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Value chain analysis of farm grown *Melia volkensii* (Gurke) timber in the South Eastern Dry lands of Kenya

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This paper analyzes the value chain of *Melia volkensii* timber grown on farms in the South Eastern dry lands of Kenya. The "*filiere*" approach was used to analyze the institutional and the economic dimensions of the chain, while technical dimensions were analyzed using on-farm timber sawing systems. Six main actors; tree farmers, timber merchants, sawyers, timber yard operators, furniture makers, and end consumers were mapped. Transporters, though temporary, played intermediary roles of facilitating the linkages. A variety of combinations determined costs and gains along the chain. Some actors circumvented some links to increase revenue. Quality of trees and sawn timber were key determinants of monetary value transacted along the chain. Inadequate farmers' skills in tree silviculture, valuation and cumbersome procedures in obtaining Government permits were also mentioned as major challenges, while timber sawyers lacked efficient sawing technology, consequently lowering income along the entire value chain. To improve the value chain, there is need to address the identified challenges through enhancing information and technology transfer to the players among other interventions.

Key words: Farm grown timber value chains, *Melia volkensii*, "filiere" approach, chainsaw.

INTRODUCTION

Forestry makes substantial contribution to global, regional and national economies as well as improving household livelihoods (Wit and Van Dam, 2010). In Kenya, forestry is a critical pillar to many sectors of the economy (Wamahiu, 2008; GoK, 2007). Farm forestry plays an important role in supplementing gazette forests in meeting forest products demand (World Agroforestry Centre, 2004; Pasiecznik, 2010). It also helps farmers to diversify income and reduce risks (Roshetko et al., 2008; Muthike et al., 2010). Forest resources assessment in Kenya reported an increase of trees on farm by over 40% between 1990 and 2010 (FAO, 2010). With ever decreasing arable land in high potential areas, dry lands, backed by research and technology, are providing the much needed alternative space for tree growing.

One of the tree species that has been successfully propagated in dry lands is *Melia volkensii*, (Gurke), which is generally referred to as Melia. The species belongs to the Meliaceae family and is native to dry lands of Eastern Africa;Ethiopia, Kenya, Somalia and Tanzania.It grows well in sandy soils with good drainage from sea level to 1700m above sea level and mean annual rainfall of

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between 300-800 mm and temperature range of 26-38°C (KFS, 2018). In Kenya, Melia was successfully introduced and propagated on farms in Tharaka Nithi, Kitui, Makueni and Taita Taveta Counties, which lie in the South Eastern dry lands of the country.

Kibwezi area, which comprises Kibwezi East and West Sub-counties in Makueni County, is one of the areas in the South Eastern Kenya. The area receives a mean annual rainfall of between 300 and 400mm (KFS, 2018). Melia was introduced on farms in Kibwezi in the mid-1990s, alongside other areas in Kitui and Tharaka Nithi counties, following extensive collaborative research between Kenya Forestry Research Institute (KEFRI) and other partners involving technology development for seed treatment to break its characteristic dormancy and propagation of the species on farms. To date, a good number of farmers in Kibwezi have adopted Melia tree farming, with a number having relatively large wood lots under *Melia volkensii* and a few running into plantation sizes. The government has continued to encourage farmers to adopt the species in an effort to bridge the gap in forest cover in line with the Kenya National Forestry Programme 2016-2030 (MENR, 2016) and the aspirations of the Kenya Constitution 2010. Other Non-Governmental organizations have also been helping farmers in other dry land areas to grow Melia trees. A good example is along the seven forks dam belt on the border of Embu and Machakos counties, where over 2000 farmers have each set aside at least 2 acres to grow Melia, with support from Better Globe Forestry (BGF) (Karuga, 2016).

The problem statement

Melia is a fast-growing dry land species, producing high value timber. Though indigenous in drylands like Kibwezi, it is new on farms and its commercial utilization is still in its infancy. Before adaptation on farms, Melia wood from wild trees had been used for building traditional houses, fencing and for tool handles. After introduction on farms in the early 1990s, mature trees are converted to sawn timber for furniture and other new products, opening new trade pathways but at small scale. However, with increase in interest in the species, more business players like timber merchants are beginning to appear, buying trees for conversion to sawn timber, which is sold to other regions (Wekesa et al., 2012). Brokers have similarly tried to find their space, connecting tree farmers and new merchants for a fee. With these increased entrants, the value chain has expanded and prices of the final sawn timber and timber products increase due to the rising transaction costs. This study was therefore designed to map and analyze the Melia timber value chain in Kibwezi area and establish the distribution of benefits along the value chain. The study analyzed the institutional, technical and economic dimensions of the Melia timber value chain and examined the challenges faced by players and possible solutions, all aiming at assisting investors interested in Melia timber to make informed choices on their preferred entry points.

METHODOLOGY

Study area

The study was carried out in Kibwezi (East and West) Sub-counties, Makueni County in the South Eastern dry lands of Kenya. The area bordering the Chulu Game Reserve and both Tsavo East and Tsavo West National Parks is fairly dry, receiving a mean annual rainfall of 300-400 mm per year, in two seasons, October-December and March – May (KFS, 2018). With such low rainfall, only drought resistant tree species can survive in the area. The area was purposefully selected for this study because many farmers have been growing Melia trees from the time of introduction, and trade activities around Melia timber have surfaces though with little organization (Wekesa et al., 2012).

Study approach and data collection

Different approaches have been used in value chain analyses, dictated by the types of chains and their complexities. The *Filiere* approach is one of the widely used methods (Bernstein, 1996). The term *filiere* means a “thread” and refers to a market chain, comprising the stages from the raw material producers to the final product consumers. The approach was developed to analyze price information through a commodity journey from raw material to final product (Freud and Dabat, 2000). It specifically addresses social relations, institutional arrangements and the role of actors in complementing conventional economics. In this study, *Filiere* approach was found appropriate owing to the newness of the product (*Mellia volkensii* timber) and therefore the type of players trying to fit themselves into the value chain.

The study aimed at documenting the various stages of the value chain; major actors; their relationships, costs and revenues involved at each stage (Bernstein, 1996). Tree farmers who participated in the initial establishment of Melia species (now organized into a cooperative) were used to provide information on tree growing and trade. To understand the timber business practices in the study area, a survey was conducted in Kibwezi town and the surrounding major market centres; Makindu, Kinduani/Mbui Nzau, and Mtito Andei, targeting timber yard operators and carpenters as well as transport service providers. This was aimed at providing information on the extent of timber-based businesses, timber species used, major sources, value addition practices and final products made as well as prices. A business census was then conducted to establish the number of sawyers, timber merchants, timber yard operators, and carpenters in the study area. Transport providers and brokers were also included to understand their involvement in Melia timber business.

Analysis of institutional, economic and technical dimensions

Data collection was grouped into three components: institutional, technical and economic dimensions. Institutional dimension involved the relationship between direct and indirect actors and their individual and/or collective objectives. Analysis of the economic dimension interrogated the costs and revenues as a result of operations at each stage of the chain. It also looked at the proportion of the price of final product (sawn timber) amongst the actors along the entire chain, the strong and weak transfer points in relation to prices, cost cutting mechanisms between stages and how players were being affected by changes in the relationships among them. For both institutional and economic dimensions, structured questionnaires were developed according to the theory and principles of the *filiere* approach (Bernstein 1996), as described by Freud and Dabat (2000). The questionnaires were pre-tested to identify the value chain links and the actors in each link, degrees of integration and the types of combinations and options in between. Computation of price transfer between stages was performed based on timber standard volume (board foot), to evaluate the value added and net margins at each stage. Group discussions were conducted separately for each category of players, aimed at determining the challenges they faced in the various links (growing, processing and marketing/utilizing Melia timber products), and their suggested solutions towards improving the value chain.

Technical dimension focused on timber sawing operations, technology used, constraints and how to improve efficiency. Due to lack of formal saw milling practices in the study area, owing to lack of forests, timber was sawn using freehand chain sawing method, which is the common sawing method used by the local timber sawyers. One local experience chainsaw operator was used to saw part of the timber. An improved framed chainsaw system, developed by KEFRI (Muthike, 2016), was used to saw the other part of the timber for comparison of efficiency. The framed chainsaw system was operated by a trained KEFRI chainsaw operator.

Six mature Melia trees of good stem form were selected from the farms and felled using chain saws. Each tree was crosscut into logs depending on market dimensions for sawn timber lengths. Log diameters were measured at the bottom, middle and top of each log. These measurements were used to compute log volumes. Half of the obtained logs were sawn using freehand chain sawing method while the other half was sawn using the framed chain sawing system. All logs were sawn to standard sawn timber dimensions. Log and sawn timber volume and recovery were computed using standard timber conversion methods (ISO, 1983; ISO, 1974). Timber surface roughness was determined using the procedure described by Richter et al. (1995) and Funk et al. (1992).

Data analysis

Data analyses were carried out using Microsoft Excel 2010, SPSS version 17 and Minitab14. Data distribution was determined using Microsoft 2010. To compare differences in the transaction costs and revenues, analysis of variance (ANOVA) was used. Univariate analysis was used to show the variation of revenues along the value chain links.

RESULTS AND DISCUSSION

Melia timber value chain mapping and analysis of institutional factors

The study mapped a multi-staged Melia timber value chain operated by different categories of actors, with varying sets of interactions as shown in Figure 1. The direct actors involved in the value chain include tree farmers, timber merchants, sawyers, timber yard operators, furniture makers and furniture consumers. Farmers grow and sell standing tree to timber merchants and other buyers including neighbours for their domestic use. The merchants hire chainsaw operators to fell and convert the trees to sawn timber. Sawn timber is sold to timber yard operators, who stock and sell the same to furniture makers for further processing into furniture and other timber products for final consumption. Within these activities, transporters are engaged in transporting sawn timber and/or finished furniture products to the designated stages in the value chain. Transporters occasionally provided additional jobs to other people as loaders.

A part from the main actors, other relationships existed, where players circumvented some chain links to cut costs (indicated by dotted lines and/or double arrow). In some cases, brokers come in between and made money by connecting players in a link, which increased the cost of the final product. Brokers for example would be hired for a commission by timber merchants to scout for mature trees. Some brokers would buy trees from farmers and sell them at a profit to merchants, sawyers, timber yard operators or furniture makers. This tends to increase the cost of trees. On the other hand, some timber yard operators bought standing trees from farmers, instead of sawn timber from merchants. Farmers themselves would at times hire sawyers to process the trees into sawn timber. Similarly, some furniture makers reported that when they have special orders that require non-conventional timber dimensions, they approached farmers to buy standing trees. These trees would later be sawn to the carpenter's specified dimensions, which enabled them to circumvent some steps tended and consequently lowering costs by shortening the value chain.

Analysis of economic factors

Results indicated that value addition took place in a variety of forms as the main and subsidiary actors interact at various links of the chain, from the standing trees to the final timber products. For ease of analysis of value addition, the study concentrated only on stages from standing trees to sawn timber. Furniture making was left out due to the additional materials needed like adhesives, varnishes and upholstery among others, which make analysis of the value addition more complex. However, consideration was given to Melia timber playing a more preferred substitute to other timber species initially brought from other regions for making furniture. The distribution of the gains due to value addition along the chain is shown in Table 1.

Other factors that influenced the value transacted at various links of the chain included the quality of the standing tree stems and that of the resultant sawn timber. The buyers sought straight long stems with fewer knots, to get high quality timber. Carpenters with specific orders (e.g. school furniture) would be willing to pay more to select the required timber from yards or select standing trees with suitable stem characteristics and pay a premium price. Thus, farmers got paid more per board foot of sawn timber when they sold trees with good stem form.

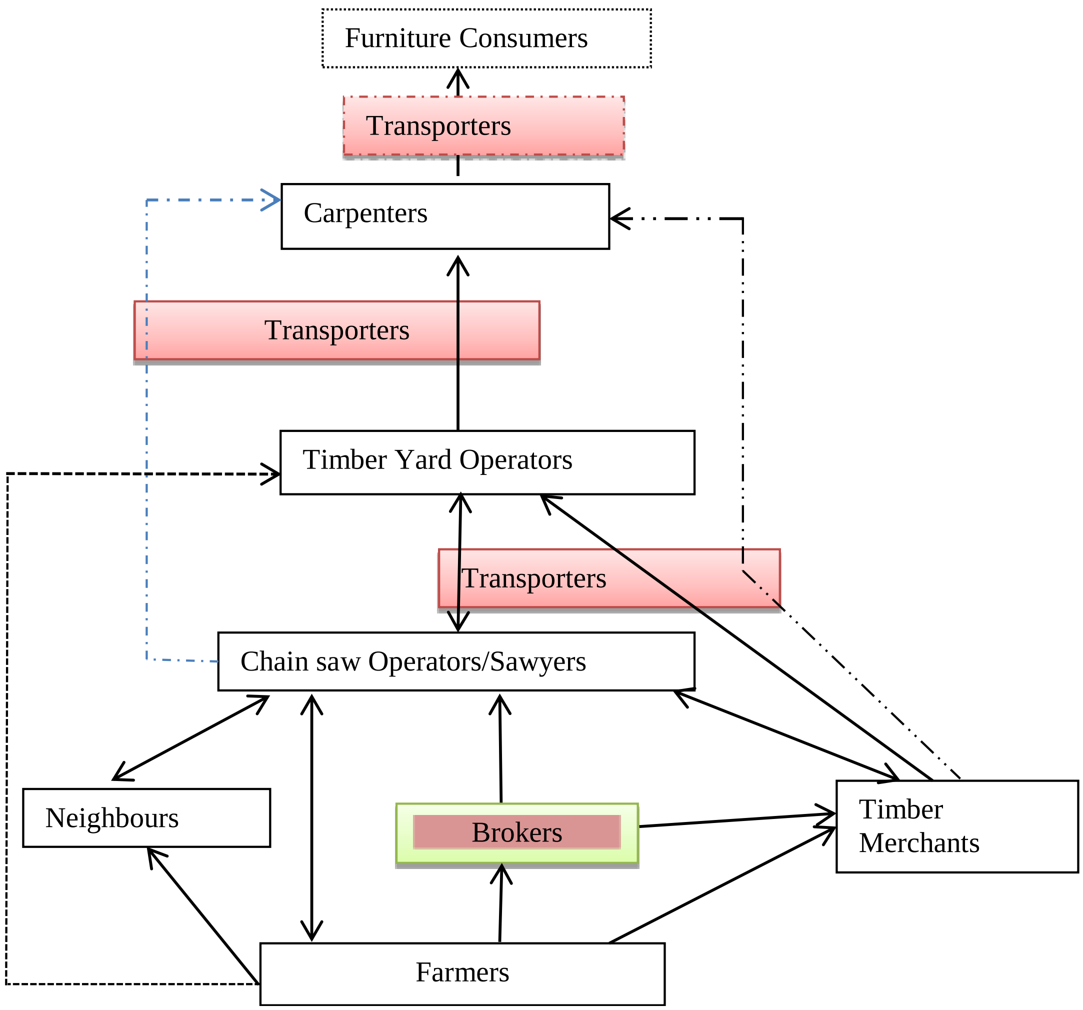

Figure 1. Melia timber value chain in Kibwezi Sub-county, Kenya. The chains indicated in one sided arrow solid lines indicate the most commonly occurring direct structures and stages of the value chain. Double solid lines indicate cases where materials go to and from each actor. Circumventive chains are indicated by dotted lines. Chains that go through transporters are indicated by lines going through Transporters. Other minor players like loaders are covered under transporters. The top two stages (Transporters and Furniture consumers) are indicated in dotted lines because they are not analyzed in this study, whose scope covered up to carpenters as the consumers of Melia sawn timber.

Costs and gains along the value chain were also influenced by players circumventing some stages and engaging in value addition operations themselves. For example, when farmers had the trees converted to sawn timber, there was an additional gain of at least KES 19-29 per board foot, attributed to value addition and sale of offcuts and fuel wood. Similarly, timber yard operators gained an additional KES 12-20 more by buying trees and converting them to sawn timber instead of buying sawn timber from merchants. This gain is additionally attributed to the value of the offcuts, which would add to the sales. Similarly, carpenters realized an additional gain of KES 10-18 when they bought standing trees directly from farmers and hired sawyers to convert the trees to sawn timber. Tree buyers tended to pay higher when they initiated the sale and less when the farmer had to look for them. Brokers were also reported to offer the lowest prices for the standing trees and in such scenario, the farmers neither got full value of their trees nor did they have power over how the trees were processed. This has been reported in other studies as one of the reasons for farmers not finding tree growing on their farms a lucrative activity owing to the length of time it takes to raise a tree to maturity (Wit et al., 2010; Fehr and Pasiecznik, 2006). Because of low volumes of sawn timber and furniture products traded in the study area, there were no designated transport providers. Therefore, players hired transport as and when needed. Major transportation means reported along the value chain was pickups and motor cycles. The cost of transportation for sawn timber

Table 1. Major Actors in Melia timber value chain.

Actor	Number identified in the study area	Mean age (Yrs)	Who they sell to/serve	Gain/BF of sawn timber (KES)	Mean Gain/BF (KES)
Farmers	15	52	Neighbours, merchants, sawyers, brokers, timber yards	18 - 21	19.5
Brokers	6	29	Timber merchants, sawyers,	9 - 13	11
Timber Merchants	4	31	Timber yards, Furniture makers	10 -16	13
Sawyers/chainsaw operators	17	25	Farmers, neighbours, Timber merchants, timber yards, Furniture makers	12 - 15	13.5
Transporters	Various	-	Farmers, neighbours, Timber merchants, timber yards, Furniture makers, consumers	10 - 14	12
Timber Yard operators	8	32	Furniture makers, house builders,	14 - 16	15
Sub-total				**78 - 95**	**86.5**
Furniture makers	21	27	Households, urban dwellers	25 – 53	39
Grand-total				**103 - 148**	**125.5**

1 USD = KES 100 (2018/2019).

Table 2. Timber recovery and quality analysis.

Sawing system	Timber recovery (%)	Dimension deviation (mm)	Surface roughness -Ra (µm)
Freehand chain sawing method	29.4	5.32	162.18 ± 32.57
Framed chain sawing system	48.7	2.48	107.54± 11.81

and furniture products was reduced when large quantities were transported at a time or when motor cycles were used for smaller consignments instead of pickups. Moreover, large trucks were not frequently used in timber business in the study area, as logs are usually sawn on felling site using chain saws.

Analysis of technical factors

Technical factors in this study focused mainly on the efficiency of sawing technologies used, timber dimensions and surface quality. Observations showed lack of formal sawmills and other value addition practices like timber seasoning, grading and preservative treatment. Technical analysis revealed that the freehand chain sawing method currently being used recovered less timber with higher dimensional variability and rougher surface than framed chainsaw system as detailed in Table 2.

Framed chainsaw recovered 48.7% of the logs into sawn timber. This was significantly ($p = 0.031$) higher than 29.4% recovered using freehand chain sawing method. Dimensional variability and surface roughness (R_a) were also significantly lower ($p = 0.001$) at means of 2.48 mm and 107.54±11.81µm, respectively for timber sawn using framed chainsaw system compared to 5.32 and 162.18±32.57 µm in timber sawn using free hand chain sawing method. These results, though slightly different, show some similarities in range with results reported in earlier studies. Guillaume et al. (2010) reported timber recovery rates ranging from 28 to 35%, for freehand chain sawing, using different timber species and stem diameters. Muthike et al. (2013) reported sawn timber recoveries of 48 to 56% for framed chainsaw system. Small variations may be attributed to among other factors, influence of log diameter and stem form as well as sawyer's experience (Muthike, 2007). The analyses in this study revealed that the technical aspects (timber sawing technology) influenced the profitability along the Melia timber value chain.

Tree buyers tended to offer lower prices for standing trees to compensate for the losses incurred through inefficient freehand chain sawing. Furniture makers and other sawn timber consumers also tended to avoid sawn timber with high dimensional variability and rough surfaces. They offered lower prices because it required more time and higher machining costs to smoothen and obtain even timber dimensions for the various applications. Inefficient sawing therefore contributed to material wastage, and has been repeatedly reported as a major contributor to the depletion of tree population in plantations and farms alike (Muthike et al., 2013; Holding-Anyonge and Roshetko, 2003). Consequently, low income to the farmers serves as a disincentive to planting more trees.

Challenges and possible solutions in Melia timber value chain

Tree farmers, sawyers and furniture makers outlined the challenges they faced. Apart from low prices offered for standing trees, farmers identified lack of tree valuation techniques, cumbersome procedures in obtaining permits from Government when intending to cut trees, and lack of more valuable alternative uses for Melia trees, as some of the other challenges they face. They proposed the following as possible solutions to these challenges; forest experts need to provide guide lines to farmers on tree volume estimation and valuation. Information on tree management particularly spacing and pruning to produce trees for sawn timber was also highlighted as important to farmers. They also pointed the need for the Government to remove the requirement for forest produce movement permits since farmers in the study area have no possibility of interfering with state forests as there is none in their neighborhoods.

Timber sawyers on their part observed that timber sawing as the sole source of income was currently unsustainable, because only a few farmers have mature trees and some are unwilling to sell or convert into sawn timber. They however were optimistic that with increase in availability of maturing trees, sawyers would be guaranteed of sustainable livelihoods. Other challenges identified include poor stem form for sawn timber production due to poor silvicutural treatment and lack of efficient sawing methods for higher timber recovery. Based on the results of technical analysis, sawyers agree that the freehand sawing method they had been using is inefficient and uneconomical, causing losses to both the tree farmer and the sawyer. They voiced a need for capacity building to adopt the improved framed chainsaw system to increase timber recovery and enhance surface quality as well as operator safety and ergonomics.

Furniture makers on the other hand identified general shortage of Melia timber and poor timber surface as key challenges to their work. They praised the introduction of framed chainsaw system as a possible solution, providing uniformly dimensioned timber with fairly smooth surface. They also suggested that farmers need to increase trees on their farms to increase supply of sawn Melia timber, which has superior mechanical properties for furniture making.

CONCLUSION AND RECOMMENDATIONS

The study highlighted institutional elements of management, economic operations and technical aspects at the various stages of the chain as the key factors influencing the efficiency of the Melia timber value chain. From the purchase of trees at the farm to the sawn timber at the timber yard or furniture workshop, best value was achieved when main players at one stage managed to shorten the chain by trading directly with the next main players. Sawyers and furniture makers gained more through improved efficiency of the timber sawing technology.

The focus group interviews demonstrated farmers' awareness that they were not getting full value of their trees, due to lack of adequate knowledge on tree management and valuation. Further, farmers and sawyers' gains were negatively influenced by inefficiency of the timber sawing technology used by sawyers. This calls for the relevant agencies to promote capacity building of farmers on tree management and chainsaw operators on improving timber recovery and quality.

Further, the study concluded that inefficient timber conversion, lack of other value addition methods lead to waste, exacerbating unsustainable wood supply scenario. There is therefore need to invest in improving wood processing technologies and capacity to diversify into high value products. While efficient conversion of trees into sawn timber instead of selling them standing was proposed as a way to improve the gains by the farmers, it was noted that the superior timber properties of Melia timber could enable it to be processed for higher value products like flooring, which would increase value along the chain.

Most of the businesses along the Melia timber value chain in the study area are small-scale and lack adequate capital for investment. Such businesses were not in a good position to trade in large quantities of round wood or sawn timber. The transactions involved selling a single tree or a few trees at a time. These are perhaps to be viewed as micro to small-scale, compared to transactions in larger and more established operators, with larger quantities along the value chain. The latter is entrepreneurial scale, which can contribute to the long-term livelihoods, employment and economic growth in such rural setups.

This is what needs to be promoted to grow alongside the growing potential fronted by Melia tree farming in dry lands. Timber recoveries and value can be improved through training farmers on silviculture and tree valuation, capacity building of sawyers to adopt efficient sawing systems, and other players along the value chain on efficient value addition at every stage. The need for timber movement permits may need to be reviewed for people trading with dry land farm grown timber since there may not be possibility of interfering with state forests as there are none in the areas producing similar timber products. It is recommended that tree farmers form and/or strengthen associations for better access to technical information on tree silviculture and management, valuation and pricing. To make the Melia players, more farmers need to be encouraged to grow the species and join the associations. With greater knowledge and capital, farmers' associations can organize centralized selling of trees or process the trees into sawn timber for higher value. Further, timber sawyers should be encouraged and facilitated to adopt framed chainsaw and other efficient sawing systems for higher timber recoveries and higher timber surface quality. Further, traders of higher value products like flooring should be encouraged to try the Melia timber due to its superior mechanical properties.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Bernstein H (1996). The political economy of the maize "filiere". Journal of Peasant Studies 23(2/3):120-146.

Food and Agriculture Organization (FAO) (2010). Global forest resources assessment 2010; Country report, Kenya. FRA 2010/107, Rome: FAO.

Fehr C, Pasiecznik NM (2006). The potential of chainsaw milling for improving rural livelihoods in Uganda and DR Congo. Policy brief. HDRA, Coventry, UK.

Freud EH, Dabat MH (2000). *Atelier de formation sur les methods d'analysedes marches agricoles.* Dossier methodologique CIRAD/ICRAF November2000 (Abstract).

Funk JW, Forrer JB, Butler DA, Brunner AG, Maristany CC (1992). Measuring surface roughness on wood: a comparison of laser scanner and stylus tracing approaches. Proceedings of International Society for Optical Engineering. Vol. 1821.

Government of Kenya (GoK) (2007). Kenya Vision 2030. Government of the Republic of Kenya. Nairobi: Government printer.

Guillaume L, Paolo OC, Edouard EM, Richard EA, Robert N (2010). Chainsaw milling in the Congo Basin. European Tropical Forest Research ENetwork. Tropenbos International, Wageningen, the Netherlands. xxii 226 pp.

Holding AC, Roshetko JM (2003). Farm-level timber production: Orienting farmers towards the market. Unaslyva 54(1):48-56.

ISO 3179 (1974). Coniferous sawn timber- nominal dimensions. https://www.iso.org/standard/8368.html

ISO 4480: (1983). Coniferous saw logs: Measurement of sizes and determination of volume. https://www.iso.org/standard/10375.html

Karuga J (2016). Arid Land Wonder Tree Spurs New Economic Opportunities. CleanLeap. http:cleanleap.com

KFS (2018). A Guide to *Melia volkensii* Growing in the Dryland Areas of Kenya 2018. Kenya Forest Service, Headquarters, Off Kiambu Road, Nairobi.

Ministry of Environment and Natural Resources (MENR) (2016). National Forest Programme of Kenya. MENR, Nairobi, Kenya.

Muthike GM (2007). Impacts of Integrating technology and Skills on Timber recovery and surface quality in on-farm timber processing in Kenya. (in) IUFRO-All Division 5 Conference, Held in Taipei, Taiwan on 29th October to 2nd November 2007.

Muthike GM (2016). Optimization of on-farm machine design parameters for efficient timber sawing based on empirical approach. Jomo Kenyatta University of Agriculture and Technology. PhD Thesis.

Muthike GM, Kanali CL, Shitanda D (2013). The contribution of Framed Chainsaw System to Improvement of Sawn Timber Quality. International Journal of Current Research 5(1):070-074.

Muthike, GM, Shitanda D, Kanali CL, Muisu FN (2010). Chainsaw milling in Kenya. Chainsaw milling: supplier to local markets, 166.

Pasiecznik N (2010). Sawmilling with chainsaws: a technical overview. Chainsaw milling: Supplier To Local Markets P 3.

Richter K, Feist WC, Knaebe MT (1995). The effect of surface roughness on the performance of finish. Part 1. Roughness characterization and stain performance. Forest Products Journal 45(7-8):91-96.

Roshetko JM, Snelder DJ, Lasco RD, van NM (2008). Futurechallenge: a paradigm shift in the forestry sector. In: Snelder, D.J. and Lasco,R. (eds). Smallholder tree growing for rural development and environmental services.

Wamahiu PW (2008). Trees on farms in Kenya. In: Recent Advances in Forestry Research for Environmental Conservation, Improved Livelihood and Economic Development. Proceedings of the 4th KEFRI Scientific Conference, 6-9 October 2008. Nairobi.

Wekesa L, Muturi G, Mulatya J, Esilaba AO, Keya GA, Ihure S (2012). Economic viability of *Melia volkensii* (Gurke) production on smallholdings in drylands of Kenya. International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) 2(8):364-369.

Wit m, Van Dam J (2010). Chainsaw milling: supplier to local markets. Tropenbos international, wageningen, the Netherlands.

World Agroforestry Centre (2004). Small-holder Timber Workshop Notes. CD-ROM. Small-holder Timber Workshop, November 29 December 1, 2004, World Agroforestry Centre, Nairobi, Kenya.