Community Tree Seedling Production in Maseno Division, Kenya

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Abstract: **- Forests and trees are important natural resources globally. The reduction of forests and tree cover has occasioned the loss of biodiversity, wildlife habitat, ecosystem integrity; increased climate variability and reduced crop yields. These have resulted into decrease in food security thus a key development challenge. The trend can be reversed by promoting on-farm tree planting using quality tree seedlings. Community tree nurseries can provide this; however many are established but soon cease to operate. The reasons for such failures have not been documented. This study, premised on production theory sought to assess tree seedling production processes of such tree nurseries in Maseno Division, Kisumu County. The study sought to: Examine reasons considered while establishing community tree nurseries; understand the factors for community tree nursery location; determine the reasons for producing given tree species; and assess the production challenges in community tree nurseries. Conceptually, tree seedling production cost depends on reasons for establishing the tree nursery, tree nursery site;species and number of seedlings produced augmented by production techniques. Purposive sampling regime with a cross-sectional survey was used. A total of 54 tree nurseries were visited and operators interviewed. To triangulate the results ten closed tree nurseries; five farmers growing trees and five key informants were interviewed. Pre-determined interview schedule was used to gather quantitative data. Qualitative data was collected through in-depth interviews and Focus Group Discussions guided by checklists. The study established that: the main reason for establishing the tree nurseries is income (53.7%); water and potting media are considered by 72.2% of the operators while location the tree nursery; Fuelwood ranks high as an end product (33.9%) and Eucalyptus is the most preferred (83.3%). It was also observed that 88.9% of the operators mainly use traditional production techniques resulting into high production costs which can be overcome through training in management of community tree nurseries as business enterprises. The findings are valuable to tree nursery operators, policy regulators and research institutions locally, nationally and international. The results can equally be used in responding to effects of climate change and Sustainable Development Goals.**

Key words: Community tree nursery, cost of production, on-farm tree growing, sustainable development

I. INTRODUCTION

Production is turning inputs into outputs. It is the usage of given raw materials to produce what is required by the market. Production involves combining the factors of production (land, labour, capital and entrepreneurship) into the desired products. The product must be able to fit in the market in terms of the variety, quality, design, features, brand, packaging, sizes, services, warranties and returns (Longenecker, Moore & Petty, 2003). Any production unit must consider the location, legality and other factors of production (Longenecker *et al.,* 2003*,* Palmer & Hartley, 1996 and Everard & Burrow, 1990).

A tree nursery is a site designed and managed for the production of tree seedlings under favourable conditions until they are ready for out planting (Roshteko *et al.*, 2010). It is a process entailing tending operations like: tree nursery site selection and preparation; potting; watering, purchase of materials, equipment and tools; seed sowing; pricking out; and hardening among others. At each level there are cost implications. The costs can be implicit or explicit. It is therefore prudent for the operators to consider why the business and how to sustain the process. The operators require land (space and soil). The space should be sizeable enough to hold the seedlings and any infrastructure that is required for the given seedling (Evans, 1982 and Roshteko *et al.,* 2010). Tree seedling production is labour intensive thus the need for such a resource (Roshteko *et al.,* 2010 and Haque, Miah & Rashid, 2007). Capital is equally required in the tree nursery in terms of equipment, tools, materials and finances. Land, labour and capital must be combined in a manner that yield seedlings required by the markets (Longenecker *et al.,* 2003).

Community tree nurseries

The future of trees is on farms inferring that the future of tree seedling production should also be on farms (Moir *et al.*, 2007). Over the year's tree seedling production, distribution and growing was the responsibility of governments. In Kenya this was so until the introduction of Structural Adjustment Programme (SAPs) in 1990s. Line ministry employees were retrenched (Easterly, 2006) despite the growing demand due to the souring population and environmental awareness. To fill the gap, a lot of liberalization occurred with non-governmental organizations (NGOs) coming up to assist through training and provision of resources required for seedling production (Oduol and Franzel, 2014). The government also promoted Community Forest Associations (CFAs) as enshrined in the Forest Act, 2005. These culminated into community tree nurseries which are tree nurseries initiated by individuals and/or groups to provide a sustained source of low cost tree seedlings purposely to grow on farming systems and public spaces, generate income and build social capital (Roshteko *et al.,*2010).Despite the growing population and increased environmental awareness thus the rising demand for seedlings, most of the community

tree nurseries produce below their optimum levels thus limited expansion and/or close-ups.

This study set out to understand the existing gaps in production processes so as to help turn-around these ventures into economic, social and environmental benefits. The study was conducted in Maseno Division of Kisumu West Sub-county (formerly part of Kisumu District), Kisumu County where tree growing has been promoted by a number of institutions over the last two decades (AFRENA 1996, 1997 and 1998). This provided a good benchmark since most of the adaptive research carried out came to realize importance of farm forestry but with wanting integration.

The information can enhance tree seedling production since the operators will know how best to relate production processes to costs incurred. This may be a pointer to sustainability hence contribution to achieving the Kenya Vision 2030 and ensuring sustainable development (using available resources without compromising the future generations) while meeting the Sustainable Development Goals (SDGs). The findings are valuable to the tree seedling operators, research institutions- international and local; the Kenya Forest Services, learning institutions and all those involved in trees and tree product value chains in ensuring sustainable supply of products. The results may not be very conclusive as has also not looked at the performance of individual tree species in the respective tree nurseries. This could have been a better pointer and decision making tool in the study field and other related fields.

II. LITERATURE REVIEW

Human wants though unlimited, competitive and at times complimentary; vary in urgency and intensity. Decisions have then to be made by producers and consumers looking at the opportunity costs (the value of the best forgone alternative). Producers choose to allocate resources (factors of production) so as to maximize profits while satisfying the unlimited wants of the consumers. On the other hand consumers have limited income therefore must rationally have preferences (Mudida, 2009). Basically economics seeks to fundamentally look at which goods and services to produce and in what quantities (total output); how should the goods and services be produced (capital or labour intensive) and how the goods and services are distributed (Mudida, 2009 and Begg, Fischer & Dornbusch, 2011).

Production is a process of combining various inputs to produce an output for consumption. It is the act of creating output in the form of a commodity or a service which contributes to the utility of individuals. A firm then has to decide what to produce using given resources and at what costs with anticipation of selling to a given market at a stated price. A combination of goods that can be produced with constant technology and resources per unit of time, such that more of one good could be produced only by diverting resources from the other, resulting in less production of the other must be made. It shows production set for fixed input quantities and gives the maximum possible production level of one commodity for any given production level of the other, given the existing state of technology (Mudida, 2009; Saleemi, 2007; and Gowland and Paterson, 1993).

Production theory defines the technical relationships between the prices of the commodities and productive factors against the quantities of these commodities and productive factors. The theory appreciates how best inputs are combined to produce output for consumption. The production function (analysis) signifies a technical relationship between the physical inputs (land, labor, and capital) and outputs of a firm using a given technology. To produce these goods the basic inputs are classified into variable and fixed inputs. It can be shown as Q = f (a,b,c,……z) where Q is the level of the output for the firm while a,b,c…..z are the various inputs or factors of production. If labor (L) and capital (K) are the only input factors, the production function would be: **Q = f(L, K).** The theory postulates fixed and variable costs in the short run while all turn to be variable costs in the long run (Boettke & Sautet 2011, Mudida, 2009 and Samuelson & Nordhaus, 1992).

In economics, production theory explains the principles in which the business has to take decisions on how much of each commodity it sells and how much it produces and also how much of raw material for example fixed capital and labor it employs and how much it will use. It defines the relationships between the prices of the commodities and productive factors on one hand and the quantities of these commodities and productive factors that are produced on the other hand (Boettke & Sautet 2011, Mudida, 2009). The importance of trees cannot be overstated hence the need for tree seedling production in community tree nurseries which goes through similar processes.

Trees provide a number of products and services: they are known to help improve soil fertility; provide shade, prevent desertification, act as windbreaks, provide fodder, timber, fruits, medicine, woodfuel and aesthetic value among others (Moir *et al.*, 2007). Maundu and Tengnas (2005), explain that trees form an essential part of diversified farm production for subsistence products, income and environmental resilience through soil and water conservation. Most rural communities directly or indirectly draw their livelihoods from trees and forests hence the valuable role in economic, social and environmental development (Jaenicke, 1999). The demand for biomass and non-wood forest products (NTFPs) will most likely increase with a possibility of expanding market and improving market access(FAO, 2003).The New York Declaration and Bonn Challenge targets could add approximately US$ 85 billion to national and local economies and remove an additional one billion tonnes of carbon from the atmosphere each year (IUCN, 2014). The Food and Agriculture Organization (FAO) report on the energy sector that woodfuel still represents about 7 percent of the world's total primary energy consumption is a point to reckon. The report notes that 76 percent of this consumption is in

developing countries, where about 77 percent of the world's population lives (Trossero, 2014).

In Kenya woodfuel accounts for over 70 percent of total energy consumption with over 80 percent of the population depending on it for their domestic energy needs. The use of woodfuel has been responsible for significant deforestation, a challenge that the government is committed to reverse through the promotion of sustainable wood resource management and efficient harvesting and end-use technology policies (International Monetary Fund, 2005). It can therefore be noted that in the rural areas trees may be most important for poverty alleviation since they are vital safety nets, helping rural people to avoid, mitigate or rise out of poverty through petty cash, savings, and hard cash(FAO, 2003 and Chia, Somorin, Somwa & Tiani, 2013).

Tree growing requires quality seedlings. This could be achieved through community tree nurseries. A tree nursery is a site designed and managed to produce tree seedlings under favourable conditions until they are ready for out planting (Roshteko*et al.*, 2010 and Evans, 1982). A tree nursery reduces the failure of newly germinated tree seedlings to compete with other plants while giving them the needed care until they are sturdy enough for out planting (Moir *et al.,* 2007, Evans, 1982 and Roshteko *et al.*, 2010). Community tree nurseries also known as own tree nurseries or on-farm tree nurseries have an anticipated longer life span due to collaboration often based on relationships and trust (Moir *et al.*, 2006; Wightman, 1999 and Roshteko *et al.,* 2010). These tree nurseries can produce up to 10,000 assorted tree seedlings per season and use locally available resources. They are mainly to grow trees on their farm systems, expand the number of tree species and also generate income. Arguably they are more sustainable, reliable and cost effective in afforestation programmes since they provide a sustained source of low cost seedlings to plant in public spaces (Roshteko *et al.,* 2010). Further, they state that community nurseries help build technical and leadership capacities and expand the number of species and quality of germplasm.

A good tree nursery site where there is permanent water supply; gentle slope; good soil; security; an area accessible throughout the year with good shade; and an area free for expansion hastens tending operation (Moir *et al*,2007and Albrecht, 1993). Other than seedling production, community tree nurseries have the potentials of generating employment and income to owners (Haque*et al.*, 2007 and Roshteko *et al.,* 2010). To be able to realize the anticipated benefits there is need for record keeping. Everard and Burrow (1990) indicate that there should be a cash register, receipt and payment records, depreciation records, special assets record for insurance policy, fixed assets and real property, tax records and payroll records. Business records should be accurately maintained with a convenient filing system permitting quick access and accurate storage (Karanja, Ngocho, Luyayi, Oduol, Muriuki and Mowo*,* 2014).

Just like any business, tree seedling production requires a number of resources. Land as would be conventionally described is required in terms of space and soil that will be used for raising seedlings. The space should be sizeable enough to hold the seedlings and any infrastructure that would be needed (Evans, 1982 and Roshteko *et al.,* 2010). Tree seedling production is labour intensive thus the need for such a resource (Roshteko *et al.,* 2010 and Haque *et al.*, 2007). The capital intensity in the production process always helps in defining the type of tree nursery. This may be in terms of equipment, tools, materials and finances. Capital thus is an important factor of production in tree seedling production. All these factors must be combined in a manner that yield seedlings required by the markets (Longenecker *et al.,* 2003).

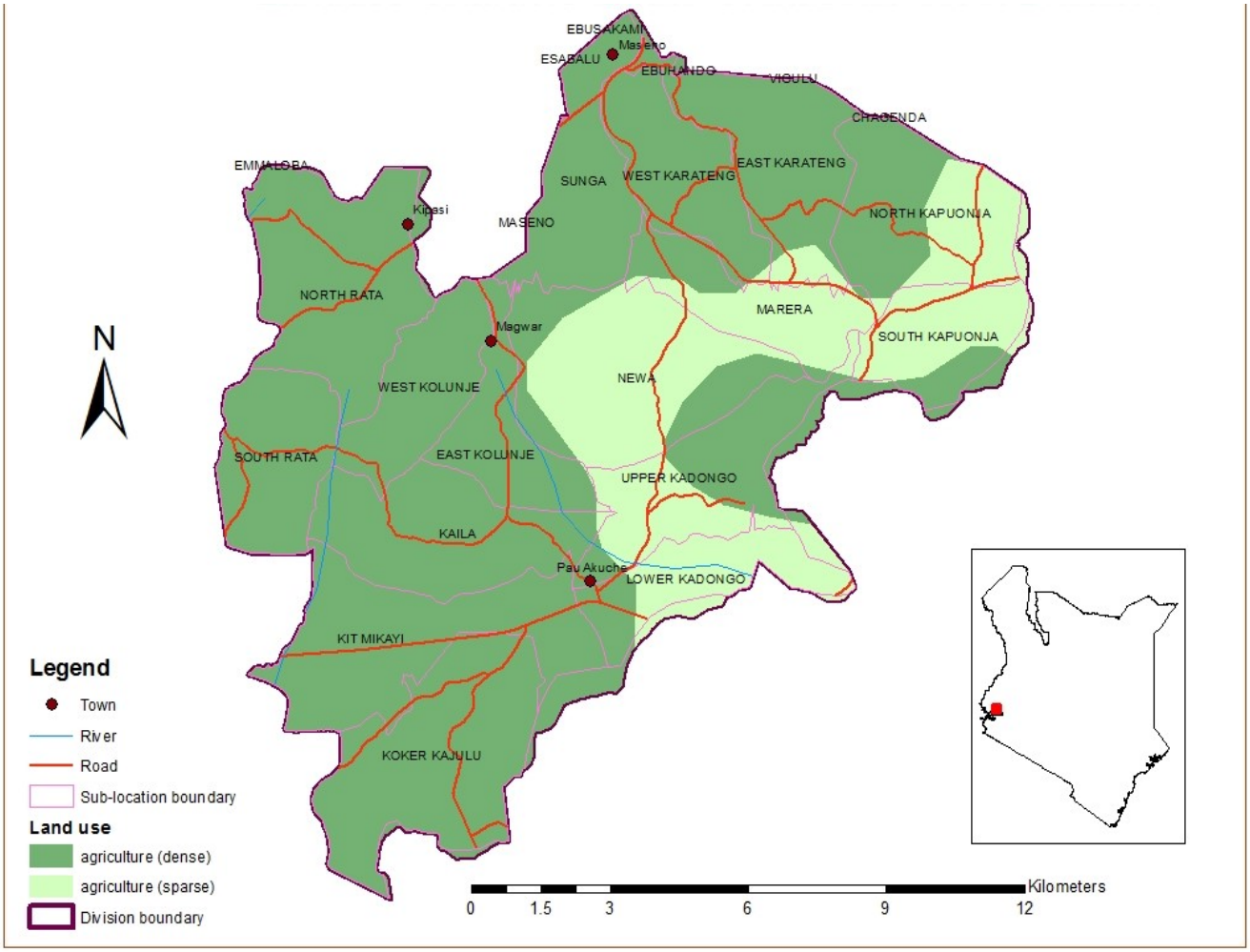
III. METHODOLOGY

Maseno Division is in Kisumu West Sub-County, Kisumu County, Nyanza Province, Kenya. The division is located within 0^0 10' 0" South and 34^0 36' 0" East. The division has an estimated 91.6 Km^2land area with almost 80 percent arable land (GoK, 2009).There are cultural and social sites like Kit Mikai which is a tourist site and connected to the Western Kenya Tourist circuit. Concerted tree growing efforts have been in the area more than two decades (AFRENA, 1996; 1997 and 1998). The area lies along the Equator and in Agro-ecological zones (AEZ) 3-4. It receives an annual rainfall between 1500-1800m. The pattern is bimodal with peaks in March-May and September-November (GoK*,* 2009).

The area has an estimated population of 46,102 with 48 percent to 52 percent males and females (Kenya National Bureau of Statistics, 2009).The area is predominantly Luo but with other tribes in the urban and government institutions like Maseno University, Maseno National School, Maseno Veterinary farm and Kenya Forestry Research Institute (KEFRI). About 65 percent of the population lives below abject poverty line depending on substance agriculture, livestock keeping and fishing (ibid, 2009).

The study employed survey research method for quantitative data collection and Focus Group Discussion (FGDs), key informant interviews (KII) and observations for qualitative data. A purposive sampling regime capturing all the 54 community tree nurseries in the Division was used. A list of the 14 existing community tree nurseries within the division was acquired from the Kenya Forest Services- Masenostation. The remaining 30 were reached in the field using the snow balling technique (Kothari, 2004; Mugenda and Mugenda, 2008 and Collins*et al,* 2000). 10 community tree nursery owners who had closed shop, 5 KII were also interviewed. The data was input and analyzed using Statistical Package for Social Scientists (SPSS) and MS Excel at a precision level of 0.05.

ADMINISTRATIVE BOUNDARY OF MASENO DIVISION



IV. RESULTS AND DISCUSSIONS

a) Factors considered while establishing a community tree nursery

A total of 54 community tree nurseries were found within the division. Among these 41 (75.9 percent) and 13 (24.1 percent) were male and female owned respectively. The study observed that among the respondents 87.1 percent were owners and the remaining consisting of relatives. Most (79.6 percent) of the respondents were in the active labour age group of 18-55 years. 23 (42.6 percent) of the operators had secondary school education and above with only 2 (3.3 percent) having no formal education. These results are almost similar to the findings of Oduol and Franzel(2014) from Lower Nyando river basin in Kenya, that 75 percent of the tree nurseries were individually operated; and average39 years for the operators. 68 percent are male and that majority (75 percent) attained up to primary school level of education while 12.5 percent have secondary and college education.

Business ownership defines the level of decisions in both production and marketing matters (Longenecker *et al.*, 2003). The study observed that 50 (92.6 percent) of the tree nurseries are individual owned and act as the main household source of income. It was not possible to get group membership information. Since most of the tree nurseries are individually owned, it is suffice to state that good production processes plays a vital role sustainability since decision making power relies on a few people giving thrust to connection power over the other power bases (Toseland and Rivas, 1998 and Mulwa, 2002). The decision making process can be well defined and posterity achieved unlike groups and institutions.

All businesses require financing. The source of finance is incumbent upon the owner as it determines the level of ownership, sacrifice and benefits access. It was noted that all the interviewed tree nursery operators access finance from on-farm sales; own savings; formal and informal group

contributions and subscriptions; and friends and relatives. Only 1 (1.9 percent) naively indicated loan as a source of finance. Financing is vital though limiting for small-holder farmers in Kisumu County as has been earlier observed as some of the impediments to agricultural development (GoK, 2009; GoK, 2013; Thorlakson, 2011; and Thorlakson and Neufeldt, 2012).Further, financing is impeded by lack of proper planning (Oduol and Franzel, 2014. This is also noticed in the under-investment in forestry which Kant and Appan (2013) assert as the central issue facing forestry since earnings from existing forests are undervalued therefore not competitive with other services. The market mostly recognizes timber and a few non-timber products not considering the other goods and services offered. Value of seedlings and the costs are equally not taken care of. There are observations in Sub-Saharan Africa that small family farms dominate. For example, in 2004 family farms contained over 92 percent of the world's 1.1 billion "dollar poor" consuming less than one US dollar per person per day (Lipton, 2005). The poverty situation would be addressed through prudent management of community tree nurseries as they improve community livelihoods and well- being, thriving on social capital while responding to environmental management and conservation (Roshetko *et al.*, 2010 and Oduol and Franzel, 2014).

Tree nurseries provide optimum care and attention to the young seedlings during their critical juvenile stage resulting in production of healthy and vigorous seedlings (Roshetko *et al,* 2010, Evans, 1982, Moir *et al.,* 2007 and Wightman, 1999). Since tree growing is a long term investment, the quality of the seedling (root shoot ratio, leaf colour and sturdiness) is important in any seedling production unit. Commonly the quantity (number of seedlings available for planting at a given time) varies and is a drive to tree nursery establishment. The study observed that 51 (94.4 percent) of the operators consider income as a reason for establishing their tree nurseries compared to 44 (81.5 percent) and 28 (51.8 percent) for quality seedlings and quantity (required numbers) at planting respectively. On ranking 53.7 percent mentioned income as the first reason to consider. These results negates Roshetko *et al. (*2010) and Wightman (1999) belief that community tree nurseries are established to fill the quantity and quality void rather than for income. The FGDs and key informants confirmed that most of those planting trees require quality seedlings and willingness to pay any prices. The most important issue is the assurance that the seedlings will grow and provide the intended end use. One tree farmer said that *"since tree planting is a long-term investment, I would rather pay a higher price for quality seedling while sure that I will get the right quality product when time comes".*

For the community tree nursery operators to realize the intended incomes, they must know the costs. Cost is the amount which is spent to produce or buy a commodity to earn income (Saleemi, 2000). They are the expenditures incurred in acquisition of both fixed and current assets therefore defined as fixed and current (variable or recurrent) costs respectively. Fixed assets are the assets that can be used for more than one season or year. Their cost is independent of the number of seedlings produced. The following assets were mentioned by the operators: shade (16.7 percent), watering cans (50 percent), watering containers (55.6 percent), spades (64.8 percent), jembes (88.9 percent), pangas (74.1 percent), sowing beds (14.8 percent) and pruning knives (14.8 percent). There were a number of variations in the costs depending on the sizes and qualities purchased. Computing actual fixed cost was a challenge since the same tools are used in other farm activities. The results are in line with Oduol and Franzel (2014) findings. However it was observed that the fixed costs constitute only on average seven percent of the total cost.

Variable costs are costs that vary with production level (Longenecker *et al.*, 2003). These included potting media, potting bags, water, labour, land rent and seeds. Different potting media (substrate) were observed in the nurseries depending on the available soil within the nursery. Most of the nurseries excavated soil from within the nursery area which is not sustainable since soon they will start excavating the top soil from the farms which may drastically affect production of other crops. Only five operators were using farm yard manure. In depth discussions revealed that most of the operators do not consider the opportunity costs. Variable costs constitute between 91 to 99 percent of the total seedling production costs. The costs are in terms of: Labour 39.1 percent; Seeds 23.7 percent; Potting media 13.1 percent; potting bags 13.1 percent: water 7.8 percent; and land rate/ rent 3.2 percent.

Reasons	Rank						Total	
	1st	Percent	2nd	Percent	3rd	Percent	All who gave the reason	Percent
Quality of seedling	19	35.2	14	25.9	11	20.4	44	81.5
Quantity of seedlings	6	11.1	14	25.9	8	14.8	28	51.8
Income generation	29	53.7	19	35.2	3	5.6	51	94.4
None	0	0	7	13.7	32	59.5		
Total	54	100	54	100	54	100		

Source: Field Data

b) Locating a community tree nursery

It is important to consider certain factors while locating a tree nursery. According to Longenecker *et al. (*2003) the individual item (tree seedlings), product line (number of seedlings per given tree species) and the product mix (number of tree seedlings per species per tree nursery) hence product mix consistency (similarity of the product lines) depends on the location of a tree nursery. The location determines the cost of production in terms of material (potting media, tree seed, labour, water) availability. Therefore considerations must be made on a number of issues in terms of seedling growth and management. Permanent (constant) water supply; a gentle slope; good potting soil (media); seedling security; accessibility during all the year; area free for expansion and shade are prerequisites (Evans, 1982,Roshteko *et al.,* 2010, Moir *et al.,* 2007 and Oballa *et al.,* 1990).

It is estimated that on average a thousand tree seedlings require 20 litres of water. Gradient affects the maintenance cost. Very steep sites would result into losses as seedlings can be washed away during heavy down pour. Too flat areas would also encourage water logging then diseases to the seedlings (Evans, 1982). Potting soil is required for each and every tree seedling therefore proximity reduces cost of production. Loss in terms of theft and/or damage by pests also increases production cost (Moir *et al.*, 2007). Accessibility reduces related production costs like transport and even customers. Any business has growth prospects therefore an area free for expansion would help reduce cost of shifting and even management (Longenecker *et al*, 2003). Shade is a must in the nursery and will always help in increasing losses especially at pricking out (Moir*et al.,* 2007, Jaenicke, 1999 and Wightman, 1999).

All the mentioned factors have implications in the overall production and production costs. The study revealed that availability of water reigned high but with same scores to security (27.8 percent) as number one priority (Table 3). The cumulative numbers revealed that water and potting soil were important as 72.2 percent of the 54 respondents mentioning them. Security was not far off (70.4 percent). The study revealed market as an additional factor considered even though mentioned by only one operator. A follow up during FGD and in-depth interview revealed that most of the operators did not consider market because they are able to sell what they produce so long as they are of good quality and at the right time. Timing is therefore an issue to reckon in community tree seedling production since most of the operators rely on weather conditions for production and marketing. The other reasons like gentle slope, accessibility, area free for expansion and shade were equally considered. These results could be attributed to the area's bimodal rainfall with climax in April and May; and the awareness on the importance of tree growing. During FGDs it was reported that every person would wish to plant a tree regardless of where and how he/she obtains the seedling.

The size of a tree nursery will determine the number of seedlings an operator can produce. Operational costs also depend on the size of the tree nursery. The larger the tree nursery the higher the likelihood of mechanization which reduces production cost. Individual nursery area is mainly determined by level of annual seedling production, method of raising the seedlings and nursery life of the seedlings (Evans, 1982). He alludes that a total area for producing an estimated one million seedlings including shade, access tracks and storage is about 4 ha where nursery life of plant is more than one year. He indicates 1.5-2ha where it is between four months and one year and 0.5-1ha where it is less than four months and several crops are grown in one year. His last description befits the operators interviewed. Most 39 (65 percent) of the tree nurseries are of 10m x 10m (0.001ha). This means that effectively these nurseries should be producing 20,000-40,000 assorted tree seedlings. This may also be dictated by the sizes of the containers. Otherwise this is in line with Roshetko *et al.* (2010) estimate of up to 10,000 seedlings per season. Oballa *et al. (*1990), also stipulate that a 10m x 10m is required to raise 10,000 seedlings per year in standard containers. This should be enough to take care of access paths and shade.

Table 1 Factors considered while locating a tree nursery site

Reasons	Rank							Total on factors
	1st	2nd	3rd	4th	5th	6th	7th	
Permanent water source	15 (27.8%)	13 (24.1%)	4 (7.4%)	6 (11.1%)	1 (1.9%)	0 (0.0%)	0 (0.0%)	39 (72.2%)
Gentle slope	2 (3.7%)	4 (7.4%	6 (11.1%)	6 (11.1%)	1 (1.9%)	1 (1.9%)	2 (3.7%)	22 (40.7%)
Potting soil	8 (14.8%)	10 (18.5%)	14 (25.9%)	3 (5.6%)	2 (3.7%)	2 (3.7%)	0 (0.0%)	39 (72.2%)
Security	15 (27.8%)	8 (14.8%)	10 (18.5%)	2 (3.7%)	3 (5.6%)	0 (0.0%)	0 (0.0%)	38 (70.4%)
Accessibility	7 (13.0%)	12 (22.2%)	5 (9.3%)	7 (13.0%	4 (7.4%)	0 (0.0%)	0 (0.0%)	35 (64.8%)
Area free for expansion	4 (7.4%)	4 (7.4%)	2 (3.7%)	6 (11.1%)	8 (14.8%)	2 (3.7%)	0 (0.0%)	26 (48.1%)
Shade	3 (5.6%)	0 (0.0%)	5 (9.3%)	3 (5.6%)	1 (1.9%)	6 (11.1%)	1 (1.9%)	19 (35.2%)
Market	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.9%)	0 (0.0%)	1 (1.9%)
None	0 (0.0%)	3 (5.6%)	8 (14.8%)	21 (38.9%)	34 (63.0%)	42 (77.8%)	51 (94.4%)	
Total	54 (100.0%)	54 (100.0%)	54 (100.0%)	54 (100.0%)	54 (100.0%)	54 (100.0%)	54 (100.0%)	

Source: Field Data

c) Species produced and reasons for their production

Tree seedlings are the product items in a tree nursery while species form the product line. Most buyers come knowing the species of tree they require and even the numbers of seedlings. It therefore means that for meaningful business venture the tree nursery operators should produce tree species in demand within the area and the neigbourhood. The economic viability would depend on the species, numbers produced and sold. Much has been done in terms of tree nursery site selection, size and number of seedlings to produce but not on which tree species to produce. Depending on the reason for establishing the tree nursery one is always guided by the prevailing weather conditions, expected end use, the technology to be used among many considerations (Roshteko*et al.,* 2010). For example if one is in the Arid and Semi Arid Areas (ASALs) the species selection will be dictated by climatic conditions and the AEZ in terms of rainfall, evapo-transpiration, soils, temperatures and humidity among others. This makes each planting site unique and requiring corresponding species and provenance (Milimo, Kimondo and Chikamai, 1990).

Tree nursery operators must be privy to such factors as they select which species to produce since this will determine the incomes. Most of the operators produce exotic tree species. Eucalyptus species tops the list (83.3 percent) followed by *Grevillea robusta* (64.8 percent), Casuarina species (22.5 percent) and *Dovyalis caffra* (17.2 percent). *Markhamia lutea* an indigenous tree species comes fifth after flowers. A total of 31 different species were reported (28 tree species, one vine, one bamboo and a number of flowers). Different tree nurseries produced different species with diversity ranging from 1-10. A number of flower species were in the tree nurseries but were lumped together.

The study observed that as much as the tree nursery operators are in business, cumulatively 86.1 percent did not know why they raise seedlings of the given species. The remaining indicated their choice to be dependent on uses, tolerance to diseases, pest and drought and seed availability. Among the uses timber reigned highest (39 percent), followed by fruit trees and agroforestry at 18.9 and 15.5 percent respectively. This could be explaining why most tree nurseries were growing *Eucalyptus species, Grevillea robusta* and *Casuarina species* thus matching the report by Oduol and Franzel (2014) in the Nyando Basin. There are eleven timber species; six fruit tree species; three for aesthetic value; three medicinal trees; three fodder trees; two fuelwood tree species; and one species for fencing. The flowers are mainly for aesthetic value while bamboo is for soil conservation.

These results confirm the preference for exotic to indigenous tree species. Eucalyptus species is reportedly the most occurring species strengthening its position as the widely cultivated forest trees in the world. These findings show the likelihood of overdependence on one species which could be having ripple effects on the environmental management. Farmers confirmed their preference for the two species (*Eucalyptus species* and *Grevillea robusta)*. Most of them like these species due to the products and potentially fast growth. There was a notion among the farmers that indigenous species are slow growing and that is why they are shying away from growing them. This notwithstanding socio-cultural values are still attached to some of the indigenous species thus their continued planting.

The results here agree with the other reports that Kenya has an estimated 100,000 ha of Eucalyptus species comprising 15, 000 ha in gazetted forests; 35,000 on private owned land by large companies; 50,000 ha on individual farmers' land and local authorities (Oballa *et al.*, 2010). Despite being introduced for woodfuel supply for the Kenya-Uganda railway in 1902, Eucalyptus is now grown for timber, plywood, transmission poles, pulp, building materials, fencing posts, rail (fittos), windbreak, ornamental and environmental enhancement (ibid, 2010).

The results conform to the findings of a survey in Murang'a district (Nieuwenhuis and O'Connor-unpublished) which reported an almost similar trend with heavy reliance in the region on a single exotic tree species, *Grevillea robusta*. Although this species fulfils many functions, such as supply of fuelwood, timber, fodder, shade and mulch (Harwood, 1992), reliance on one species is dangerous. An example of damage caused by pathogens was seen when *Leucaena leucocephala* and *Cupressus lusitanica* were attacked throughout Kenya in the early 1990s and the entire crops destroyed at nursery and plantation (Nieuwenhuis and O'Connor-unpublished).

The listed uses agreed with those highlighted by Maundu and Tengnas (2005) and Milimo *et al (*1990). The categorization is a clear indication that the operators understand the uses of the species (though disturbing because only 13.9 percent responded) they are raising even though differentiations could not be easily made on agro forestry and the other uses. The FGDs and in-depth interviews showed that all trees have agro forestry potential. It was also noted that since most men were interviewed than women, no wonder the fuelwood issue did not come up strongly as compared to timber. One of the women said *"Men always think construction. That is where we test their strength. They also love money that comes readily from timber. My strength is in the kitchen. How I wished I was in the interview. All the same we still get fuelwood when they cut trees for timber. We need trees for our day to day living."*

Despite the production of likely preferred tree species, there is always a mismatch between the demand and supply. Most of the operators indicated seasonal and annual variations in demand. This has resulted in the operators occasionally having too much or too few of given species. Since production is not synchronized there is economic loss either way. Understanding and predicting the production is vital for economic viability in the seedling production process.

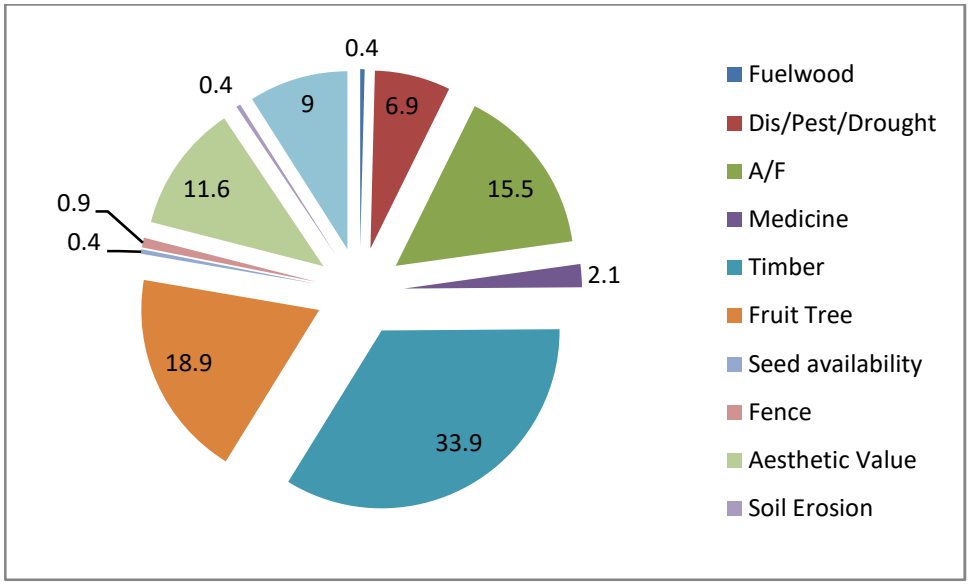


Figure 1 Tree nursery reasons for raising given species

Source: Field Data

d) Challenges in tree seedling production

1. in the tree nursery

Community tree seedling production has been riddled with a number of challenges. As indicated in Table 4 water remains a key challenge with 57.4 percent mentioning it. Oballa *et al.* (1990) estimated 300 litres of water per day for 10,000 seedlings in the dryland and 20 litres per day for 1,000 seedlings in Western Kenya. It is in line with the earlier results that 72.2 percent of the tree nursery operators mentioned as prerequisite to locating a tree nursery. The results conform to studies elsewhere by Nieuwenhuis and O'Connor (unpublished) findings in Muranga District in Central Kenya that water supply was a limiting factor in over one third of nurseries, regardless of the nursery size, the location or agro-ecological zone.

Pest and diseases have also been noted by 42.5 percent. Tree seedlings suffer from a number of pest ranging from sucking to cutting. A number of diseases like damping-off and wilting do occur. This is why every tree production book or manual must endevour to provide solutions. The results here are in line with the findings of Oduol and Franzel, 2014 in Nyando basin where pesticides had to be included in the cost of production and taking a given percentage.

Seed forms an integral part of seedling production. Availability, viability, purity and price are factors to consider (Muriuki, 2005). Oduol and Franzel (2014) also include them while costing for seedling production. Nieuwenhuis and O'Connor (unpublished) also note that there is danger in supplying of *Grevillea robusta* seed from one source. Since most of the tree nursery operators produce almost homogeneous products, competition due to free entry and interference by other actors may be real (Oduol and Franzel, 2014) but it also to a degree explains why most of the producers close-shop. They come with high expectations then realize the demand and supply dynamics. Labour, insecurity and cost of potting bags illustrate the high variable cost in this finding and the part they play in Nyando Basin (ibid, 2014). Even though most of the labour is family members occasionally the operators have to hire.

The other challenges like infertile soil and inadequate knowledge are inconsequential since the heavy presence of other actors. This notwithstanding the missing of market and poor pricing raise questions of the prevailing contrast between what the buyers consider challenge and what actually is making the operators close the business. The operators mention income as the main reason for starting the tree nurseries yet fail to mention marketing. The absence may partially the findings of Oduol and Franzel (2014) that the margins would be negative should fixed costs be included, other actors be locked out and business be left to the forces of demand and supply despite the good prices offered by neighbours. Generally, a good potting media should be light in weight to facilitate transport yet hold seedlings firmly; does not shrink nor swell in a manner that can cause seedling damage; has good water drainage capacity; well aerated; contains necessary nutrients for seedling growth and development; does not contain weed seeds; low in toxic salts and harmful micro-organisms; can be sterilized without changing the characteristics; and the quality is consistent from year to year(Wightman, 1999). These were lacking and operators can correct by mixing parts as: clay soils-one soil, two sand and two compost; loamy soils- equal parts of soil, sand an compost; and sandy soils- one soil, zero sand and one compost (Wightman, 1999, Evans, 1982 and Moir *et al.*, 2007).

Through FGDs and in-depth studies, the study discovered the existence of an unclear market structure resulting into the loss

of seedlings during and after production. It was not possible to quantify the numbers lost throughout the production process since most of the operators replace the dead seedlings and only consider the ones ready for planting and/or sale to have been produced. It was observed that this though not documented is pushing production costs up since the labour is always paid at the different tending operations (seed sowing, pricking-out, watering, weeding, hardening-off. The other loss comes due to the number of seedlings that remain unsold or unplanted. These remnants escalate production costs since they have to be continually tended. The study found out that the remnants constitute 12.6 percent while those lost through pest and diseases account for 16.5 percent. From this it was evident that only 70.9 percent of the 744,076 seedlings produced are sold and/or planted.

Table 2 Challenges in community tree seedling production

Reasons	No	Yes
Inadequate water	23 (42.6%)	31 (57.4%)
Pest and diseases	31 (57.4%)	23 (42.5%)
Expensive labour	47 (87.0%)	7 (13.0%)
High seed prices	40 (74.1%)	14 (25.9%)
Long seed procurement procedures	53 (98.1%)	1 (1.9%)
Infertile soil	51 (94.4%)	3 (5.6%)
Competitors	40 (74.1%)	14 (25.9%)
Insecurity	47 (87.0%)	7 (13.0%)
Inadequate knowledge	54 (100.0%)	0 (0.0%)
Cost of potting bags	47 (87.0%)	7 (13.0%)

Further, the tree nursery operators understand the seedling production processes. They are able to establish the tree nurseries in the right places thus reducing operational costs but water and soil are still the main constraints despite being the main items required in any tree nursery. This therefore makes running the tree nurseries expensive as most of the operators have to buy water and potting soil.

2. Production techniques

It was observed that all the tree nursery operators were using local materials with limited training and value addition. Despite the levels of education, ownership and financing, the techniques employed did not show any high level technologies like root trainer containers, soil sterilization, equipment, watering pumps and spraying machines among others (Roshetko *et al.,* 2010 and Evans,1982). Longenecker *et al.,* (2003) asserts that most businesses thrive on the depth of the product line and wider product mix. In the tree nursery set up, the higher the tree species and the higher the number of tree seedlings per given species would determine the viability of the ventures. The study revealed that only 10 (18.5 percent) of the tree nursery operators are doing value addition (grafting, rooting of cuttings, tissue culturing, air laying, cloning, seed pre-treatment) thus increasing the product line and mix. Seven are raising flowers from cuttings, two grafting mangoes while one is raising bamboo from cuttings (Figure 2). These show opportunities for diversification in the tree nursery activities.

Figure 2 Bamboo seedlings in a tree nursery

3. Training and its impacts

Training is vital in the performance of any task. As it is only 29 (53.7 percent) of the tree nursery operators interviewed indicated having had training on tree nursery establishment and management. The trainings were received mostly from NGO's and research organizations within and outside the division. There was indifference on the need for further trainings as most of those interviewed remained non-committal on the importance of the trainings. It was not possible to capture the nature of trainings and content as most of those trained only indicated tree nursery establishment and management. The FGDs revealed that most of the trainings were hands-on and took three days. Much covered was on production processes. Key informants interviewed lamented the poor organization and training delivery techniques. One of them said *"the trainings were organized to help spend money but not to empower the trainees"*. Further follow up with the trainers revealed that there was a hand-out syndrome in the community that the trainees do not attach much to the trainings. The triangulation brought to book the value of trainings and the need to have the trainees own the process.

Muriuki (2005) attests to the inadequacy of the content of training courses undertaken for tree nursery operators in tree seed collection and handling. Short training sessions, subjects handled including general agro forestry, tree nursery operations, tree management for seed production and seed harvesting made it difficult to ensure quality tree seed

production and procurement. The composition of trainees (tree nursery operators basically farmers) with co-opted extension staff in the 1980s far affected the training results and adoption.

These results therefore indicate the need to understand what content to give to what trainees and for how long. Participation should therefore be sought at all levels while designing such projects.

Figure 4 Over-grown seedlings in a tree nursery

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