Analysis of Financial Values of Tree-level Lumber in Community Forests Plantation in two Reserves, Ghana

Technical Report Submitted to ITTO and CSIR-FORIG

Project PD530/8 Rev.3 (F)

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ITTO / CSIR-FORIG Project (PD530/8 Rev.3 (F)

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Abbreviations

CSL	Chainsaw lumber
DBH	Diameter at Breast Height
MTS	Modified Taungya System
NFPDP	National Forest Plantation Development Program
OCP	Olantan Chainsaw lumber Prices
OSP	Olantan Sawmill lumber Prices
SML	Sawmill Lumber
TCP	Twumkrom Chainsaw lumber Prices
TSP	Twumkrom Sawmill lumber Prices
VAL	Estimated value per unit volume

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Summary

The improvement of Modified Taungya System (MTS) is needed to increase community and private individual involvement in the establishment and management of plantations on the degraded portions of the state forest reserves. To achieve these, the development of more efficient methods and techniques for estimation of the value of the lumber at tree-level in the established MTS plantations are required. These methods are to help farmers engaged in MTS plantation take informed decisions on the continuous commitment in their management and protection. Unfortunately, these methods and techniques are virtually not known in Ghana's forest management practice and they can hardly be used among the participating local community members, where plantations have been established. The objective of the study was to develop a farmer-friendly tree-level lumber value calculator to enable farmers estimate their lumber value at the tree-level. The goal was to enhance community forest plantation management and increase the support and commitment of farmers to continuously protect these plantations against wild fire and illegal timber harvesting effects. Biophysical data for the tree value estimation was collected from plantations that had been established in four local communities in two forest reserves of Ghana. The average merchantable volume of the standing timber tree species and lumber volumes and their sawmill and chainsaw prices per timber species in the domestic market of Ghana were used to estimate the standing tree value per hectare. This information was used to develop the calculators for each community for future estimations of the values of trees in their respective plantations.

ANALYSIS OF FINANCIAL VALUES OF TREE-LEVEL LUMBER IN COMMUNITY FORESTS PLANTATION IN TWO RESERVES, GHANA

1.0 Introduction

Deforestation and forest degradation has again attracted international attention, largely due to its contribution to the global warming effects (Hansen *et al*, 2012). In an effort to address the global warming effects, the world's attention is drawn to reduction of deforestation and forest degradation in the developing countries (ITTO 2012). The importance for this is the least cost nature for this option and the likely improvement of poverty of local communities in these countries where previous efforts have not yielded the desired results. In Ghana, efforts are being made and measures put in place to address the deforestation and forest degradation problem with much difficulty. These measures include policy reforms, strengthening of forest law enforcements, and replanting of degraded forest areas among others. In addition, various programs have been promoted to address the diminishing natural forest resources through forest plantation development. Currently, Ghana is following a strategy by combining poverty reduction with sustainable management of its forest resources. In the 1960s, the focus was on the taungya system, in which farmers were given parcels of degraded forest reserve lands to produce food crops and to establish and maintain timber trees. Under these traditional arrangements, Ghanaian farmers had no rights to benefits accruing from the planted trees (Milton, 1994). Further, farmers did not have any role to play in decision making in any aspect of forest management (Birikorang, 2001). As a result, farmers tended to neglect the tree crops and to abuse the system. The implementation of this system was therefore stopped in 1984. Since then the program has undergone changes to the modified taungya system (MTS). This new MTS is expected to achieve increased revenues and other benefits to farmers and landowning communities in line with the objectives of the 2001 Ghana Poverty Reduction Strategy (GLSS 1992 and 1999) as reported by GSS, 2000.

Following from this, various communities, private individuals and timber firms, non-governmental organizations, Governmental agencies, are actively engaged in forest plantations establishment (Amanor, 1996; FC, 2013) particularly under the National Forest Plantation Development Program (NFPDP). There are seven different components of the NFPDP each with different funding source. An estimated 168,910ha of forest plantations has been established nationwide under the NFPDP by both public and private sectors, mainly within degraded forest reserves between 2002 to 2012 (FC, 2013).

There is an increasing need for the improvement of MTS because of the increasing community and private individual involvement. In addition, these community members and private individuals would require more efficient methods and techniques to estimate the value of the lumber at tree-level in the stands in order to take informed decisions on the continuous commitment in their management. This is where methodology on decision support system (e.g. simulators and forest management planning software/tools) is very much needed (Buongiorno *et al*. 2012; Liu and Han, 2009; Raymer *et al*. 2009; Nepal *et al*. 2009). Although these methods and techniques and tools are needed to support optimum stocking, growth improvement, harvesting regimes, profitability ratios computations for improvement of the forest plantations, they are not known in Ghana's forest management practice. The worse situation is that these applications can hardly be used among the participating local community members where plantations have been established even though they are very important. In the absence of the possibility of application of these advanced technologies, a simple tree-level lumber value calculator is required by these farmers. In the event that the professional forest managers are not available farmers will be able to use these calculators on their own to determine the lumber value at the tree-level. This is all-the-more important because local people engaged in these plantations have 40% share and would want to know the worth of their share in future at present. This would motivate them to take care of and expand their holdings of these plantations, to improve their growth, use them as mortgage, and even to sell out their shares before the due date of harvest if they choose to. Similarly, individual plantation developers would need this information also to manage their own plantations.

The aim of this study was to enhance community forest plantations management and increase the support and commitment of farmers to continuously protect these plantations against wild fire and illegal timber harvesting effects. The specific objectives were to i) develop a framework for calculating lumber value at tree-level and ii) increase farmer knowledge in lumber value estimation at tree-level to enhance their decision making process on the planted trees. The study hypothesis is that farmer knowledge about the value of lumber at tree-level varies strongly with his/her commitment to protect the planted forest established on degraded lands. The assumption is that farmers will make use of the developed framework to estimate the lumber value at the tree-level that would motivate them to care more for the established plantations.

1.1 Literature review of financial values of lumber at tree-level

Trees or their products (logs) are regarded as a commercial commodity (O'Connor, undated). The value of an asset is the price for which the asset could sell in a market, which draws the attention of both sellers and buyers (Zhang *et al*, 2013). Sawn timber is largely defined by the volume of lumber products derived from logs (Prestemon and Buongiorno, 2000). Sawn timber can be assessed most appropriately in terms of the expected dollar

value of lumber and by-products derived per unit volume of log input (Carino and Biblis, 2009). Higher dollar value yield per unit volume of log input is an indication of a better log quality and vice versa. According to O'Connor (undated), the real value of a plantation is the market value of logs it contains.

The estimated value per unit volume (VAL) of each tree stem, which was the dependent variable in Havreljuk *et a.l* (2014) study was expressed in US dollars per cubic meter of roundwood ($ m^{-3}). This was estimated by dividing the sum of values from each product by the gross volume of the stem. The latter was derived from a volume equation using DBH and total tree height as predictors (Perron, 2003). VAL was preferred to total stem value, because it is less influenced by tree size and it corresponds to the units used in the industry for log procurement.

Schröder *et al*. (2014) have stated that the estimation of volume at harvest in planted forests is the main concern for forest managers as a way to determine economic yield and therefore species choice, silvicultural treatments, and rotation at any given plantation. Since rotation in forest plantations for sawn wood production takes decades, according to the report, any change in market demands related to log sizes during this period would require new estimates in standing volume. Commercial volume should be the focus of volume estimates over total volume estimates once the dimensions of the timber harvested have great influence in the economical yield (Schroder et al., 2014).

A practical approach to this issue may be the development of reduction quotients from total volume estimates to different commercial log classes (Schröder et al., 2014). While the volume of a standing tree is dependent on the changes in diameter and merchantable height, the value of the tree depends on the logs recoverable and the market prices (Reed and Mroz, 1997). Schröder et al., (2014) further indicates that volume growth of individual timber trees is dependent on changes in diameter and merchantable height, while value growth is dependent on these along with changes in tree quality, the quality of logs recovered from the tree, and market prices. In Reed and Mroz (1997) study, they utilized projection methods from the literature to develop expected rates of biological and value growth for sugar maple in managed and uneven-aged forests. Based on the estimated models, Reed and Mroz (1997) found the projected rate of biological growth to increase with tree diameter and decrease with merchantable height. The rate of value growth generally increases with tree diameter and decreases with merchantable height, but the relationships with tree grade are complex (Reed and Mroz, 1997).

2.0 Method

2.1 Study area

The biophysical data for the tree value estimation was collected in the forest plantation established in Pamu Berekum forest reserves in Dormaa Ahenkro District in the Brong Ahafo region and Southern Scarp Forest reserve at Begoro in Fanteakwa District in the Eastern Region. The plots of plantation established by Ntabene Community and Twumkrom community were used in the Brong Ahafo region, while Olantan and Ahenkwa communities' plots were used in the Eastern Region (Figure 1). The plots were established by these communities under the ITTO project (PD530/8 Rev.3 (F) in the degraded portions of the aforementioned two reserves under the Modified Taungya System Approach. These are the plots where the participating farmers in these communities have 40% share in the timber proceeds during the period of harvesting.

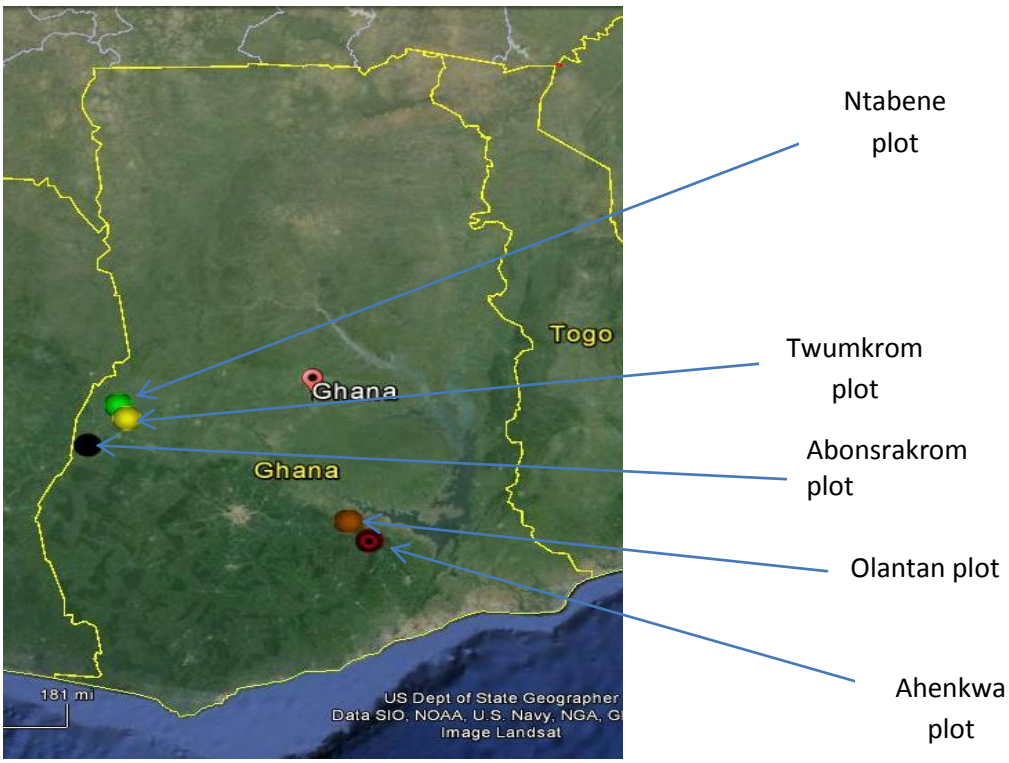

Figure 1: Map of Ghana showing sites of community forest plantation in Pamu Berekum and Southern Scarp forest reserves where biophysical data was collected

2.2 Average merchantable volume of standing timber tree species

Ten circular plots of 12.62 m radius were laid in 2013 in each of the four study plantations. The average total number of timber tree per species was obtained. Individual trees per species were counted and their diameters at breast height in the plots recorded. The average diameters at breast height of the trees were then computed (Appendix 1).

To determine the financial values (timber value) of the timber trees farmers have established before the final rotation, the merchantable timber tree volume equation developed by Wong (1989) for Ghana was used. The volume equation for all timber species combined was obtained as:

$V = (0.0004634)D^{2.201}$ ---------- (1)

Aside this, two different group equations were derived for different ecological zones. These are the following:
The Group-one equation is

$V = (0.0005229)\ D^{2.140}$ ---------- (2)

and the Group-two equation is

$V = (0.000447)D^{2.216}$ ---------- (3)

Where

V is the volume of the merchantable tree and

D is the diameter of the tree

The group-one equation (2) was used to compute the volume of timber species in Pamu Berekum forest reserves in Dormaa plantation sites and Group-two equation (3) used to compute volumes in the Southern Scarp forest reserve in the Begoro plantation sites. The merchantable volumes of tree(s) in the plots in which they appeared on species basis were estimated by substituting their average diameters at breast height into the appropriate Wong's (1989) volume equation. The total volume of the trees per species was determined. The average merchantable volume per species per plot was then estimated by dividing the total merchantable volume of the species by the number of plots in which the trees of the species appeared in the community' plot (Appendix 2).

2.3 Lumber volumes and their prices per timber species in the domestic market

To obtain the gross market value of the timber, the sale prices of all dimensions of lumber from corresponding timber species in the domestic timber market survey of Owusu *et al*. (2015) study were used. Because the lumber prices vary across the ten different administrative regions in Ghana, lumber prices in the Brong Ahafo and Eastern regions, which are the locations of the target plantations, were used. The average volume of the lumber for the different dimensions of the different species in the domestic market was obtained with the corresponding average prices for both chainsaw and sawmill. The volumes of the various dimensions of lumber per species were obtained from a national domestic market survey (Owusu *et al*., 2015), and the total estimated. This estimated total volume per species was then divided by its total number of lumber dimensions (dimensional planks) that appeared in the species to obtain an estimated average volume of the species from the survey data. Again, the estimated average chainsaw and sawmill prices for the average volume of each timber species obtained was computed from the same data source. Some tree species that were identified in the study plantations were not available in the domestic timber market of the locality. The prices of such species were estimated from the domestic markets data in the nearest regions to the regions with the study plantation (Brong Ahafo and Eastern regions) where they were available.

2.4 Tree value per hectare estimates

Standing tree value per hectare estimates

The area of each circular plot of radius 12.62 m was estimated as 500.5453 m^2. Converting this area to hectares resulted in a conversion factor of 19.9782. The Average volume of each of the timber species per square meter was then multiplied by the conversion factor to obtain the volume per species per hectare (Appendix 3). The chainsaw and sawmill values of the standing tree, on species basis, was then estimated using equation 4.

$$\left(\frac{Average\ Volume\ of\ tree\ per\ hectare}{Average\ Volume\ of\ dimensional\ planks}\right) * Average\ Selling\ Price\ (GHC) \quad \text{---------- (4)}$$

In equation (4), the estimated merchantable timber volume per species from the plantations (Wong, 1989) was then converted to total number of lumber pieces obtainable

per tree species by dividing the estimated merchantable volume of each species by the average lumber volume from the domestic markets survey of the respective timber species. This result, which is the estimated number of pieces of lumber obtainable in a given tree per species, is multiplied by each of the corresponding average prices of chainsaw and sawmill lumber to generate the lumber value of the standing timber tree on species basis.

The estimated tree value obtained is the nominal/market value and not real value of the tree per species, in the sense that, the cost of processing to lumber which includes cost of logging, haulage, milling, and transportation to market centres is not deducted.

3.0 Results and Discussions

3.1Tree value comparison

The nominal value (GHC) of standing timber trees/ha of the various wood species were estimated using the lumber prices for bush cut and sawmills from the timber market data on regional basis (Owusu *et al*, 2015) of the localities involved. These regions and communities included Brong Ahafo (Ntabene and Twumkrom) and Eastern region (Olantan and Ahenkwa). The highest number of wood species planted was recorded by Olantan community. This was followed by Ahenkwa and Ntabene/Twumkrom. As shown in Appendix 4, a total of 47 wood species were identified/planted in the four communities where the study was conducted, out of which 13 and 19 were made of lesser-used and lesser-known wood species, respectively. Nine of the wood species (*Albizia adianthifolia, Alstonia boonei, Cedrella odorata, Ceiba pentandra, Ficus exasperata, Milicia excelsa, Sterculia tragacantha, Terminalia ivorensis* and *Terminalia superba*) were common to all the four communities. These included 2 premium species, 4 commercial species, 1 lesser-used species and 2 lesser-known species. Again, *Cedrella odorata* being an exotic species, is gaining prominence in the small and medium scale forest industry. The mean diameter at breast height of all the trees of the 47 wood species that were planted in the four communities ranged from 5cm (*Diospyros kamerunensis* and *Duguetia staudtii*) to 72cm (*Bombax buonoponzense)*.

As indicated in Tables 1 and 2, Ntabene community recorded 14 and 15 different wood species for the estimation of the values of the standing trees with sawmills and bush cut lumber rates, respectively. The total value of all the wood species with respect to lumber

prices from sawmills and bush cut sources, as at June 2016, were GHC 114,874 and 76,815, respectively. Therefore, the mean values per hectare per wood species generated from the two sources in the same order were GHC8205 and GHC5121. The wood species from Ntabene were characterized into their utilization status as premium (3), commercial (3), lesser-used (5) and lesser-known (4). The high number of the wood species (11) from the 1st three utilization status is mostly available on the timber market. This indicates that the community will generate more income as the rate per volume of lumber from these species increases in addition to the increase in the sizes of the trees for the various species. The mean diameter at breast height of the trees at time of biophysical data collection in 2013 ranged from 5 cm (*Diospyros kamerunensis*) to 34.5 cm (*Cedrella odorata*).

On the other hand, Twumkrom community also registered the same number of wood species (15) as that of Ntabene. The estimated standing tree values obtained using the sawmill and bush cut rates were GHC147,328 and GHC114,933 respectively (Tables 1 and 2). The mean sawmill value per hectare per wood species was GHC10523 and GHC7662 for bush cut. The high values obtained for this community as compared to those from Ntabene was due to the high diameter at breast height that were recorded for the trees. This community also recorded some wood species as premium (2), commercial (3), lesser-used (5) and lesser-known (5). The range of the mean diameter at breast height of the trees planted was between 5.7 cm (*Funtumia elastica*) and 72 cm (*Bombax buonoponzense)*as the time of data collection in 2013.

The two communities from Brong Ahafo region, Ntabene and Twumkrom, registered 11 common wood species out of the 15. These were *Albizia adianthifolia, Alstonia boonei, Antiaris toxicaria, Cedrella odorata, Ceiba pentandra, Ficus exasperata, Milicia excelsa, Nesogordonia papaverifera, Sterculia tragacantha, Terminalia ivorensis and Terminalia superba*. Only two of these common wood species *Ficus exasperata and Sterculia tragacantha* were classified as lesser-known wood species. The first five wood species that recorded the highest values for the standing trees at Ntabene were *Cedrela odorata, Terminalia superba, Antiaris toxicaria, Nesogordonia papaverifera* and *Albizia adianthifolia* The total values for these tree species correspond to GHC98,560 and GHC62,972 as sawmill and bush cut rates. Those obtained at Twumkrom totaled GHC123,283 and GHC91,907 as

sawmill and bush cut values respectively for the standing trees of the first five species (*Bombax buonoponzense, Ceiba pentandra, Terminalia superba, Sterculia tragacantha* and *Cedrela odorata*).

Olantan, which is one of the communities in the Eastern region of Ghana, registered 33 wood species (Tables 1 and 2). The total values of the standing trees per hectare for these wood species, registered were estimated as 396,614 and 291,454 for both sawmill and bush cut price respectively. These resulted to GHC12,019 as the mean value per hectare per species with the sawmill rates and GHC8,572 with bush cut rates. The utilization status of the wood species was identified as follows: Premium (6), commercial (3), lesser-used species (11) and lesser-known species (14). Some of the wood species in the community can serve as ornamental purpose. The five dominant wood species that recorded the highest values of the standing trees included *Terminalia superba, Lovoa trichilioides, Cedrela odorata, Terminalia ivorensis* and *Croton pendulif*. All the trees grown at Olantan had reached diameters that ranged between 5cm (*Duguetia staudtii)* and 69.4 cm (*Terminalia superba)*.

The number of wood species in Ahenkwa community's plot was 49. The total values of the standing trees for the species were computed as GHC1,048,526 and GHC545,527 for sawmill and bush cut prices, respectively. The mean values per wood species were estimated as GHC45,588 and GHC20,982 for sawmills and bush cut rates respectively. The wood species identified at this community were classified into four utilization status, which include premium (4), commercial (3), lesser-used species (9) and lesser-known species (10). The first 5 wood species with the highest values for the standing trees were *Terminalia ivorensis, Milicia excelsa, Cedrela odorata, vitex ferruginea, and Albizia adianthifolia/Antiaris toxicaria*. At Ahenkwa, the mean diameter at breast height of the trees was between the range of 6.2 cm (*Entandrophragma spp*) and 60.8 cm (*Vitex ferruginea*) at the time of data collection 2013.

The 17 wood species that were common at Olontan and Ahenkwa communities in the Eastern region, included *Albizia adianthifolia, Albizia ferruginea, Albizia zygia, Alstonia boonei, Amphimas pterocarpoides, Bombax buonoponzense, Carapa procera, Cedrella*

odorata, Ceiba pentandra, Entandrophragma spp, Ficus exasperata, Milicia excelsa, Piptadeniastrum africanum, Rauvolfia vomitaria, Sterculia tragacantha, Terminalia superba and *Terminalia ivorensis*. These were into premium (3), commercial (2), lesser-used species (8) and lesser-known species (4). All these wood species are on the timber markets in Ghana, especially in the Eastern region, in the form of lumber or plywood. There is a market for these wood species in the study area and in Ghana as a whole.

Table 1: Gross value (GHC) of standing timber trees/ha based on bushcut/chainsaw lumber prices in study communities and plantations as at June 2016

Olantan			Ahenkwah			Ntabene			Twumkrom		
Species	**dbh/cm**	**Value/ha**	**Species**	**dbh/cm**	**Value/ha**	**Species**	**dbh/cm**	**Value/ha**	**Species**	**dbh/cm**	**Value/ha**
Albizia adianthifolia	19.1	3036.4	*Albizia adianthifolia*	27.4	9639.11	*Albizia adianthifolia*	23.1	3196.6	*Albizia adianthifolia*	10	305.86
Albizia ferruginea	21.8	7974.5	*Albizia ferruginea*	16.5	10591.32	*Alstonia boonei*	17.8	1489.4	*Alstonia boonei*	28.8	7712.92
Albizia zygia	20.6	5020.6	*Albizia zygia*	24.4	6330.1	*Antiaris toxicaria*	17.3	5353.2	*Antiaris toxica*	14.6	1353.01
Alstonia boonei	20.8	6636.58	*Alstonia boonei*	26.2	11528.91	*Blighia sapida*	6.8	341.4	*Blighia unijugata*	20.3	3587.07
Amphimas pterocarpoides	32	3510.95	*Amphimas pterocarpoides*	33.5	6636.54	*Cedrela odorata*	34.4	41985.68	*Bombax buonopozense*	72	29546.49
Antrocaryon micraster	43.8	7039.31	*Antiaris toxicaria*	48.3	13263.12	*Ceiba pentandra*	22.5	2643.42	*Cedrela odorata*	29.3	11277.62
Bombax buonopozense	9	281.56	*Blighia welwitschii*	6.3	95.8	*Diospyros kamerunensis*	5	103.18	*Ceiba pentandra*	34	19957.17
Carapa procera	30.2	5725.03	*Bombax buonopozense*	18	1308.12	*Ficus exasperata*	11.4	1660.32	*Dialium dinklagei*	9.5	506.99
Cedrela odorata	38.4	24406.1	*Carapa procera*	8.1	845.34	*Khaya ivorensis*	15.3	2235.26	*Ficus exasperata*	10.7	549.86
Ceiba pentandra	18.1	1824.78	*Cedrela odorata*	22.3	29638.75	*Milicia excelsa*	9.3	404.37	*Funtumia elastica*	5.7	423.25
Croton penduliflorus	43.6	13903.16	*Ceiba pentandra*	16.6	991.78	*Morinda lucida*	19.4	1783.83	*Milicia excelsa*	5.8	78.19
Discoglypremma caloneura	37.3	9861.89	*Entandrophragma spp*	6.2	178.25	*Nesogordonia papaverifera*	17.1	3222.2	*Nesogordonia papaverifera*	15.4	1842.36
Distemonanthus benthamianus	9.4	906.98	*Ficus exasperata*	10.5	709.19	*Sterculia tragacantha*	12.5	852.71	*Sterculia tragacantha*	24.8	13855.47
Duguetia staudtii	5	57.4	*Ficus sur*	9.4	413.68	*Terminalia ivorensis*	14	2328.57	*Terminalia ivorensis*	32.3	6666.42
Entandrophragma spp	10.4	2277.57	*Holarrhena floribunda*	12.6	1988.6	*Terminalia superba*	22.9	9214.43	*Terminalia superba*	27.5	17269.8
Ficus exasperata	22.2	4971.85	*Margaritaria discoidea*	16.8	841.99						
Funtumia elastica	11.5	969.39	*Milicia excelsa*	35.7	34899.77						
Harungana madagascariensis	8.4	241.64	*Pericopsis elata*	11	908.22						
Khaya ivorensis	8.1	707.38	*Petersianthus macrocarpus*	9.1	402.75						
Lovoa trichilioides	63.2	52619.82	*Piptadeniastrum africanum*	18.3	2544.83						

Macaranga barteri	14.4	4118.52	*Rauvolfia vomitaria*	8.8	345.6
Macaranga hurifolia	22	4081.32	*Sterculia tragacantha*	23.3	8054.76
Milicia excelsa	19.6	6562.61	*Terminalia ivorensis*	53.3	384550.2
Milicia regia	24.1	6218.31	*Terminalia superba*	21.1	3428.11
Morinda lucida	27.8	2142.13	*Vitex ferruginea*	60.8	14559.75
Morus mesozygia	9.6	808.12	*Voacanga africana*	10.1	832.67
Piptadeniastrum africanum	12.4	1074.21			
Rauvolfia vomitaria	8.1	278.05			
Ricinodendron heudelotii	27	3212.66			
Spathodea campanulata	18.6	1699.77			
Sterculia tragacantha	33.3	6497.88			
Terminalia ivorensis	22.5	15806.77			
Terminalia superba	69.4	82200.32			
Turraeanthus africanus	16.9	4780.24			

Table 2: Gross value (GHC) of standing timber trees/ha based on sawmill lumber prices in study communities and plantations as at June 2016

Olantan			Ahenkwah			Ntabene			Twumkrom		
Species	Av. dbh	Value/ha	Species	Av. dbh	Value/ha	Species	Av. dbh	Value/ha	Species	Av. dbh	Value/ha
Albizia adianthifolia	19.1	11094.27	*Albizia adianthifolia*	27.4	35219.21	*Albizia adianthifolia*	23.1	3601.98	*Albizia adianthifolia*	10	534.2
Albizia ferruginea	21.8	17112.24	*Albizia ferruginea*	16.5	22727.63	*Alstonia boonei*	17.8	1585.52	*Alstonia boonei*	28.8	9427.57
Albizia zygia	20.6	18344.21	*Albizia zygia*	24.4	23128.81	*Antiaris toxicaria*	17.3	5248.28	*Antiaris toxicaria*	14.6	1326.5
Alstonia boonei	20.8	12271.84	*Alstonia boonei*	26.2	21318.33	*Cedrela odorata*	34.4	74144.2	*Bombax buonopozense*	72	33133.67
Amphimas pterocarpoides	32	11171.72	*Amphimas pterocarpoides*	33.5	21117.26	*Ceiba pentandra*	22.5	3609.05	*Cedrela odorata*	29.3	22890.01
Antrocaryon micraster	43.8	18665.72	*Antiaris toxicaria*	48.3	25087.95	*Diospyros kamerunensis*	5	108.44	*Ceiba pentandra*	34	26243.51
Bombax buonopozense	9	339.97	*Bombax buonopozense*	18	1579.51	*Ficus exasperata*	11.4	1951.07	*Dialium dinklagei*	9.5	632.64
Carapa procera	30.2	20918.01	*Carapa procera*	8.1	3088.69	*Khaya ivorensis*	15.3	2194.45	*Ficus exasperata*	10.7	679.65
Cedrela odorata	38.4	43424.4	*Cedrela odorata*	22.3	52734.54	*Milicia excelsa*	9.3	424.98	*Funtumia elastica*	5.7	506.11
Ceiba pentandra	18.1	3501.28	*Ceiba pentandra*	16.6	1902.97	*Morinda lucida*	19.4	2752.19	*Milicia excelsa*	5.8	150.33
Discoglypremma caloneura	37.3	33398.87	*Entandrophragma spp*	6.2	442.08	*Nesogordonia papaverifera*	17.1	3479.97	*Nesogordonia papaverifera*	15.4	1381.77
Distemonanthus benthamianus	9.4	940.98	*Ficus exasperata*	10.5	706.14	*Sterculia tragacantha*	12.5	1299.37	*Sterculia tragacantha*	24.8	18096.95
Duguetia staudtii	5	152.21	*Ficus sur*	9.4	411.89	*Terminalia ivorensis*	14	2517.53	*Terminalia ivorensis*	32.3	9405.79
Entandrophragma spp	10.4	5003.88	*Holarrhena floribunda*	12.6	4478.23	*Terminalia superba*	22.9	11956.57	*Terminalia superba*	27.5	22919.24
Ficus exasperata	22.2	4950.42	*Milicia excelsa*	35.7	56585.73						
Funtumia elastica	11.5	1835.12	*Pericopsis elata*	11	1604.7						
Harungana madagascariensis	8.4	291.77	*Petersianthus macrocarpus*	9.1	841.56						
Khaya ivorensis	8.1	1249.85	*Piptadeniastrum africanum*	18.3	3957.68						
Lovoa trichilioides	63.2	85316.64	*Rauvolfia vomitaria*	8.8	344.11						
Macaranga barteri	14.4	7796.62	*Sterculia tragacantha*	23.3	21739.71						
Macaranga hurifolia	22	7726.2	*Terminalia ivorensis*	53.3	703529.3						
Milicia excelsa	19.6	10640.47	*Terminalia superba*	21.1	7373.11						
Milicia regia	24.1	10082.24	*Vitex ferruginea*	60.8	38607.21						

Morinda lucida	27.8	6816.18	-
Morus mesozygia	9.6	1310.26	
Piptadeniastrum africanum	12.4	1670.6	
Rauvolfia vomitaria	8.1	276.85	
Ricinodendron heudelotii	27	4131.53	
Spathodea campanulata	18.6	1692.44	
Sterculia tragacantha	33.3	17537.71	
Terminalia ivorensis	22.5	28918.26	
Terminalia superba	69.4	176794.91	
Turraeanthus africanus	16.9	8031.01	

3.2 Comparison of lumber value at tree level

Paired sample t test was conducted for the lumber value at the tree level. The results of the t test show statistically significant difference between lumber values at tree-level using chainsaw lumber prices and saw mill lumber prices in the domestic timber markets for plantations of Twumkrom community (*M*=10120, *SD*=11431 for sawmill price; *M*=7662; *SD*=8988 for chainsaw price) in the Dormaa forest District and Olantan community (*M* =17949, *SD*=32770 for sawmill price; *M* =8572; *SD*=16177 for chainsaw price) in Begoro forest district (Figures 2b & 3c). This means that at the two communities, sawmill prices should be used to determine the value of trees for sale to enable them increase their turn-over.

No significance difference was found for the plantations in Ntabene community (*M* =8205, *SD*=19196 for sawmill price; *M*=4829; *SD*=10785 for chainsaw price) in Dormaa forest district and Ahenkwa community (*M*=40508; *SD*=136261 for sawmill price; *M*=20982; *SD*=74681 for chainsaw price) in the Begoro forest district (Figures 2a & 3d). The outcome indicates that Ntabene and Ahenkwa communities could use either sawmill or chainsaw prices to estimate the values of trees at any point in time for sale.

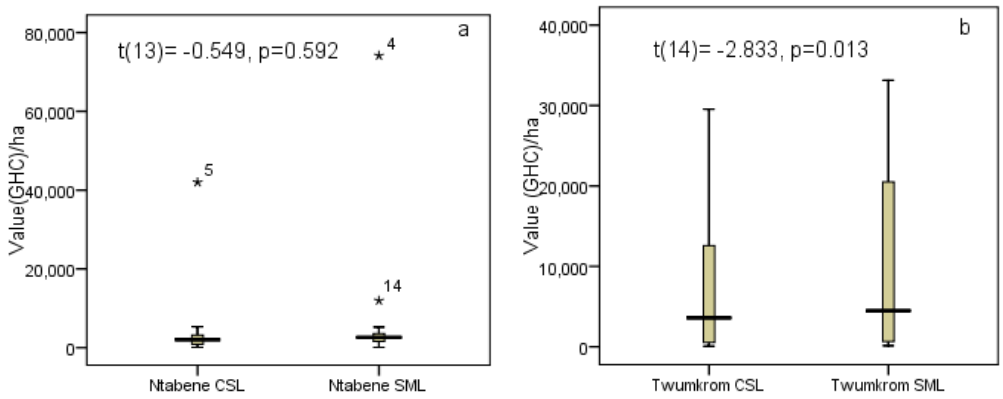

Figure 2: Value of lumber of the plantations of Ntabene and Twumkrom study communities (a & b) based on 2015 chainsaw lumber (CSL) and sawmill lumber (SML) prices on the domestic timber market in Ghana

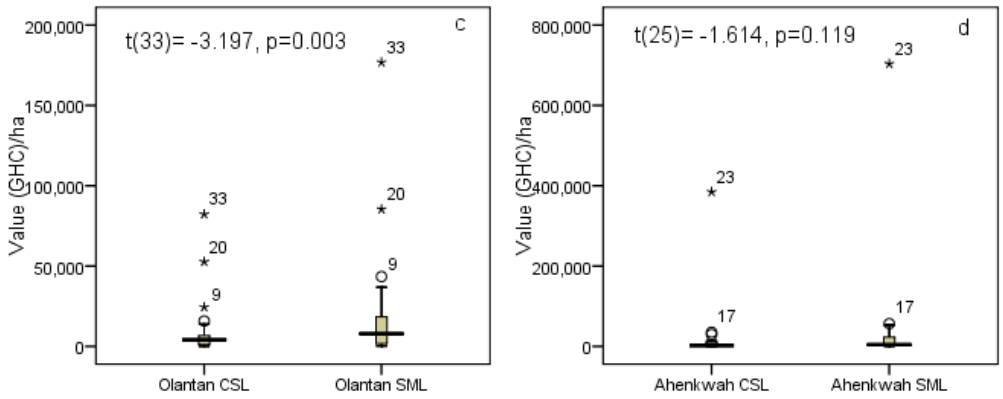

Figure 3: Value of lumber of the plantations of Olantan and Ahenkwa study communities (c & d) based on 2015 chainsaw lumber (CSL) and sawmill lumber (SML) prices on the domestic timber market in Ghana

3.3 Calculators of lumber value at tree-level

Based on significance test results, calculators for lumber value at tree-levels were developed for the farmers of the respective plantations. In the Ntabene and Ahenkwa communities one calculator each was developed for the farmers of the established plantation since there were no significance difference between the lumber value based on chainsaw and sawmill prices in the domestic markets (Figure 4 a & b).

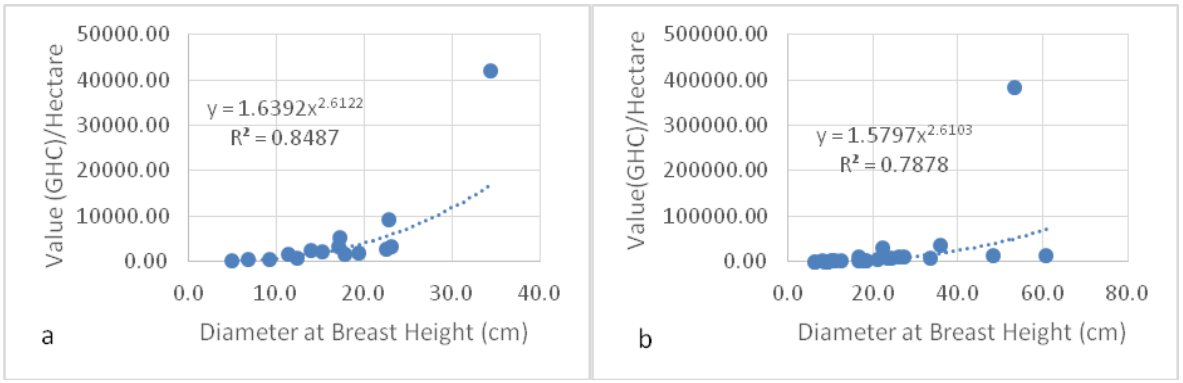

Figure 4: Scatter plot of tree diameter and value (GHC) in Ntabene (a) and Ahenkwa (b) communities plantations in Dormaa and Begoro forest districts respectively

In the case of the Olantan and Twumkrom communities, two calculators each were developed. One each using chainsaw lumber prices (Figure 5 OCP & TCP) and the other using sawmill lumber prices (Figure 6 OSP & TSP) in the domestic timber markets.

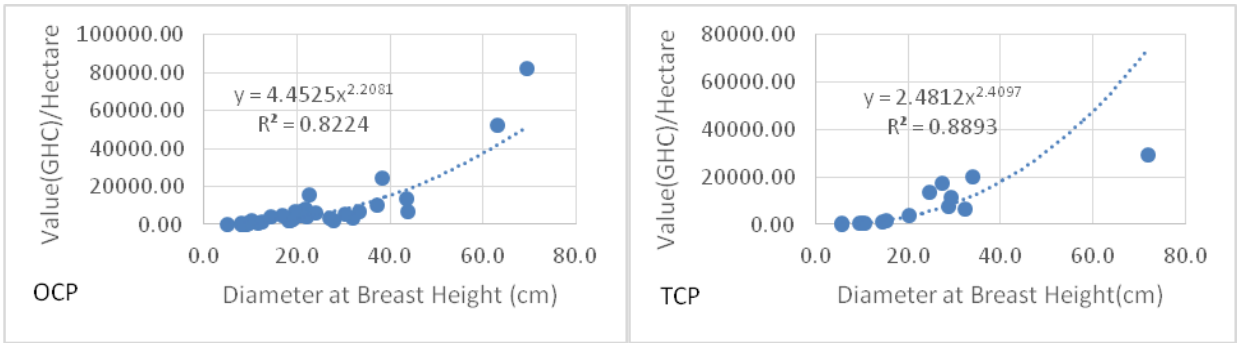

Figure 5: Scatter plot of tree diameter and lumber value (GHC) based on chainsaw prices in Olantan (OCP) and Twumkrom (TCP) communities plantations in Dormaa and Begoro forest districts respectively

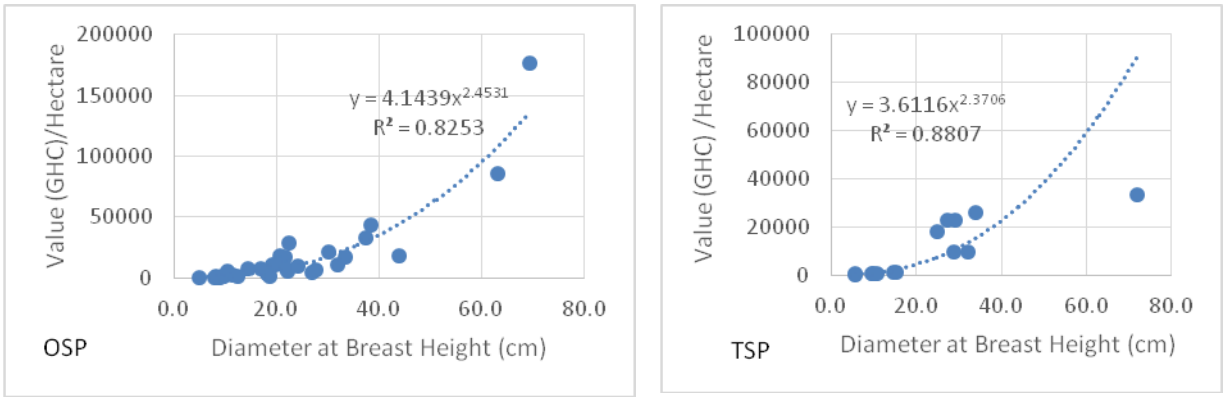

Figure 6: Scatter plot of tree diameter and lumber value (GHC) based on sawmill prices in Olantan (OSP) and Twumkrom (TSP) communities' plantations in Dormaa and Begoro forest districts respectively

These calculators developed are meant to assist the communities in determining the values for their plantation trees in order to take informed decision regarding transfer to third parties or bequeathing to their heirs. This will encourage them to develop more plantations, which will support the communities in their developmental projects without necessarily relying on the government. This will also enable the concept to be trickled down to the surrounding communities and beyond.

4.0 Conclusion

Four mixed plantations have been established at Ntabene and Twumkrom communities in the Dormaa district, Brong Ahafo region and Olantan and Ahenkwa in Begoro forest district of the Eastern region. A total of 47 wood species were planted with only one exotic species (*Cedrella odorata*). The species were classified according to premium, commercial, lesser-used and lesser-known wood species. Wood species that were available at all the four communities included *Albizia adianthifolia*, *Altsonia boonei*, *Cedrella odorata*, *Ceiba pentandra*, *Ficus exasperate*, *Milicia excelsa*, *Sterculia tragacantha*, *Terminalia ivorensis* and *Terminalia superba*. The values of the trees, on species basis, have been estimated and calculators for future estimations developed for each community. The estimated values of the wood species were arrived at using the lumber prices of sawmill and chainsaw (bush cut) on the domestic timber markets that had been established in the regions that the communities are located. Statistical analysis indicated insignificant differences between sawmill and chainsaw lumber prices at Ntabene and Ahenkwa communities while differences existed for Twumkrom and Olantan communities. All the communities have been trained in the use of the calculator for plantation trees value estimations. The total values of the standing trees for all species developed at Ntabene, Twumkrom, Olantan and Ahenkwa were estimated to be GHC114,874; GHC147,328; GHC396,614 and GHC1,048,526 respectively for sawmill prices and GHC76,815; GHC114,933; GHC291,454 and GHC545,527 for chainsaw (bush cut) prices in the same order.

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6.0 Appendices

Appendix 1: Samples on tree information (species, DBH, H., Forest reserve, community plot radius, plot number and volume) obtained from a given site (Begoro) plantation

Species	Family	DBH	H	2= Plantation sites	Major Site Name	Specific Site name	Plot Radius m	Expansion Factor	New Plot Code	Volume m^3
Albizia adianthifolia	Mimosaceae	48	26	2	Southern scarp	Ahenkwa	12.62	19.99	98	2.376502
Albizia adianthifolia	Mimosaceae	16.8	19.5	2	Southern scarp	Ahenkwa	8	49.74	98	0.232056
carapa procera	Meliaceae	10.1	10.1	2	Southern scarp	Ahenkwa	8	49.74	98	0.075142
carapa procera	Meliaceae	10.6	12	2	Southern scarp	Ahenkwa	8	49.74	98	0.083634
carapa procera	Meliaceae	8.5	12	2	Southern scarp	Ahenkwa	8	49.74	98	0.051274
carapa procera	Meliaceae	5	6.4	2	Southern scarp	Ahenkwa	8	49.74	98	0.015821
Cedrela odorata	Meliaceae	35.6	24.3	2	Southern scarp	Ahenkwa	12.62	19.99	98	1.225521
Cedrela odorata	Meliaceae	37.4	24.8	2	Southern scarp	Ahenkwa	12.62	19.99	98	1.367071
Cedrela odorata	Meliaceae	30.3	19.6	2	Southern scarp	Ahenkwa	12.62	19.99	98	0.857402
Ficus exasperata	Moraceae	14.2	13.4	2	Southern scarp	Ahenkwa	8	49.74	98	0.159874
Milicia excelsa	Moraceae	56.7	24.4	2	Southern scarp	Ahenkwa	12.62	19.99	98	3.437539
Terminalia ivorensis	Combretaceae	26.4	25.6	2	Southern scarp	Ahenkwa	8	49.74	98	0.631803

Appendix 2: Individual tree species per plot, their count, sum of volumes and average volumes per species per plot that the tree species appeared

Appearance of individual species in the plots of a community	Count of individual tree species	**Sum of Volume of trees**	Average volumes of species per plot
Acacia kemerune	1	**0.064085363**	0.064085363
112	1	0.064085363	
Albizia adianthifolia	5	**1.80568231**	0.451420578
109	2	0.547436826	
111	1	0.719796483	
114	1	0.45655294	
116	1	0.08189606	
Albizia ferruginea	4	**2.088865648**	0.696288549
111	2	0.344816077	
113	1	0.409168595	
117	1	1.334880976	
Albizia zygia	7	**3.732085079**	0.746417016
108	1	0.194125491	
109	1	0.443347214	
112	1	1.03593955	
113	3	2.034975971	
117	1	0.023696854	
Alstonia boonei	3	**1.178633633**	1.178633633

Appendix 3: Samples of tree value computation from plots at Olantan in Begoro district

Begoro Olantan	Plot size: 500.5453m2										
Species	Average Vol/m2	CF	Average Volume/Ha	Bush Cut Average Dimensional Volume	Average Price	Sawmill Average Dimensional Volume	Average Price	Quantity of Bush Cut	Value	Quantity of Sawmill	Value
Albizia adianthifolia	0.4514	19.9782	9.018571	0.036632111	12.3	0.0378	46.5	246.193	3036.381	238.5865	11094.27
Albizia ferruginea	0.6963	19.9782	13.91059	0.036632111	21.0	0.0378	46.5	379.7376	7974.491	368.0051	17112.24
Albizia zygia	0.7464	19.9782	14.91207	0.036632111	12.3	0.0378	46.5	407.0764	5020.609	394.4992	18344.21
Alstonia boonei	1.1786	19.9782	23.54698	0.035189743	9.9	0.0378	19.7	669.1432	6636.585	622.9359	12271.84
Amphimas pterocarpoides	1.1612	19.9782	23.19775	0.066072643	10.0	0.0353	17.0	351.0947	3510.947	657.1601	11171.72
Antrocaryon micraster	1.9401	19.9782	38.75882	0.044048428	8.0	0.0353	17.0	879.9137	7039.31	1097.983	18665.72
Bombax buonopozense	0.0582	19.9782	1.162694	0.033036321	8.0	0.0342	10.0	35.1944	281.5552	33.99689	339.9689
carapa procera	0.8511	19.9782	17.00432	0.036632111	12.3	0.0378	46.5	464.1916	5725.03	449.8497	20918.01
Cedrela odorata	2.5258	19.9782	50.46155	0.036182638	17.5	0.0294	25.3	1394.634	24406.1	1716.379	43424.4
Ceiba pentandra	0.4158	19.9782	8.306494	0.032863658	7.2	0.0344	14.5	252.7562	1824.777	241.4679	3501.284

Appendix 4: List of wood species used to establish plantations in four communities in Ghana

Scientific names	Local names	Scientific names	Local names
Albizia adianthifolia	Pampena	*Harungana madagascariensis*	Kosowa
Albizia ferruginea	Awiemfosamina	*Holarrhena floribunda*	Sese
Albizia zygia	Okoro	*Khaya ivorensis*	Dubini
Alstonia boonei	Nyamedua/Sinduro	*Lovoa trichilioides*	Dubinibiri
Amphimas pterocarpoides	Yaya	*Macaranga barteri*	Opam
Antiaris toxicaria	Kyenkyen	*Macaranga hurifolia*	Opamfufuo
Antrocaryon micraster	Aprokuma	*Margaritaria discoidea*	Ofuruma
Blighia sapida	Akyee	*Milicia excelsa*	Odum
Blighia unijugata	Akyebiri	*Milicia regia*	Odum-Nua
Blighia welwitschii	Akyekobiri	*Morinda lucida*	Konkroma
Bombax buonopozens	Akata	*Morus mesozygia*	Wonton
Carapa procera	Kwakuobese	*Pericopsis elata*	Dahoma
Cedrella odorata	Cedrela	*Petersianthus macrocarpus*	Esia
Ceiba pentandra	Onyina	*Piptadeniastrum africanum*	Dahoma
Croton penduliflorus	Nyamrem	*Rauvolfia vomitaria*	Kakapenpen
Dialium dinklagei	Dwedweedwe	*Ricinodendron heudelotii*	Wama
Diospyros kamerunensis	Omenewa	*Spathodea campanulata*	Akuakuo-Ninsuo
Discoglypremma caloneura	Fetefre	*Sterculia tragacantha*	Sofo
Distemonanthus benthamianus	Bonsamdua	*Terminalia ivorensis*	Emire
Duguetia staudtii	Kumdwie	*Terminalia superba*	Ofram
Entandrophragma utile/angolense	Efobrodedwo/Edinam	*Turraeanthus africanus*	Apapaye
Ficus exasperata	Nyankyerene	*Vitex ferruginea*	Otwentorowa
Ficus sur	Nwadua	*Voacanga africana*	Pepea
Funtumia elastica	Fruntum		