African Journal of Agriculture and Utilisation of Natural Resources for Sustainable Development 1 (1): 38-45, January, 2015
ISSN 2313-1306
Available Online at www.ajausud.org

Financial analysis of growing *Eucalyptus grandis* for production of medium size power transmission poles and firewood in Kenya

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Abstract: *Eucalyptus grandis* are grown in most ecological zones and variety of soils in Kenya. Eucalyptus production is likely to increase due to rising demand for transmission poles and firewood. The demand has motivated tree growers to grow *E. grandis* for income. Costs of seedlings, plantation establishment and maintenance and growth data were collected through field surveys and from five experimental plots of KEFRI at Londiani and 13 plantations in Kericho County owned by Sotik Tea Company. Secondary data on yields were obtained from existing literature on Eucalyptus growing in Kenya. Growth data was used in estimating wood volume per unit area. Financial analysis was undertaken using Net Present Value (NPV), Equal Annual Equivalent (EAE) and Internal Rate of Return (IRR) for a 10-year rotation period for medium power transmission poles and firewood production at discount rates of 8, 12 and 16 percent. It was observed that Eucalyptus growing for firewood generated undiscounted net income of KES 390,306 with NPVs of KES 147,707 ha^{-1},85,343 ha^{-1} and 45,546 $ha^{-1}yr^{-1}$, and EAEs of KES 40,560 $ha^{-1}yr^{-1}$, 15,105 $ha^{-1}yr^{-1}$ and 9,419 $ha^{-1}yr^{-1}$ at discount rates of 8, 12, and 16 percent respectively. The medium power transmission poles production gave undiscounted net revenue of KES 1,940,305 ha^{-1} with NPVs of KES 860,707ha^{-1}, 581,345 $ha^{-1}yr^{-1}$ and 402,046 $ha^{-1}yr^{-1}$, and EAEs of KES 237,555 $ha^{-1}yr^{-1}$, 102,898 $ha^{-1}yr^{-1}$ and 83, 143 $ha^{-1}yr^{-1}$ at discount rates of 8, 12 and 16 percent respectively. The firewood and medium power transmission poles production had a positive IRR of 5.2% and 27.5%, respectively. Growing *E. grandis* for medium size transmission poles and firewood is profitable in Kenya.

Key words: Financial analysis, Eucalyptus, Internal Rate of Return

INTRODUCTION

The genus Eucalyptus comprises of more than 900 species and various hybrids and varieties. Eucalypts were introduced to Kenya in 1902 to provide firewood for Kenya-Uganda Railway and to substitute declining natural forest vegetation. They are grown in most ecological zones in Kenya and on a variety of soils. They are popular among tree growers because of fast growth, good stem form, coppicing ability, tolerance to water logging, multipurpose use, and good working characteristics. Eucalypts are used for timber in construction and joinery, plywood making, power transmission poles, pulp and paper, fencing posts, firewood, bee forage, medicine, oils for perfumes and pharmaceuticals, ornamental, provision of shade, windbreaks, and soil stabilization.

There are over one hundred Eucalyptus species grown in Kenya (Gottneid and Thogo, 1975) and they cover an area of 20,000 in gazetted forests. The small scale farmers, large companies and local authorities own large tracts of Eucalyptus forests estimated to be over 200,000 ha (Kenya Forest Service, 2009). *Eucalyptus grandis* is mainly planted in humid and sub-humid regions (Ecological zone I) between 1400 and 2500 m above sea level (a.s.l). The area under Eucalyptus is likely to increase due to rising demand for power transmission poles, materials for construction industry, fuelwood, establishment of carbon sequestration and climate change mitigation projects.

The readily available market for Eucalyptus products has in the recent years motivated farmers to grow the species as a cash crop. However, there is limited empirical data on costs and benefits of Eucalyptus production in Kenya. This study assessed financial viability of growing *E. grandis.* The objective of is the study was to provide information on yields, costs and benefits of growing *E. grandis* for production of medium power transmission poles and firewood.

MATERIALS AND METHODS

Both primary and secondary data were used. Primary data were collected from field surveys and inventory of five years old *E. grandis* experimental plots of Kenya Forestry Research Institute (KEFRI) at Turbo and Londiani Centres, and 13 plantations of E. *grandis* in Sotik, Kericho County. Secondary data were collected through desk study in form of literature review of both published and unpublished sources. The collected information included growth performance, costs and benefits, and models for estimating yields of Eucalyptus at diverse local conditions in Kenya. Growth data were obtained from an inventory of the above 13 plantations. The study area is located at an altitude of between 1725 and 1852 m and with an average annual rainfall of 1685 mm, and average annual temperature of 22ºC.Twenty temporary sample plots of 10 m by 10 m were established in each age between 5 and 13 years. Data on trees diameter at breast height (DBH) and total height were measured using diameter tape and Suunto hypsometer, respectively. The costs of seedlings, plantation establishment and maintenance were obtained from the 13 plantations. Growth data were supplemented from records at Kenya Forestry Research Institute (KEFRI) and Kenya Forest Service (KFS). Labour task rates for various forest operations (nursery, tending etc.) were obtained from KFS files.

Growth data were entered into Microsoft Excel for cleaning and analysis. Mean values for the diameter at breast height (DBH) and height were calculated and used to estimate volume applying growth and yield model developed by Kiriinya (2004) for young *E. grandis* plantations at Muguga. The model is presented below.

Yield Model: $V = \quad C_O + C_1 D^2 H$

Where, V - Total volume over bark (m^3);

D - Mean diameter at breast height (cm);

H- Mean total height (m);

C_O and C_1 are constants adopted from (Kiriinya, 2004).

Forest investments are affected by diverse factors, some of which are easy or difficult to measure

due to dynamic business environment. To ease the complexity in analysis, it was necessary to make assumptions to reflect the likely scenarios. The interest rates were assumed to be constant throughout the rotation. Assumptions were also made on prices of products; cost of land, capital, labour and yields.
Current and future prices of products are affected by demand and supply situations; location of the stand and tree species under consideration. Prices of both firewood and power transmission poles were assumed to be constant throughout the rotation period and were derived from the average current market prices.

Cost of land was estimated using current land lease value per year. Prices of farm inputs and labor were actual market prices and were assumed to apply throughout the rotation period.
The growth performance was based on the collected growth data, a stoking of 1600 plants per ha (spacing of 2.5 m x 2.5 m) with a survival of 80% and 70% of the trees classified as class II power transmission poles and the remaining 30% as firewood, no intermediate thinning at every cutting cycle, yield prediction model by Kiriinya (2004), and incomes were tax exempt.

A discount rate is the interest rate applied to convert future revenue streams and costs to present values and rates of between 8% and 15% are adopted for forest projects (Gittinger, 1982). In our analysis, discount rates of 8%, 12% and 16% were used. Net present value (NPV), internal rate of return (IRR) and equal annual equivalent (EAE) were used to assess the profitability. The NPV is the present value of expected future revenues minus the present value of expected future costs, with the costs and benefits discounted at the appropriate interest rate and are calculated as follows:

$$NPV = \sum_{0}^{n} \left(\frac{B_t - C_t}{(1 + r)^r} \right)$$

where, B_t = Benefit in each year;
C_t = Cost in each year; t = (1, 2… n),
n = Rotation and
r = Discount rate

The Internal Rate of Return (IRR) rate is the of interest at which the initial investment NPV is zero, and the Equal Annual Equivalent (EAE) is an annual payment that pays off the NPV of an asset during its lifetime The EAE is calculated as follows:
EAE = Net Present Value (NPV) multiplied by annuity factor (A_f)

where, Annuity factor $A_f = \left(\frac{r(1+r)^t}{(1+r)^t) - 1} \right)$

r- Discount rate,
t - Time in years

RESULTS AND DISCUSSION

The growth of *E. grandis* in Sotik highlands had an average diameter at breast height (dbh) of 12.2 to 20.3 cm and height of 13.2 to 25.2 m for ages 5 to 10(Table 1). The potential yield varied from 30.4 to 57.4 $m^3 ha^{-1} yr^{-1}$ (Table 2).

Table 1: Mean DBH and height of *E. grandis* at Sotik in Kenya

Age (years)	Diameter at breast height (cm)	Height (m)
5.0	12.19(2.30)	13.20(0.92)
6.0	14.78(3.63)	15.6(1.99)
7.0	15.69(3.59)	15.80(2.28)
8.0	17.88(5.65)	23.65(2.65)
9.0	20.23(5.16)	24.65(3.44)
10.0	20.33(4.31)	25.15(4.47)

Values in parenthesis are standard deviations (SD)

Table 2: Potential yields of *E. grandis* at Sotik in Kenya

Age (years)	Volume $tree^{-1}(m^3)$	Volume $(m^3\ ha^{-1})$	Mean annual increment (MAI) $(m^3\ ha^{-1} yr^{-1})$
5.00	0.09	151.76	30.35
6.00	0.16	252.11	42.02
7.00	0.20	326.41	46.63
8.00	0.27	434.34	54.29
9.00	0.32	517.25	57.47
10.00	0.35	562.99	56.30

Table 3: Growth data of *E. grandis* in Kenya

Site	Age (years)	Volume $(m^3\ ha^{-1})$	MAI $m^3\ ha^{-1} yr^{-1}$	Source(s)
Turbo	7.0	299.0	42.7	Kimondo, J and Konuche P.K. (1989)
Turbo	6.0	215.0	35.8	KEFRI unpublished data at Turbo
Muguga	6.0	104.2	17.4	Holland and Freeman (1970), Dyson, W.G (1974), Kaumi, S.Y.S (1983)

The volume of wood produced from 1 ha of land in a given period depends on many factors including: site quality, quality of seedlings, silvicultural operations, competition and use of fertilizers. This is reflected by variable yields reported from various parts of Kenya for *E. grandis* (Table 2 and 3). Based on fuel wood production research conducted at Muguga from 1955 to 1977 (Holland and Freeman, 1970; Dyson, 1974; Kaumi, 1983), yields from Eucalyptus plantations ranged from 17.3 to 39.6 $m^3ha^{-1}yr^{-1}$ for the seedling crop and from 16.5 to 55.8 $m^3ha^{-1}yr^{-1}$ for coppices. Results from KEFRI research trials in Turbo give the yield of seedlings crop as from 35.8 to 43.3 $m^3ha^{-1}yr^{-1}$. Selected high quality seed source of *E. grandis* under intensive management regimes have attained higher productivity of between 48 $m^3ha^{-1}yr^{-1}$ and 75 $m^3ha^{-1}yr^{-}1$ at Kericho (FAO/World Bank, 1989). This is consistent with other findings that *E. grandis* from quality seed sources planted in high potential areas under intensive management yields 60 $m^3ha^{-1}yr^{-1}$(Kiriinya, 2007. The Results from recent inventories of Eucalyptus plantations in Changoi Estate in Kericho, and Kaimosi in Nandi showed E. *grandis* yields of between 38 to 62 $m^3ha^{-1}yr^{-1}$ (KEFRI unpublished data, 2009). The cost of establishing and maintaining 1ha of *E. grandis* from planting of seedlings to a rotation age of 10 years was KES 69,695 (Table 4).

The undiscounted net revenue for *E. grandis* firewood enterprise at 10 years was KES 390,306 ha^{-1} and returned a NPV of KES 147,707 ha^{-1}, 85,343 ha^{-1} and 45,546 ha^{-1} at 8%, 12%, and 16% discount rate respectively. The firewood enterprise has the potential to generate between about KES 40,560 $ha^{-1}yr^{-1}$, 15,105 $ha^{-1}yr^{-1}$ and 9,419 $ha^{-1}yr^{-1}$ at 8, 12, and 16 percent discount rate, respectively. It is notable that growing Eucalyptus for firewood is profitable at low discount rate and as the rate increases, the NPV and EAE decreases. Under the current set of assumptions, the internal rate of return (IRR) for firewood production 5.2%, which is comparable to other investments including bank savings accounts, government securities and corporate bonds with annual yields ranging from 4% to 13% (KNBS, 2012). This implies growing of Eucalyptus for firewood at high discount rates is not attractive.

The medium power transmission pole production gave positive net returns at the higher discount rates. The undiscounted gross revenue for *E. grandis* medium power transmission poles production was about KES 2.0 mil.ha^{-1} and its NPV ranged from KES 402,046 ha^{-1} to KES 860,707 ha^{-1}. This is equivalent (EAE) of between KES 83,143 $ha^{-1}yr^{-1}$ and 237,555 $ha^{-1}yr^{-1}$ at the various discount rates (Table 5). The medium power transmission pole production had an IRR of 27.8% which is much higher than other investments including bank savings accounts, government securities, and corporate bonds.

Table 4. Costs of planting and maintenance of 1 ha of *E. grandis* for 10 years

Year	Activity/items	Units	Unit cost (KES)	Total cost (KES)	PV (8%)	PV (12%)	PV (16%)
1	Seedlings purchase	1700	10	17000	17000	17000	17000
1	Transport of seedlings	1600	1	1600	1600	1600	1600
1	Land preparation						
	1st ploughing	1	6175	6175	6175	6175	6175
	2nd ploughing	1	5400	5400	5400	5400	5400
	Harrowing	1	3700	3700	3700	3700	3700
	Staking	10LD	230	2300	2300	2300	2300
	Pitting	20LD	230	4600	4600	4600	4600
	Planting	15LD	230	3450	3450	3450	3450
1	Fertilizer	50kg	60	3000	3000	3000	3000
2	Slashing/general cleaning	12LD	230	2760	2567	2456	2374
3	General cleaning	12LD	230	2760	2374	2208	2042
	Round up	1.0 l	800	1000	860	800	740
	Labour spraying	3 LD	230	690	593	552	511
4	General cleaning	12LD	230	2760	2180	1960	1766
	Round up	1.0 l	800	1000	790	710	640
	Labour spraying	3 LD	230	690	545	490	442
5	Slashing/general cleaning	12LD	230	2760	2042	1766	1518
6	General maintenance	7LD	230	1610	1095	918	773
7	General maintenance	7LD	230	1610	1014	821	660
8	General maintenance	7LD	230	1610	934	725	564
9	General maintenance	7LD	230	1610	869	644	500
10	General maintenance	7LD	230	1610	805	580	499
	Sub-total			69,695	63,893	61,855	60,254
11	Harvesting	M^3	200	240,000	110,400	76,800	55,200
	Total			309,695	174,293	138,655	115,454

Table 5: Financial evaluation of 1 ha of *E. grandis* firewood and power transmission pole enterprises at 10 years.

				Discount rate		
A. Firewood		Quantity	Total	0.08	0.12	0.16
Total costs			309,695	174,293	138,655	115,454
PV	2000	350	700,000	322,000	224,000	161,000
Undiscounted net revenue			390,306			
NPV				147,707	85,343	45,546
Equal annual equivalent (EAE)				40,560	15,105	9,419
IRR (%)						
5.2						
B. Medium power transmission pole						
Total costs			309,695	174,293	138,655	115,454
1.Revenue (sale of poles)	2,300	900	2,070,000	952,200	662,400	476,100
2.Remnants 10% of total volume sold as fire wood		90	180,0000	82,800	57,600	41,400
Total benefits			2,250,000	1,035,000	720,000	517,500
Undiscounted net revenue			1,940,305			
NPV				860,707	581,345	402,046
Equal annual equivalent (EAE)				237,555	102,898	83,143
IRR (%)						27.8

CONCLUSION

Based on the current market prices and prevailing economic conditions, growing of *E. grandis* for medium power transmission pole production and firewood is profitable and is more profitable for medium power transmission poles than firewood.. The IRR of growing *E. grandis* in Kenya varied from 5.2% and 27.8% for firewood and medium power transmission poles, respectively. The IRR compares well with other alternative investments including liquid capital investments. Those growing *E. grandis* in Kenya are therefore encouraged to target medium power transmission poles production.

ACKNOWLEDGEMENTS

We are grateful to KEFRI Management for providing the financial support for this study and the KEFRI Editorial Committee namely: E. Chagala-Odera, B. Kamondo, P. Tuwei, D. Ochieng and J. Wanjiku for their inputs in the manuscript. Sincere thanks to management of Sotik Tea Company for providing the data.

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