficiency varied between the three categories. Efficiency analysis was undertaken for tree growers, sawmillers, and traders to understand the variation in efficiency between the different categories of actors.

4.2.1 Efficiency assessment among tree growers in Kenya

Among the tree growers, the DEA model had a single input and a single output. The input was the establishment cost of sawn timber plantation per hectare while the output was volume of sawn timber harvested/ expected to be harvested at maturity in m^3. The approach allowed for accounting for all cost items required to establish and maintain a commercial forestry plantation. Efficiency analysis was done for three main commercial sawn timber species in the country namely eucalyptus, cypress, and pine. The rotation age for eucalyptus for transmission poles was 10 years while that of pine and cypress for sawn timber was 28 years.

The results were relatively similar across the three species with the overall efficiency scores being 0.723, 0.754 and 0.760 for eucalyptus, cypress, and pine, respectively (Tables 6, 7 and 8). Further disaggregation of results revealed that, across the three species, large scale growers had the highest efficiency scores while the small-scale growers had the least efficiency scores. The mean efficiency scores for eucalyptus growing were 0.847, 0.760 and 0.563 for the large, medium, and small-scale growers, respectively, the trend was similar in cypress and pine production too (Tables 6, 7 and 8).

Table 6: DEA efficiency assessment of eucalyptus production in Kenya

Grower category	Observations	Mean	Std. Dev.	Min	Max
Large scale	7.000	0.847	0.162	0.629	1.000
Medium scale	13.000	0.760	0.141	0.609	0.985
Small scale	13.000	0.563	0.111	0.401	0.704
Mean efficiency	0.723				

Table 7: DEA efficiency assessment of cypress production in Kenya

Grower category	Observations	Mean	Std. Dev.	Min	Max
Large scale	6.000	0.911	0.073	0.809	1.000
Medium scale	14.000	0.746	0.032	0.682	0.793
Small scale	6.000	0.613	0.034	0.556	0.660
Mean efficiency	0.754				

Table 8: DEA efficiency assessment of pine production in Kenya

Grower category	Observation	Mean	Std. Dev.	Min	Max
Large scale	5.000	0.924	0.074	0.809	1.000
Medium scale	5.000	0.753	0.044	0.682	0.791
Small scale	5.000	0.604	0.028	0.556	0.632
Mean efficiency	0.760				

These efficiencies were corroborated by field observations where large-scale commercial forestry plantations were mostly managed professionally, using recommended silvicultural practices. Large scale establishments used superior tree germplasm , like Kakuzi holdings who imported their eucalyptus germplasm from South Africa, and most of their operations were also largely mechanized thus reducing their operation cost per unit. They also enjoyed economies of scale when harvesting and selling, thus increasing efficiency even further.

Analysis of the tree seed and seedlings planted by smallholder farmers revealed that in general, most of the farmers planted ordinary seeds (64.94%) and seedlings (77.63%). Some of the reasons for the preference of ordinary seed and seedlings included availability, accessibility, and affordability, due to the lower cost vis a vis the certified seeds, and lack of awareness on the advantages of planting certified seeds (Table 9).

Table 9: Types of commercial tree seeds and seedlings planted by smallholder farmers in Kenya.

Species	Seed				Seedlings			
	Certified (%)		Ordinary (%)		Certified (%)		Ordinary (%)	
	Freq	%	Freq	%	Freq	%	Freq	%
Eucalyptus	9	28.13	23	71.88	10	31.25	22	68.75
Cypress	5	45.45	6	54.55	9	42.86	12	57.14
Pine	1	33.33	2	66.67	0	0.00	3	100.00
Grevillea	1	33.33	2	66.67	2	15.38	11	84.62
Mean (%)	35.06		64.94		22.37		77.63	

The tree growers cited high cost of certified seeds (KES 5000/ Kg) as compared to locally collected tree seed that retailed at between KES 500 – 1000 per Kg to be a hinderance to adoption. The tree nurseries also did not differentiate between tree seedlings from certified and non-certified sources. Seedling prices, in most cases, also did not vary, whether certified or non-certified. Eucalyptus, cypress, pine, and grevillea seedlings retailed at approximately KES 10/ unit while indigenous tree seedlings retailed at KES 1 per unit. The findings indicated that most of the small-scale tree growers did not follow the recommended silvicultural management practices due to technical and financial constraints. Smallholder farmers mostly intercropped trees with other crops, did not plant high quality tree germplasm, and often had little knowledge on proper tree species suited for their agro ecological zones. These factors contributed to their low efficiency levels.

4.2.2 Efficiency of sawing timber in Kenya

The efficiency analysis was done on 5 large scale millers, 6 medium and 9 small scale millers to understand how efficiency varied with the size and scale of operation. In general, the mean aggregate efficiency for the assessed sawmills was low at 0.266 out of the possible 1. Disaggregated results revealed that large scale sawmillers had the highest efficiency rates (0.627) followed by the medium scale (0.200) and the least efficiency was depicted by small scale sawmillers (0.137). (Table 11).

Table 10:Efficiency assessment among sawmillers in Kenya

Sawmill category	Observation	Mean	Std. Dev.	Min	Max
Large	5.000	0.627	0.270	0.413	1.000
Medium	6.000	0.200	0.128	0.043	0.413
Small	9.000	0.137	0.264	0.006	0.827
Mean efficiency		0.266			

This could be attributed to most large scale sawmillers having invested in efficient sawmilling technologies such as the wood-mizers and twin band saws that minimized on wastage unlike the small-scale millers. Large-scale millers interviewed such as Kakuzi and Komaza indicated that they had invested in circular economy models where waste from one process e.g., sawdust, wood shavings, and uneven branches were used as inputs to other processes such as timber seasoning and powering steam boilers, thus increasing their efficiency. The large scale sawmillers had also invested in modern harvesting, haulage/transportation equipment which further reduced the cost of harvesting and haulage. The small-scale millers on the other hand mostly used inefficient technologies such as power saws for harvesting and splitting timber. Rarely did they season the timber, thus reducing efficiency. The results also revealed that most of the sawmillers in Kenya, apart from sawmilling, undertook other complementary functions such as trading, value addition, harvesting, haulage and transportation to maximize their returns and profitability while diversifying risk. This was attributed to the ongoing timber harvesting moratorium which reduced the supply of roundwood thus negatively impacting their business operations.

4.2.3 Assessment of efficiency among sawn timber traders in Kenya

Most of the sawn timber traders interviewed indicated that the supply and quality of sawn timber in Kenya had declined since the introduction of the timber harvesting moratorium in 2018. The supply of cypress roundwood which is mostly preferred for sawn timber was the most affected. Traders in major urban towns of Kenya such as Nairobi, Machakos, Kitui and Mombasa said they relied on imports of pine sawn timber from Tanzania to substitute for the decline in supply of cypress in the country. It was also observed that the reduced supply of roundwood from public plantations led to an increase in the supply of juvenile timber in the market from other sources. The overall efficiency among the sawn timber traders was estimated at 0.744. This, however, varied with the size of the enterprises. Large scale traders had the highest efficiency (0.870) followed by the medium scale (0.814) and finally the small-scale traders at 0.651.

Table 11: Efficiency analysis among sawn timber traders in Kenya

Trader category	Observation	Mean	Std. Dev.	Min	Max
Large	6.000	0.870	0.067	0.811	1.000
Medium	9.000	0.814	0.080	0.691	0.955
Small	15.000	0.651	0.165	0.287	0.886
Mean efficiency		0.744			

We also found out that most of the traders interviewed (70%) performed other complementary functions in the timber value chain such as planning, grooving, door frame making and, in some cases, furniture making. This was done as a strategy to maximize returns and profitability. One key gap that was identified in the value chain was the lack of proper seasoning of timber in the market. Most of the timber sold in the country was not seasoned, with stakeholders indicating that over 80% of the timber sold through the small and medium sawmillers was unseasoned. Seasoning was mainly done through air drying timber under a shade by those who practiced it.

Photo 2: Timber seasoning in a shed at a mill in Nanyuki, Kenya

Equipment mostly used by timber yard merchants were power saws (95%) and the bench saw (80%). According to manufacturers' specifications, this equipment has low recovery rates of between 20 -20% (Muthike et. al., 2009), thus negatively affecting the sawn timber value chain efficiency.

4.3 Assessment of the industrial roundwood material availability and its sustainability

Sawn timber value chain actors were asked state their perception on industrial roundwood material availability in the last 5 years between 2017 and 2022 and propose ways to meet demand for sawn timber on a sustainable basis. Most of the actors stated that the supply and quality of roundwood has been declining over the last 5 years while demand has been increasing. This is attributed to the ongoing timber harvesting moratorium of 2018 that banned all harvesting of roundwood from public plantations and community forests. Before 2018, the economy largely relied on public plantations for supply of its industrial roundwood; however, since the moratorium, sawmillers have been relying on private tree growers, mostly being smallholder farmers.

Increased demand for sawn timber occasioned by population increases and economic growth has led to increased harvesting of juvenile trees for sawn timber production, and this affects the quality of sawn timber in the market. The government has rolled out various initiatives to promote commercial forestry especially on private and community lands in Kenya to increase the supply of sawn timber. Currently, the Kenyan Government has rolled an ambitious plan to restore 10.6 million hectares of degraded landscapes in the country, of which approximately 800,000 ha will be restored through establishment of commercial private forests and restocking of forest plantations in gazetted forests. The government has also lifted the harvesting ban on mature and over mature plantation stock which will see the release of approximately 5000 ha/ year to the market for the next 5 years. This is expected to reduce the deficit in the country's sawn timber demand by adding an extra 250,000 m^3 annually to the country's sawn timber supply; assuming an average yield of 50m^3/ ha on public commercial plantations.

4.4 Assessment of governance structures across the sawn timber value chain

Forest governance refers to existing processes and mechanisms that enable forest stakeholders to have a direct stake in forest resources and be part of decision making in all aspects of forest management, including formulating, and implementing policy and legal frameworks. Some key elements of forest governance include devolution, management structures, transparency, benefit sharing, access to resources, and the protection of the interests of local and indigenous communities as enshrined in the Constitution of Kenya 2010, and other sectoral laws like the Forest Conservation and Management Act 2016 (FCMA, 2016). Public plantations, which for a long time have been the main suppliers of roundwood to the saw milling industry in the country, have been facing enormous challenges leading to their degradation.

Good forest governance is thus critical in addressing not only management issues but also interests from competing sectors such as agriculture and real estate. The dominant player in the sawn timber value chain is the Kenya Forest Service which plays a dual role (roundwood production and a regulator). The Ministry of Environment, Climate Change and Forestry (MECCF) through the State Department for Forestry (SDF) plays an oversight role through development of policies and laws and as well ensuring compliance, not only to national but also global commitments.

The Constitution of Kenya 2010 transferred some roles from the national (central) government (KFS) to the county governments. These roles include offering forestry extension services (advising and assisting communities and individuals in the management of community and private forests), farm forestry activities, as well as promoting afforestation (FCMA, 2016). Other public agencies are involved in facilitating and regulating the sawn timber value chain from production, through to processing, and utilization, depending on their overlapping mandates and operations at both national and international levels.

Participatory Forest Management (PFM) is one of the key governance instruments that articulate co-management of public forests between KFS and forest adjacent

communities, individuals, and other interested groups. PFM offers guidelines on forest management and protection by promoting sustainable forest development through influencing social behaviour and organization of operational structures in forest practice. The main objectives of PFM are to preserve biodiversity while at the same time enhancing people's livelihoods, as well as promoting sustainable use of forests for both the present and future generation (MoENR, 2007). Table 12 summarizes key sectoral legislations and their implication on forest governance in Kenya.

Table 12: Summary of sectoral legislation and their implication of forestry governance

Sectoral legislation	Implication on forestry governance
Forest Conservation and Management Act (FCMA), 2016	• Management of public plantations in Kenya • Promotes Participatory Forest Management • Regulates the harvesting, processing, and movement of forestry products in Kenya
Environmental Management and Conservation Act (EMCA), Cap 387, Laws of Kenya	• Power of NEMA to approve SEA and EIA over forestry activities. • Role of NEMA concerning oversight over national forestry management
Wildlife (Conservation and Management) Act, No. 47 of 2013	• Institutional authority of the KWS over national parks that contain forests
The Energy Act, No. 12 of 2006	• Provision of alternative fuels sources to firewood and charcoal
Agriculture, Fisheries and Food Authority Act, No. 13 of 2013	• Regulation of tree planting and forest establishment on private farmland
County Governments Act, No. 17 of 2012	• Overall establishment and definition of the functions and powers of County Governments, including County Integrated Development Planning and sectoral plans that impact forestry.
Water Act, No. 43 of 2016	• Governance over the management of water resources, and water catchment areas. • Institutional linkage between KFS, County Governments and the WRA on management of water resources.
National Museums and Heritage Act, No. 6 of 2006	• Provides the regulatory framework for management of forest areas that are classified as cultural or natural heritage, including shrines.
Mining Act, No. 12 of 2016	• Provision concerning mining in forest areas.
Land Act, No. 6 of 2012	• Governs the administration of public land

Sectoral legislation	Implication on forestry governance
	including forests. • Sets out the functions of the National Land Commission over management of public land.
Community Land Act, No. 27 of 2016	• Governs the administration of community land, including establishment and management of community forests. • Sets out the functions of community land management structures such as the Community Assembly and the Community Land Management Committee.
Climate Change Act, No. 11 of 2016	• Provides a binding national regulatory framework requiring all sectors, including forestry, to mainstream climate change actions.

There also exists a diverse range of institutions of varying sizes including tea estates, social entrepreneurs, investment syndicates, individuals, and wood-based industries, with interest in tree growing, wood processing, and trade in wood products, largely driven by commercial and business interests. The latest entrants are social- philanthropic enterprises whose philosophy revolves around the concept of Non-Profit Organizations (NPOs). Their primary motive is to invest in people's wealth creation within the forestry and green economy sectors.

4.5 Other determining factors and approaches influencing efficiency

Other factors critical in influencing sawn timber value chain efficiency in the country include:

4.5.1 Policy, legal, and institutional challenges

Tree growers are required to obtain multiple permits/ authorizations from representatives of national government (chiefs), county governments, as well as KFS to obtain tree felling and forest products' movement permits. The cumbersome procedures are costly in terms of time spent and transport costs incurred. Further, such legal instruments open space for additional levies that are charged on operators dealing with forest products at various stages of the value chain, in addition to bribes paid to enforcement agencies along the roads. All these increase the cost of doing business by disadvantaging both producers and consumers as merchants attempt to maintain their profits margins.

Trade in forest products is not well mainstreamed in existing policy and legislation leaving room for abuse by enforcement agencies especially on harvesting, transportation, and marketing nodes. The gaps leave room for various interpretations by the different agencies leading to unnecessary interference with forest products' movement and trade.

This results in higher transaction costs that eventually push up retail prices in selling centers. Apart from VAT and license fees, the enactment of the Constitution of Kenya 2010 brought about two levels of government (National and County) with each imposing its own taxes on natural resources-based businesses and products. This has made the cost of doing business in the forest sector very high, uncompetitive, and discouraging to investors.

4.5.2 Unsustainable management of public forest plantations

Over time, public plantations in the country have been unsustainably managed leading to overharvesting and degradation of forests. Productivity of public plantations also remains low averaging 40m^3/ ha vis-a-vis up to 400 m^3/ha recorded in private plantations. This has led to imposition of various timber harvesting moratoriums in Kenya (2002 – 2012) and 2018 – 2023 that reduce the supply of quality timber to the market thus negatively affecting value chain stability and efficiency.

4.5.3 Roundwood quality

The quality of roundwood directly affects sawn timber quality in the market. It is influenced by several factors, including the type of seed and germplasm, species to site matching, silvicultural management practices, harvesting, haulage, processing, transportation, storage, and seasoning technologies. Since the imposition of the timber harvesting moratorium of 2018, Kenya has been relying on farm forestry for its local supply of roundwood. Most of the trees established under smallholder farm forestry were not professionally grown and managed for commercial purposes. They are thus characterized by various quality issues such as deformities from animal damages, nail wounds, heavy branching, and small diameters. This causes higher rejection rates in the market and discounted pricing thus reduced incomes to producers. Roundwood quality issues contribute to high recovery losses at processing/conversion, thus discouraging investment in the sawmilling sector. There is need of capacity building, especially for smallholder tree growers on tending trees, use of superior germplasm, good spacing, management of the stands, and use of superior processing technologies for improved roundwood quality and increased efficiency along the sawn timber value chain.

4.5.4 High transport costs

Transportation cost is one of the major drivers of inefficiency along the sawn timber value chain in Kenya. Most of the smallholder farmers did not plant trees of their own as pure stands; and in most cases, trees were intercropped with other annual crops. This increased the cost of harvesting, haulage, and aggregation before transport to processing facilities, thus increasing the cost per unit volume of harvested wood. The high transport costs was also contributed by poor road networks connecting production to consumption areas, especially off trunk roads that contribute significantly to delivery prices. For example, transport costs for sawn timber in Nairobi accounted for approximately 45% of the factory gate prices. To internalize the high transportation costs of roundwood and sawn timber, most actors processed the roundwood at site and at low recovery rates that are normally associated with small scale processing equipment/machinery. A good number of traders also had invested in their own general-purpose trucks to transport their sawn timber from the sawmillers' sites to their timber yards.

The trucks could also be hired out to do general transportation and thus supplement their incomes. Good road networks will cut down the share of transport costs that can significantly reduce delivery price and improve tree growers take home incomes. However, general road infrastructure improvement is outside the capacity and responsibility of the industry.

4.5.5 Low incentives for forestry investments

The Forest Conservation and Management Act 2016 provides economic incentives through the establishment of a forest conservation and management fund for commercial forestry. The proposed tax and fiscal incentives are likely to increase investments in commercial forestry plantations and adoption of efficient technologies across the entire value chain. Generally, financing to commercial forestry, especially smallholder farm forestry remains low in the country. A few organizations, such as FAO through its smallholder farm forestry programme is supporting smallholder commercial tree growers by capacity building them on appropriate silvicultural practices, quality tree seeds and seedlings, financing, and marketing. Other organizations, such as Komaza, aggregate many smallholder farmers, provides them with inputs as well as extension services, and eventually purchase their trees when they are mature. There is also need to promote dryland commercial forestry in the Kenyan arid and semi-arid areas (ASALs) that make up over 80% of the total land area in Kenya.

4.5.6 Many players in the sawn timber value chain

Marketing of forest products involves many players that offer services between production to consumption points and each taking a share of the final price. These include growers, loggers, loaders, transporters, brokers, and financiers that are active within the tree product value chain. The longer chain of actors between production and utilization of the sawn timber may be attributed to information asymmetry and excessive regulation of the sector. This leads to unnecessarily additional costs to actors and higher final sales price of the product. Thus, policy and legal reforms should be geared towards reducing the cost of doing business by excluding the need for extra players to facilitate trade in forest products.

4.5.7 Inadequate technical knowledge on commercial forestry

Inadequate technical knowledge on proper establishment and management of a commercial woodlot such as tree nursery establishment and management, recommended silvicultural management practices, species to site matching, pests and diseases, inaccessibility to quality germplasm, seeds, and seeds are some of the limiting factors towards efficiency of smallholder commercial tree growers in Kenya who make the majority of roundwood producers out of gazetted public plantations; this affects their efficiency.

4.5.8 Lack of forest certification

Forest certification ensures that forests are managed in such a way that they preserve biological diversity while ensuring benefits to local people as well as economic viability. Forest certification systems monitor how forests are managed by putting in place mechanisms to label and trace roundwood, timber, and other forest products all the way

to their consumption points. Lack of forest certification disadvantages roundwood producers by limiting their access to high value premium markets thus reducing the incomes derived from forestry operations. Kenya has adopted interim standards for forest certification but is yet to certify any of its forests. This has contributed to an increase in illegal logging in existing forests due to lack of robust chain of custody monitoring systems. The lack of forest certification indirectly influences efficiency since actors do not have incentives to invest in efficient production and processing technologies.

5. CONCLUSIONS

The forestry sector in Kenya has been facing numerous challenges occasioned by high demand for wood products that has impacted on scarce forestry resources. There is need to improve the productivity of forests and efficiency in operations to enhance sustainable use of the forestry resources in the country.

In conclusion, the following key observations were noted;

- The sector is characterized by many value chain actors distributed across the country undertaking various roles along the value chain such as tree nursery operators, tree growers, timber merchants and sawmillers. The actors mainly operate independently with weak linkages among them.
- Efficiency in the sawn timber value chain was found to be generally low, driven by poor quality of germplasm, lack of adequate information on appropriate silvicultural management practices amongst tree growers, and use of inefficient technologies for sawn wood processing.
- In respect to roundwood availability and sustainability of supply, the country has over the years relied heavily on supply from public plantations to meet the growing demand. This has not been forthcoming given the frequent moratoriums that have disrupted the market supply. To bridge the supply gap, the country has relied on imports from neighbouring countries as well as promotion of commercial forestry on private land.
- The country has put in place adequate policy and legislative frameworks to govern the forestry sector. However, gaps exist in development and enforcement of the frameworks to guide promotion of forest certification, chain of custody and traceability systems which are key in enhancing efficiency across the value chain.
- Increasing efficiency at the various levels of the sawn timber value chain from production to consumption will increase the national timber production and improve efficiency of the sawn wood operations.

5.2 Recommendations for improving efficiency of the sawn timber value chain in Kenya

a) Efficient management of public plantations

The productivity of public plantations remains low compared to similar private plantations.

This is attributed to several factors including mismanagement of plantations, lack of proper accounting and valuation of existing stocks, lack of adherence to management plans partly due to government-imposed logging bans, among others. There is need to strictly adhere to management plans as well as proper valuation of existing stocks. Mature plantations should be harvested, and the lands replanted to ensure sustainability of roundwood supply in the country. The country could also adopt innovative commercial forestry plantation establishment models such as lease of bare forest land to private investors for commercial forestry establishment.

b) Promotion of commercial forestry on private and community lands

There is need to promote commercial forestry for sawn timber production in private and community lands to supplement the supply from public plantations. Currently, Kenya has an annual sawn timber supply deficit of more than 10 million m^3 and depends on imports from other East African countries. There is need to incentivize commercial forestry production in private and community lands through developing species suitable for dryland forestry such as *Melia volkensii,* capacity building of actors on species to site matching, as well as development of improved germplasm for adoption by farmers.

c) Strengthening forestry training and technologies:

Actors revealed that there was a general gap in woodworking skills, as well as operation and maintenance of efficient sawmilling machinery in the country. Wood processing technology courses could be mainstreamed in technical and vocational colleges training including certification and recognition of apprenticeship training within local mills. The government should regulate the sector by licensing and recognizing only certified actors.

d) Streamlining the policy, legislations, and institutional frameworks governing forestry in Kenya

There is need to streamline the policy, legislation, and institutional frameworks governing the forestry sector in Kenya through promoting forest certification, chain of custody and traceability systems to reduce long procedures and bureaucracies in acquiring tree harvesting and forest products movement permits. Policies supporting infrastructural development such as improved road network and constant stable electricity are important in timber processing as well as other sectors.

Policy actions could support the industry through guaranteeing supply continuity for multi-annual purchasing contracts, rolling out of forest certification and chain of custody systems for flow of timber products, transparent trading procedures such as full information on available volumes, timber quality and accessibility to forest stands, regulatory mechanisms that grant incentives to the most efficient players and not rewarding privileged positions through opaque allocation systems. All these could improve investment in efficiency improving technologies across the sawn timber value chain (UN Environment, 2017).

e) Promoting the utilization of processing residue through adopting circular economic models

Adoption of circular economic models where residue from one process is used as inputs to other processes could be used to improve efficiency across the sawn timber value chain in Kenya. Mill cull including timber offcuts and sawdust can be used to generate heat and electricity for sawmill and processing equipment such as kiln dryers or wood fired electricity generating systems.

f) Promoting timber seasoning before use

Drying timber before use improves timber stability during use thus improving its quality and durability. Kiln drying systems available at small and medium scales (15-20 m^3) capacity using shipping container and solar energy could be used at individual/ group level to improve wood quality, thus increasing financial returns to small and medium scale producers.

g) Guaranteeing constant supply of quality roundwood to processors

There is need to guarantee a constant and secure supply of raw materials to investors through improving the operation and management of public plantations, promoting tree growing on farms, species to site matching, promotion of dryland suitable species, investment in irrigation technologies, among others. Ensuring a constant supply of raw materials will justify the need for efficiency improving investments along the value chain as the investors will be assured of full utilization of the machinery and associated incomes in return. In Kenya, sawmills tend to perform basic processing works with minimum value addition to raw materials leaving higher margins to resellers and wholesalers. Insecure supply of raw materials forces local sawmills to close or become second-tier businesses dealing with imported sawn wood. Timber imports is thus likely to increase in the country in future because of increased restrictions on roundwood imports by exporting countries. The viability of any investment in efficiency improving technologies to a large extent depends on the supply stability of raw materials (roundwood).

h) Strengthening value chain actors' coordination frameworks

There is need to strengthen institutional frameworks that promote synergy and coordination among value chain actors such as participatory forest management as envisioned in the FCMA, 2016. Incentives structures for the establishment of community forest associations, tree grower associations, timber manufacturers associations and cooperatives, are critical to aggregating smallholder tree growers and improving their economies of scale. This can be achieved through provision of financial support to actors in the sawn timber value chain, technical training, and fiscal incentives to tree growing in the country.

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ANNEXES

Annex 1: Sawn timber value chain activities and actors

Activity	Actors
Seeds production	KEFRI (Certified seed), local seed collectors
Seedling production	Nursery operators (Registered/ unregistered), individual farmers
Tree production	Public plantations in KFS land Smallholder farmers (<10 acres): Tree production mainly done jointly with other farm enterprises Medium scale farmers (10< acres<25 Large scale farmers > 25 acres of land Private companies Institutions (schools, hospitals, and churches)
Tree harvesting	Private companies (Raiply, Timsales, Biashara Masters, etc. Local harvesters Individual farmers
Transportation and handling	Specialized transporters (Mainly by private companies Local transporters (use the regular trucks and tractors used to transport other commodities
Processing	Large roundwood processing companies (High value products such as plywood, veneer products Small and medium scale sawmillers who mainly produce sawn timber products Furniture makers (also offer value addition services such as planing, grooving, molding, door and panel making
Trading	Large companies who sell their processed goods Small and medium scale timber merchants Sawmillers

Annex 2: Technologies used along the value chain

Technology	Type	Frequency	Percentage
Tree seed/ seedlings	Certified	5	25
	Noncertified	15	75
Tree harvesting	Power saws	19	99
	Others	1	1

Technology	Type	Frequency	Percentage
Processing (sawmilling)	Power saw	12	60
	Wood Mizer	2	10
	Tractor drawn circular saws	3	15
	Bench saws	3	15
Log transportation	General trucks	9	45
	Specialized trucks	8	40
	Tractors	4	20
Sawn Timber transportation	General trucks	16	80
	Specialized trucks	2	10
	Tractors	2	10
Handling and loading	Manual labour	17	85
	Forklift	2	10
	Skidder	1	5

Annex 3: Gender roles in the sawn timber value chain

Activity	Gender	Frequency	Percentage
Tree nursery activities	Male	6	30
	Female	14	70
Tree production	Male	14	70
	Female	6	30
Harvesting and handling	Male	18	90
	Female	2	10
Log and sawn timber transportation	Male	17	85
	Female	3	15
Sawmilling/ processing	Male	18	90
	Female	2	10
Sawn timber trading	Male	6	30
	Female	14	70

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