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Participatory forest management: A case of equity in the forest plantation establishment and livelihood improvement Scheme in Gathiuru and Hombe forests in Central Kenya.

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Abstract
The study analysis equity in participatory plantation establishment and livelihood scheme (PELIS) formally known as *shamba* (farm) system in Gathiuru and Hombe forests Kenya. This is done by determining annual inputs and outputs of three partners in PELIS including the Kenya forest service (KFS), three saw milling companies and the communities farming in Hombe and Gathiuru forests. The study uses Adams equity theory and applies the equity theory ratios as the basis of formulating equity under PELIS arrangements. The analysis is limited to a three year period (2012 to 2014), which corresponds to the number of years farmers cultivate in one plot under the scheme. Equity ratio analysis based on annual average annual output: input ratios for KFS 2012-2014 were 4.1:1; 2.6:1; and 3.1:1; for the three timber companies were 2.8:1; 3.1:1 and 1.9:1 while for community were 2.8:1; 2.4:1 and 2.8:1. The three year average ratios were 3.2:1 for KFS, 3.0:1 for the timber companies and 2.7:1 for communities. This indicates that the equity ratios were very close meaning that they all benefitted at the same level of respective inputs between 2012 and 2014. The study therefore concludes that applying the equity theory ratios can provide an opportunity to address inequity in PELIS under participatory forest management.

Key words: Plantation establishment, inputs, outputs, partners, communities, equity

Introduction:

After the global discourse on the environment and development and the publication of the Bruntland report of 1987 'our common future', community participation in natural resource management was widely adopted as the most appropriate approach to address sustainable development and management of the resources including forests (Hobley and Shields, 2000; Alden and Mbaya 2001; Willy, 2003; Schreckerberg *et al.*, 2006). The global re-emphasis of participatory approaches as necessary for sustainable development brought with it the question of equity that is costs and benefits (Nelson and Agrawal, 2006; Bram, 2011).

One of the community engagement in forest participation is cultivation under establishment of tree plantation is taungya that originated from Myanmar, which in Kenya has been known as shamba (farm) system. The concept dates back to the early periods of plantation establishment in originated from Myanmar in 1886 and spread to other Asian countries including India, Nepal and Vietnam ((King, 1987; Jordan, et al., 1992). It was introduced in Africa during the colonial era (Enabor, et al., 1979, Ndomba et al., 2015). It is applied in many countries as an innovative approach to establish forest plantations and facilitate participatory forest management (Nair, 1989; Thenya et al., 2007; Witcomb and Doward 2009). During the

colonial rule, the practice was introduced in Africa to meet various needs among them, to provide wood fuel for steam locomotives, provide energy for mines and to meet other industrial demands for timber (Imo 2008). In post independence years, the system was adopted as a means of addressing landlessness, poverty and high costs in development of forest plantations (Enabor et al., 1979; Chamshama et al., 1992; Kagombe, 1998; Imo, 2008).

The shamba system that initially involved forest residential system starting early 1900s has involved to non-residential farming in 19980s and to total ban in the 1990s. It was re-introduced as plantation establishment and livelihood improvement scheme (PELIS) around 2007, mostly facilitated by change in forest legislation in 2005 that incorporated participatory forest management (PFM) (GoK 2005). However, the reintroduction of the system did not resolve the lingering question of equity, popularly referred to as cost-benefit sharing (Thenya et al 2007; Ongugo et al., 2008, Witcomb and Doward 2009).

This paper seeks to analyze equity in PFM and apply the equity theory ratios as the basis for formulation of costs and benefit sharing mechanism in PELIS under PFM arrangements. Adams theory of equity postulates that the perception of equity in an employer/employee relationship is influenced by comparing inputs that each colleague contributes into the work and the outputs or gains each colleague gets as a result. The level of equity is then gauged based on comparison of ratios of outputs against inputs amongst the colleagues. The closer the ratios the more equitable is the relationship (Adams, 1963).

$$\textbf{Equity achieved when:} \quad \frac{\text{Outcomes } X_{i..n}}{\text{Inputs } X_{i..n}} = \frac{\text{Outcomes } P_{i..n}}{\text{Inputs } P_{i..n}}$$

(Ratios can be real or perceived)

According to Equity theory situations are evaluated as just if ratios in the above formula are equal and unjust if unequal and when the ratio of one comparing with another is less or greater, inequity is perceived (Adams, 1963, Walster *et al.,* 1973). This paper takes the PELIS implementing local communities, the Kenya forest service and the saw-milling companies as partners who benefit from the forest plantation resource. The theory of equity is applied to assess the proportions of outputs against inputs among the three partners.

2.0 The study area:

Biophysical characteristics:

Gathiuru and Hombe forests are located at the South slopes of Mt Kenya about 290Km from the capital city Nairobi and 45 Km from Nanyuki town. Gathiuru forest station is located at latitude -0.0500^0 and longitude 37.0833^0. The Gathiuru and Hombe forests are a part of Mt Kenya ecosystem in Central Kenya Highlands; one of the ten Country's management zones (Fig.1). Mt Kenya ecosystem has been under state management since 1943 (Logie and Dyson 1962). The Ecosystem consists of three sub-ecosystems, which include a national park occupying 71,510 ha, a natural forest reserve covering over 2,000 km^2 and gazzetted plantation forests measuring 8,994 ha Plantations were established between 2000-3000 masl (Emerton, 1999; KFS 2010b; KWS, 2010).

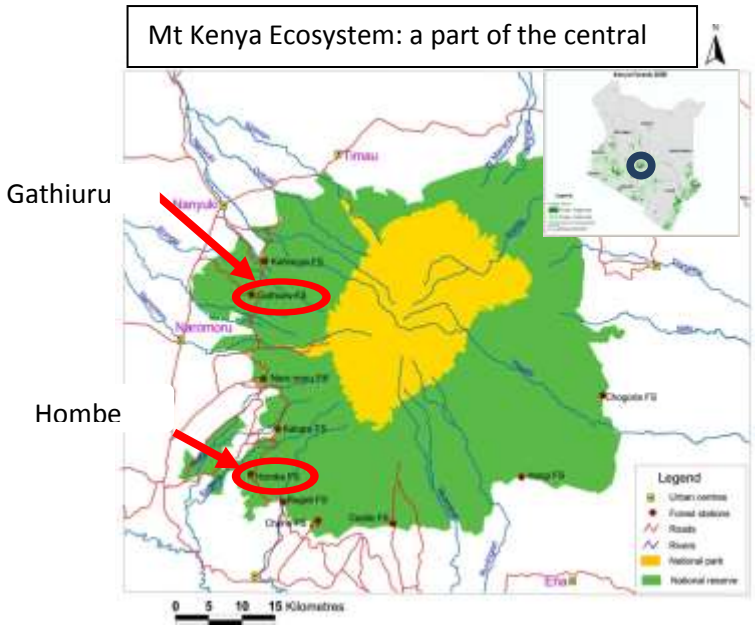

Figure 1: Location of Gathiuru and Hombe forests in the Mt Kenya ecosystem
Inset: The location of Mt Kenya Ecosystem on the Kenya forests map.
(Source Kenya Forest Service)

The vegetation in Gathiuru and Hombe forests include forest plantations, indigenous forests, bush-land, grassland and bamboo. The natural forest covers 10,319.6 ha while plantations occupy 3,500 ha in both forests. Gathiuru forest holds 2,365 ha of plantations while about 1,150 ha are in Hombe forest. By 2013 a total of 969 ha in Gathiuru and 761 ha in Hombe were under PELIS (KFS, 2010a, KFS, 2012). The main forest plantation species in the two forests are *Cupressuss lusitanica*, *Pinus patula*, *Pin*us *radiata* and *Eucalyptus saligna.* Small areas are also under planted indigenous tree species for example *Vitex kiniensis* in Gathiuru and Hombe respectively (KFS, 2010a, KFS, 2012).

Socio-economic characteristics:
Gathiuru and Hombe forests are surrounded by agricultural communities of mainly Kikuyu and Meru ethnic origin (Nair, 1989; Kariuki, 2007) who also keeps cattle, goats and sheep. The farms around Hombe forest are of low productivity as a result of soil exhaustion from many years of cultivation. Land sizes have been subdivided to small scale areas of between 1-5 acres. Large areas outside the forest land have also been under tea and coffee farming especially around Hombe forest thereby increasing scarcity of land availability for food crop cultivation. Gathiuru forest is on the leeward site of Mt Kenya and therefore surrounding land is drier and less productive. It is mainly bush and grassland and livestock keeping is more prevalent in the lower slopes (Emerton, 1999).

3.0 Study methodology:

Sampling and data Collection: The study used a sample size of 321 respondents computed based on a confidence level of 95% and a margin error of 5%. Using the PELIS population of 1947 farmers a total of 225 (70%) of the sample were drawn from Gathiuru forests and 96 (30%) were drawn from farmers cultivating in Hombe forest.

The sample was further distributed proportionately based on the farmers allocation of plots in each forest compartments, which was used to compute proportionate forest block sample size (table 10. The respondents were systematically picked from every sixth plot were selected. Primary data was collected by use of a questionnaire.

Table 1: The samples drawn from each PELIS unit

Name of Forest	Forest compartment	No of units in each block	No of farmers allocated plots in each unit.	Sample from each PELIS unit	% of sample
Gathiuru	Station	1	30	5	1.6%
	Burgret	9	468	79	24.6%
	Mugeria	8	840	141	43.9%
	Gathiuru total	**18**	**1338**	**225**	**70.1%**
Hombe	Polytechnique	1	48	6	1.9%
	Gathunya	1	172	27	8.4%
	Kiori	4	389	63	19.6%
	Hombe Total	**6**	**609**	**96**	**29.9%**

Data analysis: The study applied descriptive statistical tools to determine characteristics of respondents variables such as frequencies, percentages and cross tabulation. Assessment of relationships between variable and comparison of inputs and outputs under PELIS was analyzed using cross-tabulation. The study analyzed inputs and outputs into the PELIS system by communities, the Kenya Forests Service and three saw-milling companies. Secondary data provided by the Kenya forests service was also used in analyzing the inputs and outputs for the KFS and the saw-milling companies.

4.0: Results

In the study area, the main forest plantation tree species planted are *C. lusitanica*, *P. patula*, *P. radiata* and *E. saligna* while the main agricultural food crops cultivated include potatoes and legumes (peas and beans). Up-to 84.8% of the sampled respondents planted *C. lusitanica* and 10.7% planted *E. saligna* during the three year period of the study. About 4.5% of the respondents planted other tree species including *P. patula*, *P. radiata* and *Vitex kiniensis.* The results in the study indicated that between 87.8% and 95.2% of the respondents farming in Gathiuru forest cultivated potatoes while in Hombe forest the percentage was between 92.2% and 94.1%. Legumes (beans and peas), maize and vegetables are produced at minimal levels in the two forest areas.

Further analysis, shows that 90-93% of the respondents produced potatoes as a cash crop and 60-76% of those who cultivated legumes (beans and peas) produced the crops for subsistence purpose (Table 2).

Table 2: Farmers cultivating cash crops and subsistence crops in Gathiuru and Hombe Forests

Percentage of farmers producing Cash crops			
Year	Potatoes	Legumes (beans & peas)	No crops reported
2012	90.0%	0.7%	9.3%
2013	92.1%	1.0%	6.9%
2014	93.1%	1.7%	5.2%
Farmers cultivating subsistence crops			
Year	Potatoes	Legumes (beans & peas)	No crops reported
2012	1.0%	68.0%	30.9%
2013	0.7%	62.2%	37.1%
2014	1.7%	76.6%	21.6%

4.1 Input and output analysis:

Input /Output Analysis for PELIS Communities in Hombe and Gathiuru

***INPUTs*:** On average the PELIS cultivated area in Gathiuru farmers was 128 ha per year while for Hombe farmers the area was 100 ha per year (Table 3&4). The average inputs for the production of both agricultural and tree crops for farmers in Gathiuru forest was Ksh 68,185 per hectare and that for Hombe PELIS farmers was Ksh 83,020 per hectare (Table 3).

Table 3: Total quantifiable inputs for PELIS communities per hectare.

	Community inputs: total production per hectare. (Standardized per ha)				
	Year of Inputs	Area cultivated each year (In hectares)	In puts in agricultural cash & subsistence crops production /ha	In puts into plantation (tree crop) production per ha	Overall inputs (agric & trees) production per ha
Gathiuru Forest	2012	113	46,276	15,888	62,164
	2013	128	46,518	18,647	65,165
	2014	142	61,690	15,536	77,226
Average per hectare		**128**	**51,494**	**16,690**	**68,185**
Hombe Forest	2012	99	62,127	29,896	92,022
	2013	102	50,927	20,752	71,679
	2014	99	65,035	20,324	85,359
Average per hectare		**100**	**59,363**	**23,657**	**83,020**

***OUTPUTS*:** Results for total earnings per ha indicates that farmers in Gathiuru earned an average of Ksh 209,116 per hectare while in Hombe the average earnings were Ksh. 192,633 per hectare (table 4).

Table 4: Total quantifiable outputs for PELIS communities per hectare.

		Communities standardized earnings: outputs per hectare.				
	Year of outputs / Earnings	Area cultivated each year (In hectares)	Earnings Potatoes + legumes per ha	Earnings from assorted timber products per ha	Firewood & domestic use benefits per ha	Aggregate earnings per hectare
Gathiuru Forest	2012	113	274,038	1,168	4,128	279,335
	2013	128	194,357	867	5,002	200,226
	2014	142	147,015	0	773	147,789
Average per year		128	205,137	678	3,301	209,116
Hombe Forest	2012	99	98,140	0	1,441	99,582
	2013	102	110,088	0	1,486	111,575
	2014	99	361,176	1,010	4,556	366,742
Average per year		100	189,802	337	2,495	192,633

Inputs and outputs analysis for KFS

INPUTS: The total cost that KFS incurs in establishing one hectare of *C. lusitanica* plantation is Ksh 271, 966. (Table5). These calculations are based on annual task rates, which are stipulated in the Kenya forest service technical orders and also used to develop the KFS plantation enterprise business plan 2012-1017. The daily wage rate remained Ksh 421 during the period of the study.

Table 5: Cost for establishing a typical one hectare cypress stand

Typical silviculture commitments for a well-managed cypress stand				
	Year	Person days	Daily wage	Cost (Ksh/Ha)
Seedlings	1	110	421	46,310
Clearing	1	25	421	10,525
Staking	1	11	421	4,631
Planting	1	25	421	10,525
Weeding	1	30	421	12,630
Weeding	2	28	421	11,788
Weeding	3	24	421	10,104
Pruning	3	4	421	1,684
Pruning	4	12	421	5,052
Pruning	7	15	421	6,315
Pruning	11	11	421	4,631
Pruning	15	20	421	8,420
Thinning	4	23	421	9,683
Thinning	8	13	421	5,473
Thinning	15	9	421	3,789
Inventory & mapping	15	12	421	5,052
Inventory & mapping	25	8	421	3,368
Protection (one beat = 30 ha)	28	270	421	106,092
Fire breaks (Maintenance)	10	6	421	2,526
Fire breaks (Maintenance)	15	4	421	1,684
Fire breaks (Maintenance)	25	4	421	1,684
Total				**271,966**

Source: Kenya Forest service business plan 2011-2012 the business model and KFSTOs (KFS10c, 2013a and b)

Outputs: *KFS plantation sales and revenues***:** To determine the outputs for the Kenya Forest Service (KFS) and inputs for saw-milling companies, sales and trading data for three timber trading companies are used. The companies include Timsales, Rai-ply and Comply Ltd companies. Analysis of the secondary data included areas in hectares harvested annually by each company, the timber volumes derived from harvests and amounts paid each year for the timber volume determined from the standing trees. Based on the sale and revenue reports of 2011/2012 to 2015/2016 from the Kenya forest service, it is established that in 2012, KFS received an average of Ksh 1,135,333 per hectare from Timsales company, which clear felled 105 ha and obtained 421 $m^3$of round wood per hectare. In 2013 the KFS got on average Ksh 789,709 while in 2014 the revenue collected was an average of Ksh 614,136 per ha. Rai-ply and Comply companies paid revenue of Ksh 1,158,189 and Ksh 997,625 per ha respectively in 2012. In 2014 KFS received Ksh 817,782 per ha from Rai-ply Company (Table 6).

Table 6: KFS outputs-based on revenues from Timsales, Rai-Ply and Comply timber companies.

KFS income based on three key trading companies				
Company harvesting timber	Yr timber was harvested	KFS revenues from the sawmilling companies		
		Area harvested	Total revenue Collected	Average revenue per ha
Timsales	2012	105	119,210,000	1,135,333
	2013	348	274,897,757	789,709
	2014	357	219,492,264	614,136
	Average in the year	270	204,533,340	757,531
Rai-ply Timber Company	2012	127	147,090,000	1,158,189
	2013	628	341,727,232	544,585
	2014	146	119,559,724	817,782
	Average in the year	300	202,792,319	675,224
Comply Timber Company	2012	299	298,290,000	997,625
	2013	504	400,573,111	795,577
	2014	249	268,317,978	1,079,750
	Average in the year	351	322,393,696	919,374

Source: KFS, 2016

Input / Output analysis for the three saw-milling companies.

Inputs: The payments the companies made to KFS are considered as output or earnings for KFS while for the companies, these payments are viewed as the inputs into the investments. Results indicate that the Companies' inputs ranged from Ksh 400,000 to about Ksh 1.2 million per ha. Timsales company invested over Ksh 1,135,333 per hectare in 2012 and Ksh 614,136 per ha in 2014. Rai-ply invested Ksh 1,158,189 in 2012. Comply Co ltd input over Ksh 1 million per hectare in 2014 (Table 7). On average Timsales' average inputs for the three years were Ksh 757,531 per ha, Raiply's average inputs were Ksh 675,224 while Comply ltd inputs were Ksh 919, 374 per ha for the same period.

Table 7: Inputs into PELIS process by saw milling companies.

Inputs into PELIS system by the selected saw-milling companies. {The revenue paid to KFS becomes the Saw-milling companies' inputs (Ksh/Ha)}					
			Amounts companies paid to KFS during the year		
Company harvesting timber	Yr timber was harvested	Area harvested	Average Vol m^3/Ha	Total amounts paid to KFS	Company inputs expressed in (Ksh/Ha)
Timsales	2012	105	421	119,210,000	1,135,333
	2013	348	308	274,897,757	789,709
	2014	357	214	219,492,264	614,136
Average per year		270	315	204,533,340	757,531
Rai-ply	2012	127	471	147,090,000	1,158,189

Inputs into PELIS system by the selected saw-milling companies.
{The revenue paid to KFS becomes the Saw-milling companies' inputs (Ksh/Ha)}

Company harvesting timber	Yr timber was harvested	Area harvested	Amounts companies paid to KFS during the year: Average Vol m^3/Ha	Total amounts paid to KFS	Company inputs expressed in (Ksh/Ha)
	2013	628	176	341,727,232	444,585
	2014	146	264	119,559,724	817,782
Average per year		300	304	202,792.319	675,224
	2012	299	307	298,290,000	997,625
Comply	2013	504	274	400,573,111	795,577
	2014	249	317	268,317,978	1,079,750
Average per year		351	299	322,393,696	919,374

Outputs: The net benefits from the volume of timber purchased by the companies are calculated based on a timber recovery rate of 62.2% determined by the Kenya Forest Service for Nyeri county timber industries. Kenya forest service undertakes a market survey for timber prices and determines rates to apply in setting timber prices prescribed in the Kenya forest Service Technical Orders (KFSTOs) (KFS, 2010c). The market rates per m^3 of wood determined annually were used to estimate volume based sales for each sawmilling companies each year. The total earnings are also calculated less 50% which is assumed to go into the companies' operational costs. Gains made from value addition processes are not considered in the analysis.

Assuming the 50% operational costs, the results indicate that in the year 2014, Timsales Co. Ltd earned about Ksh 2.644 million per ha, Rai-ply earned Ksh 2.350 million and Comply Co Ltd earned approximately Ksh 2.817 million per ha (Table 8).

Table 8: Sawmill outputs from plantation forests.

Determining sawmilling company sales each year
Net outputs at 62.2% recovery and assumed 50% operational costs for the selected saw-milling companies.

Company name & year of business transaction	Average Vol m^3/Ha	Annual rates based on market prices Ksh /m^3	Ksh/ha= Avg Vol m^3/ha X sale rates per m^3	Taking 62% timber recovery rate:	Assume 50% of sales is operational cost

Company Name	Year timber was sold	Total Volume harvested in (m^3)	Area harvested (Ha)	Average Vol m^3/Ha = Total Vol (M^3) /Total area (ha)	Market rates used by KFS	expected sale of total volume of timber sold would be (Ksh/ha)	Outputs = (62% x expected total sales) Ksh per ha	Net output becomes (50%*62% X Outputs) per ha
Timsales	2012	44,248	105	421	25,300	10,661,661	6,610,230	3,305,115
	2013	107,383	348	308	28,500	8,791,788	5,450,909	2,725,454
	2014	76,451	357	214	28,700	6,139,206	3,806,308	1,903,154
	Average per year	76,027	270	315	27,500	8,530,885	5,289,149	2,644,574
Rai-ply	2012	59,874	127	471	25,300	11,927,655	7,395,146	3,697,573
	2013	110,551	628	176	28,500	5,021,023	3,113,034	1,556,517
	2014	38,621	264	264	28,700	7,581,476	4,700,515	2,350,258
	Average per year	69,682	300	304	27,500	8,176,718	5,069,565	2,534,783
Comply	2012	91,659	299	307	25,300	7,755,762	4,808,572	2,404,286
	2013	137,953	504	274	28,500	7,808,683	4,841,383	2,420,692
	2014	78,697	249	317	28,700	9,088,961	5,635,156	2,817,578
	Average per year	102,770	351	299	27,500	8,217,802	5,095,037	2,547,519

4.2 Comparing equity theory ratios:

The **Equity theory ratios = Outputs/Inputs,** computed based on Adams theory**.** In the study, the output and inputs are determined using the hectare as the common unit of measure. Results show that Kenya forest service ratios varied from the lowest ratio of 2.0:1 in 2013 where Rai-ply paid the lowest revenue of Ksh

544,545 per ha. The highest ratio was 4.3:1 in 2013 again where Rai-ply paid the highest revenue of Ksh 1,158,189 per ha. Considering revenues paid by Comply, the lowest ratio was 2.9:1 and the highest 4.0:1 (Table 9). With regard to the three company output: input ratios the lowest was 2.4:1 for Comply company in 2012 and the highest ratios were 3.9:1 in 2013 where Rai-ply paid the lowest revenues 44,545 (Table 9)

Table 9: KFS outputs: inputs ratios

KFS outputs : inputs ratios based revenues and production per ha for three sawmilling companies												
	Timsales Timber Company				**Rai-ply Timber Company**				**Comply Timber Company**			
	2012	2013	2014	Average	2012	2013	2014	Average	2012	2013	2014	Average
Revenue (output) Ksh/ha	1,135,333	789,709	614,136	846,393	1,158,189	544,585	817,782	840,185	997,625	795,577	1,079,750	957,651
Inputs Ksh/ha	271,966	271,966	271,966	271,966	271,966	271,966	271,966	271,966	271,966	271,966	271,966	271,966
(outputs: inputs) ratios	4.2:1	2.9:1	2.3:1	3.1:1	4.3:1	2.0:1	3.0:1	3.1:1	3.7:1	2.9:1	4.0:1	3.5:1
Saw milling company outputs : inputs ratios based on production per ha												
	Timsales Timber Company				**Rai-ply Timber Company**				**Comply Timber Company**			
output Ksh / ha	3,305,115	2,725,454	1,903,154	2,644,574	3,697,573	1,556,517	2,350,258	2,534,783	2,404,286	2,420,692	2,817,578	2,547,519
inputs Ksh/ Ha	1,135,333	789,709	614,136	846,393	1,158,189	544,585	817,782	840,185	997,625	795,577	1,079,750	957,651
(outputs: inputs) ratios	2.9:1	3.5:1	3.1:1	3.1:1	3.2:1	2.9:1	2.9:1	3.0:1	2.4:1	3.0:1	2.6:1	2.7:1

When all community gains from agricultural and tree crops were compared against all community inputs into PELIs, the lowest equity theory ratio of output against inputs was 1.1:1 in 2012 for farmers in Hombe forest and the highest was 4.5:1 in 2012 Gathiuru forest. The lowest ratio in Gathiuru forest was 1.9:1 while

for Hombe farmers, the lowest ratio was 1.1:1 in 2012 wand the highest was 4.3:1 in 2014. The average for the three years was 3.1:1 in Gathiuru and 2.3:1 for farmers in Hombe.

Table 11: Communities' Outputs: Inputs ratios

Community ratios: (Outputs: Inputs) based on per hectare production								
Outputs vs inputs	**Gathiuru**				**Hombe**			
	2012	2013	2014	Average	2012	2013	2014	Average
Aggregate earnings per hectare	279,335	200,226	147,789	209,116	99,582	111,575	366,742	192,633
(Agric & tree inputs) production per ha	62,164	65,165	77,226	68,184	92,022	71,679	85,359	83,020
Ratios (Outputs: inputs)	4.5:1	3.1:1	1.9:1	3.1:1	1.1:1	1.6:1	4.3:1	2.3:1

The highest average ratio for KFS was in 2012 where it was 4.1:1. The highest average ratio for the three companies was in 2013 where it was 3.1:1 but communities had the least average in the same year-2.4:1 For communities farming in the two forests, the average ratio was 2.8:1 for the period of the three years while for KFS it was 3.4:1 and for the three companies it was 3.0:1 for the same period (Table 12). The range of ratios is between 2.6:1 and 4.1:1 for the Kenya Forest service while for the three companies the ratio ranges between 1.9:1 and 3.1:1. For the communities farming in Gathiuru and Hombe forests, the ratios range from 2.4:1 and 3.1:1.

Table 12: Equity theory ratios for KFS, Saw-milling companies and PELIS communities

PELIS Partner	**Company**	**2012**	**2013**	**2014**	**Average**
Kenya Forest Service (outputs: inputs) in PELIS	Timsales	4.2:1	2.9:1	2.3:1	3.1:1
	Rai-ply	4.3:1	2.0:1	3.0:1	3.1:1
	Comply	3.7:1	2.9:1	4.0:1	3.5:1
Average		4.1:1	2.6:1	3.1:1	3.2:1
Sawmilling Companies (Outputs: inputs) in PELIS	Timsales	2.9:1	3.5:1	3.1:1	3.2:1
	Rai-ply	3.2:1	2.9:1	2 .9:1	3.0:1
	Comply	2.4:1	3.0:1	2.6:1	2.7:1
Average		2.8:1	3.1:1	1.9:1	3.0:1
PELIS Communities (Outputs: inputs) in PELIS	Gathiuru	4.5:1	3.1:1	1.9:1	3.2:1
	Hombe	1.1:1	1.6:1	4.3:1	2.3:1
Average		2.8:1	2.4:1	3.1:1	2.8:1

4.3: Parameters to consider for improved equity in costs and benefits:

To ensure equity this study proposes enhancement of accountability and transparency when formulating regulations and guidelines for cost –benefit sharing mechanisms. This study revealed that some of the key parameters that influence inputs and outputs in PELIS include participation in silvicultural operations, which in the views of communities are technical and tedious. These activities include staking, pitting, seedlings production, planting, pruning and thinning. The communities argue that they should only be engaged in land preparation and weeding, which has direct effect on agricultural production. In determining community inputs, the individual input into each specific task should be taken into account.

In the proposed model, the total community labour inputs for example in seedlings production should take into account the sum of individual inputs both in cash and in kind (SP_i) where subscript 'i' represents all of the individuals inputs in that particular task. The total costs or inputs SP for a CFA with 'n' number of members should then be $Sp_{(i\ldots n)}$.

It therefore follows that the total input by a given CFA in tree seedlings production will be

$SP = Sp_{(i..n)}$, Where $Sp_{(i..n)} = \sum(Sp_1+Sp_2\ldots Sp_n)$

A similar process is carried out for all tasks and inputs by individuals involved in any given activity. The total inputs should then be the value of the sum of all activities by all individuals, which should guide the proportion of benefits appropriate for community and individuals.

The total benefits from the model should also be computed including all monetary and material products from the forests:

Total Benefits = $\sum$(TPs(i…n)+ Prs(i…n)+ Ths (i…n)+ Hvs(i …n) +Grs(i..n) + others….) where
TPs(i…n) = All benefits derived from Timber products
Prs(i…n) = all benefits derived from prunnings
Ths (i…n) = All benefits derived from Thinnings
Fw(i …n) = All benefits derived from firewood
Grs(i..n) = All benefits from grazing
OB(i..n) … = Any others measurable benefits…

Proposed equity parameters for inputs:

Table13: Spectrum of plantation establishment costs and proposed distribution of subsequent benefits/profits

Cost Activities	Land preparation Digging, Harrowing, staking, pitting	Seedlings production	Planting: (Setting and covering)	Weeding	Pruning	Thinning	Harvesting	Post harvesting costs
Sum of total activity Costs	LP= $Lp_{(i\ldots n)}$	SP= $Sp_{(1\ldots n)}$	PC= $Pc_{(i\ldots n)}$	WC= $Wc_{(1\ldots n)}$	PR= $Pr_{(1\ldots n)}$	TH= $Th_{(1\ldots n)}$	HV= $Hv_{(1\ldots n)}$	PH= $Ph_{(1\ldots n)}$
Individual sub-activity costs	$Lp_{(i\ldots n)}= \sum Lp_1+Lp_2 Lp_3...Lp_n)$	$Sp_{(1\ldots n)}= \sum Sp_1+Sp_2 \ldots Sp_n)$	$Pc_{(i\ldots n)}= \sum((Pl_1+Pl_2\ldots. Pl_n)$	$Wc_{(1\ldots n)}= \sum Wd_1+Wd_2+Wd_3)$	$Pr_{(1\ldots n)}= \sum Pr_1+Pr_2+P_3)$	$Th_{(1\ldots n)}= \sum Th_1+Th_2+Th_3)$	$Hv_{(1\ldots n)}= \sum Hv_1+Hv_2 ..v_n)$	$Ph_{(1\ldots n)}= \sum Ph_1+Ph_{2\ldots\ldots} Ph_n)$
Other parameters	Other costs (OCs) = (meetings, workshops , conflict resolutions) $OC_{(i\ldots n)}= \sum OC_1+OC_2+OC_3\ldots OC_n)$				Other benefits $(OB_{(i..n)})$=			
Monetary Benefits	Total inputs =(LP:SP:PC:WC:PR:TH:HV:PH+ OCs) (OC-Other costs) Total Benefits= $\sum(TPs_{(i\ldots n)}+ Prs_{(i\ldots n)}+ Ths_{(i\ldots n)}+ Fw_{(i\ldots n)}+Grs_{(i..n)}+ OB_{(i..n)} \ldots.)$ (OB- Other Benefits) The costs and benefits for agricultural productions should also be included. Sharing of costs and benefits can then be based on the outcome of the computations. Discounting may be essential.							

5.0: Discussion.

Although several authors have highlighted the value and benefits of shamba (farm) system in forest plantation establishment to communities and governments (Chamshama *et al.,* 1992; Adenkule & Bakare 2004; Thenya *et al*., 2007; Kalame *et al.,* 2011; Khalumba *et al*., 2015), the approach is also castigated in equal measure. It has been blamed for contributing to forest destruction including in areas like Mt Kenya forest ecosystem among other forest ecosystems (Jordan *et al.,* 1992; Bussmann, 1996; Gathaara, 1999; Kariuki, 2007; Maathai, 2009; Witcomb and Doward 2009). This is because the system has been subjected to abuse by officials and persons taking advantage of legislative gaps and weaknesses in its implementation and governance (Kagombe and Gitonga, 2005; Musyoka, 2008). Thus, the system can benefits approach that requires continuous improvement guided by empirical and practical scientific, evidence that takes into account socio-economic dynamics.

Under the shamba (farm) system now currently renamed plantation establishment and livelihood improvement scheme (PELIS), the farmers are expected to benefit from availability of land for farming, the agricultural produce and other ecological services that forests may provide. Under these arrangements, the forest managers gain from reduction in the cost of forest plantation development and the revenues from the sale of the tree products. The farmers' gains are limited to food production, income generation through sale of the agricultural crops (Witcomb and Doward 2009, Ndomba et al., 2015). According to communities' perception inequity exists in costs and benefit sharing in this participatory agreement. While the communities undertake activities such as seedlings production, pitting, staking, tree planting, pruning, thinning, policing and coppice reduction and other activities all geared towards establishment of the forest plantations the communities view these as technical obligations of the forestry agencies and are seen to be over bearing on the farmers. In contrast the forest agencies play no role in support of production of the agricultural crops from which communities benefit. Some communities argue that the forestry agency should separately compensate them for example in partial or complete wages for the communities inputs towards the plantation development activities. However, this study demonstrate that there is no greater variation in input and output among community, KFS and timber companies.

Findings in this study indicate that the ratios of outputs: inputs for KFS and those of sawmilling companies were very close (3.2:1 and 3.0:1) respectively during the three years of study. The average ratios for the communities were slightly less 2.8:1. This result indicates that there was equity between the KFS and the saw millers but even though the ratio for communities was slightly less. However, it would be motivating to protect the tree seedlings if benefits associated with tree would be allowed to trickle to farmers. While this would enhance the equity ratios, it is also likely to enhance the communities' sense of tree ownership and hence motivate farmers to protect the trees. Overall farmers have reported improved livelihoods through engagement in PELIS (Matiku, 2013; Mutune, 2016) for communities neighboring the Mau forest complex.

The shamba system has often been hailed as one of the successful agroforestry systems that has supported expansion of the forest cover, helps meet domestic and industrial demand for wood and supports rural livelihoods (Nair, 1989). Researchers have pointed out that if well managed the shamba system is a suitable approach that can ensure sustainability of forests (Kagombe and Gitonga, 2005). The system has capacity to provide multiple benefits both to government and communities under good governance. While Witcomb & Dorward, (2009) addresses the need for administrative transparency and clear benefit sharing mechanisms.

While the general view has been that communities are not adequately compensated for the inputs into the participatory plantation establishment, results of this study reveals the output: input ratios for KFS and saw-milling companies are relatively close but the communities' ratio, were slightly lower comparatively. This reflects the likely source of the discontent often expressed by communities but also supports the KFS arguments against sale of forest plantation based on reserve prices but rather sale based on a free market and open bidding as the options to raise the value of the plantations and subsequent revenues (KFS 2013a). According to Adam's theory of equity, the parties that perceive inequity in the relationship seek alternatives that attempt to address the inequity. The reaction of communities in participatory forest management is often to contend with Kenya forest service to provide the communities with sawmilling opportunities. However, limitations in terms of government procurement requirements and financial resources make this alternative difficult leaving the communities contesting against plantation allocations to saw-milling companies.

In this study 98.9% of farmers in Gathiuru forest and 85.3% of those in Hombe forest view PELIS as a profitable engagement. Regardless of this sense of profitability, the perception of inequity persists. The study found out that the communities attribute the income from agricultural crop to their hard work and intense inputs into crop production and could not relate the benefits to trees or the forest. However, the

analysis in this study shows that the returns among the three stakeholoders is based on their input and thus for one stakeholders to improve returns, they would have to improve their input. The perception of communities, other stakeholders and some researchers that the benefits derived from PELIS under PFM are insufficient is not true and there is thus clear methods and increasing returns as demonstrated in this study. What might be necessary is to assist local community through policy formulation to access credit for higher input ventures such as saw milling, which has been pointed out by other researchers (Jordan *et al.,* 1992; Matiku *et al.,* 2011). The study provides a formula that integrates all inputs from partners and compares each output as a benefit to each partner.

However, casting the community as 'peasant farmers' 'forest users' and the shamba system as a forest –user right tends to demean and weaken the power devolvement to communities thus limiting the programmes potential to both facilitate and embody the participation of local people in forest management (Witcomb, and Doward, 2009). It also fails to capture emerging socio economic dynamics where farmers are empowered gradually angling towards high input engagement.

6.0 Conclusion

The study concludes that applying the equity theory ratios can provide an opportunity to address inequity in participatory forest management. Aggregating all inputs specific to each partners' inputs and comparing the outputs amongst the concerned partners is an important part of this process.

Based on computed ratios, there exists a slight difference in benefit sharing and there is need to balance the ratios through increasing gains to forest custodians. While this is possible, it is not clear how could be achieved. The KFS applying free market forces in sale of forest plantations could be an option to increase revenues. Supporting communities in production and marketing of the agricultural crops could enhance output per unit land thereby increasing outputs and bridging the ratio gap.

The saw-milling companies and the forestry agencies may re-distribute part of the benefits to the communities' through the corporate social responsibilities (CSR) umbrella. Such support may be directed to technical activities such as inputs into land preparation, raising of tree seedlings, tree planting or silvicultural activities. This would go a long way in bridging the gap between the ratios, improve equity, and enhance relationships among players and impact sustainable forest management positively.

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