Impacts of Participatory Management of Ruvu North Forest Reserve on Reforestation and Food Availability in Two Villages in Kibaha District

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Abstract: *The study explored the impacts of participatory management of Ruvu North forest reserve on reforestation and food availability to farmers in two villages in Kibaha District. Specifically the objectives were: (i) to find out number of households that participated in tree planting and the survival rates of trees during the project life; (ii) to enquire the reasons for famer's participation in tree planting and tending; (iii) to appraise the land available for farming households before and at end of the project's life; (iv) to assess the households food availability at the beginning and end of the project's life; (v) to determine the growth rates of planted tree species and then estimate the age when they attain withies, pole and timber size classes and (vi) to examine the tree tenure arrangement in the study area. A questionnaire was used to collect socio economic data from fifty farming households sampled purposively. A systematic sampling of trees was carried out on three farms to assess the growth rates of trees. Farmers provided the age of woodlots. Interviews with key informants and observations complemented data collection methods. Quantitative and qualitative data were analyzed using GenStart statistical package and content analysis respectively. Growth of trees was analyzed by MS Excel spread sheet. Correlations between height, diameter breast height (dbh) and age were generated and the results presented in form of graphs. The results showed increased number of participating households for 5 year with about 1/3 being headed by women. One point three million trees were planted and 0.73million survived at the rate 58.2%. Land was acquired through buying (33%) and allocation by village government (2%). Before project 95.4% of respondents had farms of 1.0 hectare or less. Respondents benefited by gaining access to fertile forest land, getting poles, charcoal, cash for paying school fees, firewood and building houses. Households produced sufficient food crops only at the beginning of the project and currently 78% have food shortages. Mean dbh, height and age of trees showed strong linear correlations (r^2 = 0.997 to 0.679). Trees yielded withies and poles at the age of 2.5 and 5 years respectively. Trees will reach a dbh of 60-65cm after 30 years of growth. It was concluded that farming households cannot exist without forest woodlots. Therefore contract agreements to manage the woodlots should be extended for the next 20 years so that farmers can harvest and sell timber.*

Key words: Participatory forest management, tree survival, growth rates and food availability, Ruvu North Forest Reserve.

INTRODUCTION

Participatory forest management (PFM) encompasses processes and mechanisms that enable those people who have a direct stake in forest resources to be part of decision making in some or all aspects of forest management, from managing resources to formulating and implementing institutional frameworks (Schreckenberg and Luttrell 2009; FAO 2012). Food availability refers to the physical availability of food stocks in desired quantities (Swaminathan, 1986). Production of food grains and legumes was used as a proxy for food availability in the study area. The two definitions were adopted in this study.

There are three forms of PFM in Tanzania. The first one is joint forest management (JFM) which takes place in forest reserves owned and managed by either central or local government. JFM is implemented in national forest reserves with high biodiversity and ecological values. Timber harvesting is strictly forbidden. Adjacent villagers enter into management agreements with the government to share responsibilities and benefits for the management. The second form of PFM is community based forest management (CBFM) and takes place on village forest reserves that are owned and managed by village government through a village natural resource committee. The village government (VG) owns the forests and carries the costs of management. The benefits obtained during harvesting of timber go to the VG (Bromely and Ramadhan, 2006; Blomley and Iddi 2009; Vyamana, 2009).

The third form of PFM is the “shamba” or "taungya" or rotational agroforestry system. The "shamba" is a Kiswahili word for field or farm (Oduol, 1998; Imo, 2008) and “taungya” is Burmese word for hill cultivation (Amoah, 2009). In this system the forest department provides forest land to needy or landless villagers who plant trees together with food crops for a limited period of up to five years until the trees start shading food crops. After five years, the land is then left for trees to continue growing without agricultural crops. The villagers are provided with a new parcel of forest land to start the process again (Chamshama et al., 1992; Witcom and Doward 2009). The “shamba” system has received very little research attention in Tanzania compared to other African countries like Kenya, Ghana and Nigeria.

The Shamba (Taungya) System

Traditionally the shamba system aims at wood production. Production of food crops is a short term benefit accrued to farmers who plant and tend trees. Under this arrangement, farmers do not benefit from the later sell of harvested timber (Chamshama et al. 1992, Agyeman et al., 2003; Kagombe and Gitonga 2005). Also they do not make decisions in forest management (Agyeman 2003). As a result, farmers tend to neglect the tree crops. Also forest departments in many developing countries do not supervise the farmers properly due to inadequate funding and corruption (Agyeman *et al.*, 2003).

Impact of the Shamba System on Afforestation and Economic Returns
The shamba system is used in many countries in Africa (Nwonwu 1987, Chamshama et al., 1992; Agyeman et al., 2003; Kagombe and Gitonga, 2005; Amoah, 2009; Kalu et al., 2011) and South East Asia (Watanabe et al., 1988; Jordan et al., 1992; Boonkird et al., 1994) in the re-forestation programs. The total area of forest plantations in Tanzania is estimated at 250,000 ha. Out of this, government owns about 85,000 ha which were established with both paid labour and taungya system (Ngaga, 2011). In Kenya the shamba system was used by the government to afforestate 160,000 hectares (Kagombe and Gitonga, 2005). In Ghana over 53,000 hectares of new forest plantations were established between 2001 and 2005 using the modified taungya system (Nsiah, 2010).

In Tanzania, Chamshama et al., (1992) found that the productivity of taungya system in terms of net present value was significantly higher (TZS 392,425) than that of pure wood production (TZS 23,293). They also reported that income per Labour Day under taungya system was 5 times higher than income obtained in pure afforestation activities. They concluded that taungya was attractive to participating farmers. Similar findings were reported from taungya farmers in Kiambu District, Kenya where the system ensured food availability (Kangombe, 1998). Elsewhere in Eastern and Southern Africa, Hoekstra, (1994) reported that taungya system was found to be economically viable where there was land scarcity and cheaper return to labour.

Nigeria the taungya system reduced the cost of afforestation to the forest department by 58% (Enabor, 1978). Nwonwu (1987) reported from Nigeria that the cost per hectare of establishment of beech wood (*Gmelia arborea* Roxb.*)* plantation was lowest with taungya labour and highest with permanent labour. The savings in costs was 30% and 40% lower by taungya over casual labour respectively compared to permanent labour. In contrast to these results, Adekunde and Bakare (2004) obtained lower revenue from taungya crops (Naira 59, 974.00) than revenue received from crops grown outside taungya system (Naira 72,976.00). In their study timber harvests were not counted. It appears that farmers participate in shamba system due increased food availability and economic gains. They can benefit more if they can get a certain percentage from the sale of tree harvest.

Efforts to Improve the Shamba System
Improvement to the system has occurred in Ghana through the modified taungya system in which the participating farmers get revenue of 40% from timber sales (Agyeman *et al.*, 2003; Amoah, 2009). In Tanzania improvement to the system was initiated at Ruvu North forest project in Kibaha District where the participating farmers were promised ownership 80% of the trees they planted. This is the only project in Tanzania where participating farmers had a direct ownership of trees they planted. Each of the selected heads of farming households from 4 villages was allocated 3 hectares degraded forest reserve for implementing agroforestry. As an incentive they were allowed to produce and sell charcoal and firewood from the reserve. On the cleared forest land farmers simultaneously intercropped agricultural crops with tree seedlings in a rotational agroforestry or taungya system. The planted trees were exotic species mainly Sabah

salwood (*Acacia mangium* Willd.), Northern wattle (*Acacia crassicarpa* A. Cunn. ex Benth), blue or Mysore gum (*Eucalyptus tereticornis* Smith) from Australia and black wood (*Senna siamea* (Lamarck) Irwin et Barneby) (Msuya et al., 2004).

Unlike in Kenya (Kangombe, 1998; Imo, 2008, Witcom and Doward, 2009), Ghana (Agyeman et al., 2003; Amoah, 2009) and Nigeria (Nwonwu, 1987; Adekunde and Bakare, 2004) where a lot of research has been published on the taungya system, very little has been reported from Tanzania. Only the studies by Chamshama et al., (1992) and Ngaga (2011) were found in the literature. Despite an increase in number of donor funded projects in Tanzania implementing PFM in the form of JFM (Pfliegner and Moshi, 2007; Blomley et al., 2008; Nshumbemuki et al., 2009), and CBFM (Vyamana 2009; Kajembe et al., 2009; Ngaga et al., 2009) very little has been done on the shamba system and food availability. In JFM participating villagers are reported not benefiting from this arrangement because the sale of timber is prohibited. In the CBFM participating villagers are reported to benefit because the sale of timber is allowed (Ngaga et al., 2009; Vyamana et al., 2009). This gap in PFM where a lot of researches and resources are being directed to CBFM and JFM and very little to shamba system aroused the interests of the author to do research on the later system.

The research reported here was directed at exploring the impacts of participatory management of Ruvu North forest reserve on reforestation and food availability of participating farmers in Mkuza and Msangani villages in Kibaha District. Specifically the objectives were:

(i) To find out number of households that participated in tree planting and the survival rates of trees during the project life;
(ii) To enquire the reasons for famer's participation in tree planting on government's land;
(iii) To appraise the land available for farming households before and at end of the project's life;
(iv) To assess the households food availability at the beginning and end of the project's life;
(v) To determine the growth rates of planted tree species and then estimate the age when the trees attain the withies, pole and timber size classes.
(vi) To examine the tree tenure arrangement in the study area

METHODOLOGY

Research Location

The research was conducted in Msangani and Mkuza villages close to Ruvu North forest reserve which covered 32,000 hectares (Solberg, 1988). The reserve is located in Kibaha District, Coast Region, and 60 km west of Dar es Salaam along Dar es Salaam – Chalinze highway. It lies between latitude 6^o33-$6^o43'$ S and longitude $38^o48'$-$39^o03'$ E; and at altitudes ranging from 60 to 90 meters above sea level. The topography is almost flat and gently undulating. Soils are sandy loam, sand clay loam and clay (Solberg, 1988). The area has two rainy seasons namely the short rains from November to

December and long rains from March to May. Mean annual rainfall varies between 900 and 1,600mm. It falls in irregular patterns. Temperature ranges between 18 and 33^{o}C (Ndomba, 2004).

Sample Size and Sampling Method

Farmers from four villages at Kongowe, Msangani, Mkuza and Mwendapole entered into co-management of Ruvu North Forest reserve with the project in 2000. The first two villages are close to the forest reserve and the last two are four kilometres away along Dar – Chalinze highway. Management agreements were signed between heads of households and the project staff initially for 10 years up to 2010. These agreements could be renewed upon satisfactory implementation on both sides. The criterion used to allocate the plots to farmers by the project was that of being a farmer with no other occupation. In each village 3 hectares of degraded forest was allocated to each head of household by the project to plant trees. The project availed potted seedlings and farmers planted them together with agricultural crops. In each village 100 households were involved. In total there were 400 households. Only Mkuza and Msangani villages were purposively selected for this study. The former village was selected due to closeness to the main road leading to Dar es Salaam and the later was chosen due to closeness to forest reserve. In each selected village, 25 participating households were selected systematically (every 4th household) from the list of 100 households who owned woodlots.

Data Collection Methods

Secondary data were collected from the reports available at the Ruvu North forest project at Kongowe village, offices of the village government at Msangani and Mkuza, District Natural Resources Office at Kibaha, Ministry of Natural Resources and Tourism in Dar es Salaam and other printed sources. These include the number of households which planted trees, type of trainings given to farmers, the number of trees that were planted and survival rates each year. This gave information on the rate of adoption of tree planting and survival rates during the project years (objective i).

Primary data on socio economic situation of participating farmers before and after the project was assessed using a structured questionnaire administered to heads of 50 households. Farmers were asked about their family sizes, education levels, reasons for participating in tree planting (objective ii), land available for agriculture before and after project (objective iii), how they acquired land, if the food crops they produce were sufficient to feed their families for the whole year at beginning of the project and after the project (objective iv). Tree tenure arrangement was assessed through documents availed by farmers and project staff. These were compared to tree tenure system common in Tanzania (objective vi). Interviews with key informants (village government, project staff and agricultural extension workers) were conducted to obtain expert opinion. Transect walks with farmers and direct observations supplemented the methods of data collection. By comparing the data before project and after project, the researcher was able to assess whether the farmers at Msangani and Mkuza villages have enough land to sustain the food production for their families.

Parameters of Tree Performance

Primary data on tree growth were collected on three farms of 3 hectares each in size which were three kilometres apart. The criteria for selection of the farms were presence of enough trees and willingness of the farmer to cooperate with researcher. The growth of planted trees was assessed empirically through systematic sampling of five circular plots of 500m2 in each woodlot of 3 hectare. Similar sampling procedures have been used elsewhere in Tanzania (Fungameza 2011). The diameter breast height (dbh) of each standing tree (dependent variable 1) was measured using tree callipers in each circular plot and farm, and then recorded per tree type. The height (dependent variable 2) of three sample trees in each sample plot was measured using Blumeleis hypsometer. Farmers were asked about the age of their woodlots (independent variable) which was recorded. These data formed the basis of establishing correlations between dbh, height and age of trees according to species. Trees were classified into withies (dbh= 2.5-4.9cm) and poles (dbh= 5-15cm) according to Blomley et al., (2008). The age of 30 years used for timber rotation of teak at Kilombereo, in Morogoro was adopted (Bekker et al., (2004). This was done for each type of tree species and the corresponding dbh was calculated (objective v).

Data Analysis and Presentation

Secondary data on tree survival rates and primary data from tree diameter and heights were analysed using Microsoft Excel spread sheet. Data from tree diameter and heights generated growth equations and correlation coefficients. Data from structured questionnaire were analysed using GenStat Statistical Package Version 10 (Payne et al., 2007). Descriptive statistics and correlation analysis were generated and presented using Tables and Figures. Data from interviews were subjected to content analysis (Krippendorff, 2004).

RESULTS AND DISCUSSION

Characteristics of Heads of Farming Households in Research Villages

Table 1 shows sex, education level and marital status of responds from two villages. Seventy two and 28% of the farming households were headed by men and women respectively.

Table 1: Sex, Education Level and Marital Status of Heads of Households in Msangani and Mkuza Villages

Variable	Msangani (N= 25)	Mkuza (N= 18)	Total
Sex			
Male	18	13	31 (72.0)*
Female	7	5	12 (28.0)
Education level			
No formal education	4	3	7 (16.3)
Primary education	20	15	35 (81.4)
Secondary education	1	0	1 (2.3)
Marital status			

Variable	Msangani (N= 25)	Mkuza (N= 18)	Total
Sex			
Single	3	3	6 (14.0)
Married	18	13	31 (72.0)
Divorced	2	1	3 (7.0)
Widowed	2	1	3 (7.0)

(* = Numbers in brackets indicate percentage)

Eighty one point four percent of respondents finished primary school. Sixteen point three percent did not have formal education and 2.3% reached secondary education. Seventy two percent of the farming households were couples, 14% were singles while 7% each were either divorced or widowed respectively.

Age Distribution of Household Heads and Size of Households in Msangani and Mkuza Villages

The age distribution of heads of households in the two villages is shown in Table 2. All the respondents were above 30 years. Forty percent were aged between 31 and 50 years. Sixty percent respondents were above 50 years.

Table 2: Age Distribution of Household Heads in Msangani and Mkuza Villages

Age group (years)	Msangani (N= 25)	Mkuza (N= 18)	Total (N=43)
30 or less	0	0	0 (0.0)*
31-40	4	4	8 (18.6)
41-50	7	2	9 (21.0)
51-60	10	6	16 (37.2)
Over 61	4	6	10 (23.2)
Total	***25***	***18***	***43 100)***

(* = Numbers in brackets indicate percentage)

Table 3 depicts the different sizes of households in Msangani and Mkuza villages. Twenty seven point nine percent of the household had 1-4 people. Fifty eight point one percent of the households consisted of 5-8 people. Fourteen percent of the households had 9 and more members.

Table 3: Size of Households in Msangani and Mkuza Villages

Size of HH Members	Msangani (N= 25)	Mkuza (N= 18)	Total
1-4	8	4	12 (27.9)*
5-8	13	12	25 (58.1)
9 or more	4	2	6 (14.0)
Total	***25***	***18***	***43(100)***

(* = Numbers in brackets indicate percentage)

Farmers Participation in Tree Planting and Survival Rates of Trees at Ruvu Forest

One hundred eighty farming households participated in tree planting during the first year in 2000. This number increased in each year to 670 households in 2004 (Table 4). Participating farmers planted 1,239,000 in a period of 5 years. In total 712,297 trees survived. Tree survival rates ranged between 50 and 70% with a mean of 58.2%. This medium survival rate can be attributed to drought stress which occurred in 2002 and 2003 and also the lack of replacement of dead seedlings. Also this survival rate observed was similar to that of 57% assessed by Omonyemi et al., (2000) on taungya farmers in Nigeria. Survival rates of between 61and 77% were measured by Kiangi (2010) in plantations of weeping and slash pines at Sau Hill forest plantation in Iringa Region. Plantations were established using taungya labour (Ngaga, 2011). Nduwamungu et al., (2002) reported from Kilosa District in Morogoro region that trees planted by farmers for the period of 10 years had on average survival rate 75%. In the North Pare Mountains of Mwanga District, Fungameza (2005) measured average survival rate of 88% for trees planted on farms for period of five years. Higher survival rates of 80% to 91% were measured by Chamshama et al., (1992) in taungya forest plantation at West Kilimanjaro. These higher survival rates were attributed to higher rainfall and better tending in those sites compared to Ruvu in the Coast region where rainfall is unreliable and resulted in wilting of young trees in years 2002 and 2003.

Table 4: Number of Farming Households, Trees Planted and their Survival Rates

Year	No. of farming households who planted trees	Trees planted each year	Trees that survived	Survival rate (%)
2000	180	200,000	140,000	70
2001	250	240,000	145,000	60
2002	310	285,000	142,700	50
2003	400	273,000	136,250	50
2004	670	241,895	148,347	61
Total		1,239,000	712,297	
Average survival rate %				**58.2**

Source: Ministry of Natural Resources and Tourism (2004); Ruvu Project Files

Reasons for Participation in Tree Planting at Ruvu Forest Reserve

Eighty one point four percent of respondents joined the project because they needed the land for growing food crops (Table 5). Other reasons were getting wood for selling (42%), production and sell of charcoal (14%) and soil conservation (4.7%). All the respondents who produced charcoal came from Msangani village which is close to the forest reserve.

Table 5: Reasons for Participation in Tree Planting on Government Land

Reason	Respondents from Msangani (N= 25)	Respondents from Mkuza (N= 18)	Total (N= 43)
Get land for growing food crops	21	14	35 (81.4)*
Plant trees for selling wood	15	3	18 (41.9)
Charcoal burning and selling	6	0	6 (14.0)
Environmental conservation	2	0	2 (4.7)

(* = Numbers in brackets indicate the percentage of respondents)

Land Available to Farming Households Before and After Joining the Project

Table 6 shows that 44.2% of respondents were landless and 51.2% possessed land between 0.1and 1.0 hectare before the project. All respondents had access to 3 hectare land after joining the project. Therefore land scarcity was the major driving force in participation in afforestation project. This finding confirms the observations made by Chamshama et al., (1992) in Tanzania, Kangombe and Kitonga (2005) in Kenya and Amoah (2009) in Ghana that most of the farmers practicing taungya have land scarcity.

Table 6: Land Available to Each Household for Cultivation Before and After Joining the Project

Size of farm land (ha) per household	Before Project			After Project		
	Msangani (N=25)	(Mkuza (N=18)	Total	Msangani (N=25)	(Mkuza (N=18)	Total
Landless	8	11	19 (44.2)	0	0	0 (0.0)*
0.1-1.0	16	6	22 (51.2)	0	0	0 (0.0)
1.1-2.0	1	1	2 (4.6)	0	0	0 (0.0)
2.1-3.0	0	0	0 (0.0)	8	11	19 (44.2)
3.1-4.0	0	0	0 (0.0)	16	6	22 (51.2)
>4	0	0	0 (0.0)	1	1	2 (4.6)

(* = Numbers in brackets indicate the percentage of respondents)

Land Acquisition by Farming Households in Msangani and Mkuza Villages

Table 7 indicated that land was acquired through the project (100%), buying (33%) and allocation by village government (2%). Land provided by the project played an important role in food crop production of households. The land allocated by village government was very minimal without any significance. According to Luoga et al., (2004) most of the households in the study villages are immigrants from upcountry. This is probably the reason why there was no land acquired through inheritance which is most common in many rural areas of Tanzania (Tesha 2000).

Table 7: Types of Land Acquisition by Households in Msangani and Mkuza Villages

Type of acquisition	No. of respondents in Msangani	No. of respondents in Mkuza	Total	Percentage
Village government	0	1	1	2
Buying	11	3	14	32.5
Project	25	18	43	100

Benefits Accrued to Farmers by Participating in Tree Planting at Ruvu North Project

Table 8 presents the responses of the famers about the benefits they get from participation in the shamba system. All respondents (100%) gained access to fertile land for growing food crops. Other benefits were harvesting and selling poles (44%), charcoal production and selling (41%), cash for paying school fees (21%), getting firewood (18.5%), building houses (9.3%), training on nursery techniques (4.6%), attending seminars and study tours (4.6%), training on the production of wood saving stoves (2.3%), getting tree shade for homesteads (2.3%) and buying television (2.3%).

Table 8: Benefits to Participating Farmers at Ruvu North Project

Type of benefit	Msangani (N= 25)	Mkuza (N= 18)	Total	Percent
Land for growing food crops	25	18	43	100 (1)*
Harvesting poles for home use & selling	13	6	19	44.2 (2)
Charcoal production and selling	9	9	18	41.8 (3)
Paying school fees	5	4	9	21.0 (4)
Firewood for home consumption & selling	4	4	8	18.5 (5)
Building a house	4	0	4	9.3 (6)
Training on nursery techniques	0	2	2	4.6 (7)
Attending seminars & study tours	1	1	2	4.6 (7)
Training on production of wood saving stoves	1	0	1	2.3 (8)
Tree shade for Homestead	0	1	1	2.3 (8)
Bought Television	1	0	1	2.3 (8)

(* = Numbers in brackets indicates the ranking)

Tree Tenure Arrangement

The farmers signed management agreements with the project to use the forest plots for initially 10 years (2000 to 2010). These agreements could be renewed upon satisfactory implementation of the obligations contained in the agreements. Although some farmers sell withies and poles of blue gum (*E. tereticornis*) and black wood (*Senna siamea*) most of woodlots are left growing (Figures 1) until they attain timber size class. Respondents indicated that the current agreement of using the woodlots for 10 years has created fear of losing their trees. This is what a 77 year's old man in Msangani village said: "*nangojea nione nini kitatokea, maana nimetumia nguvu zangu kupanda miti na kuitunza, sijui kama wataninyanganya"* It means that this old man was waiting to see what will happen to him. He has invested a lot of time and labour in tree planting and tending. He is not sure if the project will repossess all the trees and live him with nothing.

Figure 1: A Typical Farm Woodlot at Msangani with Red Wattle *(Acacia crassicarpa* (A. Cunn ex Benth) L. Pedley) (foreground) and Blue Gum (*Eucalyptus tereticornis* Smith) (background). Right is mud house of a participating farmer.

In order to get timber, trees need more years to grow so that they attain bigger dimensions (dbh). On the question on "for how long they would like the agreement to be extended", the following were their responses (Table 9). All the respondents wanted the signed agreement to be extended beyond ten years. Seventy two percent wanted the extension of 30 years which is similar to the rotation period used for Teak plantations at Kilombero, in Morogoro (Bekker et at., 2004). At the age of 30 years blue gum (*E. tereticornis*) was estimated empirically in this study to have a dbh of 59.85cm, red wattle (*A. crassicarpa)* a dbh of 65.94cm and brown Sal wood (*A. mangium)* a dbh of 62.43cm. About 16.3% of the responds wanted the extension of 40 to 50 years and 11.3% did not know for how long.

Table 9: Extension Period Wished for Using Forest Plots at Ruvu Project

Extension period in years	**Msangani (N= 25)**	**Mkuza (N= 18)**	**Total**	**Percent**
30	20	11	31	72.0
40	2	3	5	11.7
50	1	1	2	4.6
I don't know	2	3	5	11.7
Total	***25***	***18***	***43***	***100***

Current Food Availability to Farming Households in Msangani and Mkuza Villages

The food availability was assessed in terms of months with sufficient food to feed the family throughout the year. Table 10 presents the current food availability from farmers own production in Msangani and Mkuza villages. Only 21 % of the households had enough food throughout the year. About 7% had enough food for 7 to 9 months. Over 51% of the farming households had enough food for 4 to 6 months. About 21% of the households indicated that the harvested food crops are enough only for 3 months. When data from the two villages were analysed separately, only 24% of households in Msangani village produced enough food crops. There was food availability throughout the year only in 16.7% of households in Mkuza. Data from MNRT (2004) indicated that there was food availability throughout the year in all the farming households in Msangani. Farmers from Mkuza village had food availability for 10 months. The deterioration in food availability in 79% most of the households might be attributed to the presence of tall trees in the farms (Figures 1) which shaded the crops. Also respondents did not use manure and chemical fertilizers.

Table 10: Current Food Availability in Farming Households in the Study Villages

Months with enough food	Msangani (N= 25)	Mkuza (N= 18)	Total	Percent
10-12 months	6	3	9	20.9
07-09 months	1	2	3	06.9
04-06 months	13	9	22	51.2
03 months	6	3	9	20.9

Growth of Trees Species Planted by Farmers in the Study Area

Figure 2 presents a portion of a woodlot managed by a farmer at Ruvu forest project. Growth data on diameter breast height and height are presented in Table 11. Mean dbh and mean dbh increments for woodlots of varying ages and species are presented in Table 12. Mean dbh was 7.7cm for a 2.5 year old woodlot of blue gum (*E. tereticornis)* and reached 20.7cm in year 11 after planting. The mean dbh increment was 3.1cm in year 2.5 and decreased to 1.8cm in the 11th year.

Figure 2: An 8 Year Old Woodlot of Blue Gum (*Eucalyptus tereticornis* Smith)

Table 11: Mean Diameter and Height Growth of Trees Planted by Famers at Ruvu

Tree species	Tree age (years)	Mean DHB (cm) (N= 75)	Mean DBH increment (cm/a)	Mean Height (m) (N=15)	Mean Height increment (m/a)
E. tereticornis	2.5	07.7	3.1	11.0	4.4
	3.5	08.3	2.4	11.5	3.3
	8	15.8 SE = 0.6	2.0	21.7 SE = 0.4	2.7
	10	19.1 SE = 0.8	1.9	22.8 SE = 1.1	2.3
	11	20.7 SE = 1.7	1.8	23.5 SE = 1.0	2.1
A. crassicarpa	2.5	06.7	2.7	10.3	4.2
	8	24.1 SE = 0.8	3.0	20.0 SE = 0.6	2.5
	9	26.8 SE = 0.9	2.9	21.5 SE = 0.6	2.4
A. mangium	4.5	10.8	2.4	10.5	2.3
	5.5	11.8	1.8	11.5	1.9
	8	15.6 SE = 0.9	1.9	14.0 SE = 0.8	1.8

Source: Research Findings (2012) and Project Files for Woodlots Aged 2.5 – 5.5 years SE= standard error, cm= centimetre, cm/a = centimetre per annum, m= metre, m/a= metre per annum

These results are similar to the ones reported from Uganda where 4 year old plantation of forest red gum (*E. camaldulensis* Dehnh.) was 14m tall and 10cm in diameter (Eldridge et al., (1993). The same tree species was 10cm in diameter at the age of six years in Nigeria (Otegbeye 1991). The dbh growth measured at Ruvu was higher than the ones reported from Morogoro, Tanzania by Chamshama and Hall (1987) and Ahimana and Maghembe (1988). Wide spacing of 4m and more observed at Ruvu project probably contributed to growth in dbh (see Figures 1 and 2). Eucalyptus trees will reach dbh of 60cm at the age of 30 years which is the rotation age of teak timber in Tanzania (Bekker at al. 2004).

There was a strong linear correlation between mean dbh and age (Figure 3). This relationship was presented by a formula y= a*x where: y= dbh of blue gum (*E.*

tereticornis), a= a constant (= 1.955 in this study), x= age in years and r^2 = coefficient of determination, = 0.925 for blue gum. By inserting any age in the equation you get the corresponding dbh. According to Bromley et al., (2008) classification of withies (dbh of 2.5-4.9cm) and poles (dbh of 5-15cm) the blue gram species started producing withies at the age of 1.5 years and poles at the age of 3 years. Some farmers were observed selling building poles.

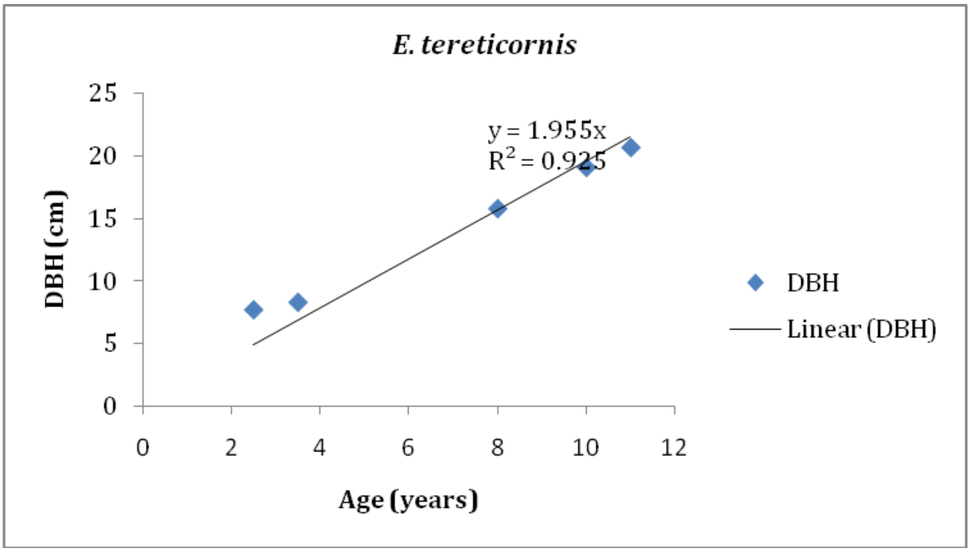

Figure 3: Correlation Between Diameter Breast Height and Age of Blue Gum (*E. tereticornis* Smith)

The mean height was 11.0m in year 2.5 and reached 23.5m in the 11th year. The mean height increment was higher at the age 2.5 years (4.4m per annum) and lowest at the age 11 years (2.1m per annum). There was a strong correlation between mean height and age of blue gum (*E. tereticornis*) trees (Figure 4). The equation developed for predicting the height growth with age was y=2.398*x, where: y= height (m), x= age in years and r^2= coefficient of determination, = 0.679 in this study.

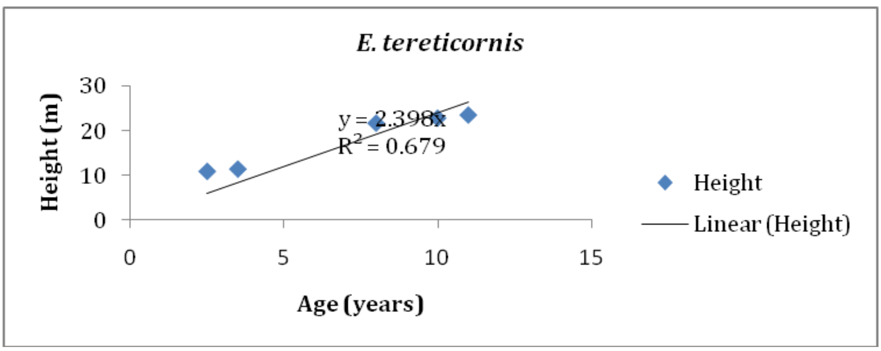

Figure 4: Correlation Between Mean Height and Age of Blue Gum (*E. tereticornis)*

There was a strong linear correlation (r^2= 0.915) between mean height and mean diameter breast height of forest red gum (Figure 5). This was expressed by the equation y= 1.233x, whereby y= mean height in meters and x= mean dbh.

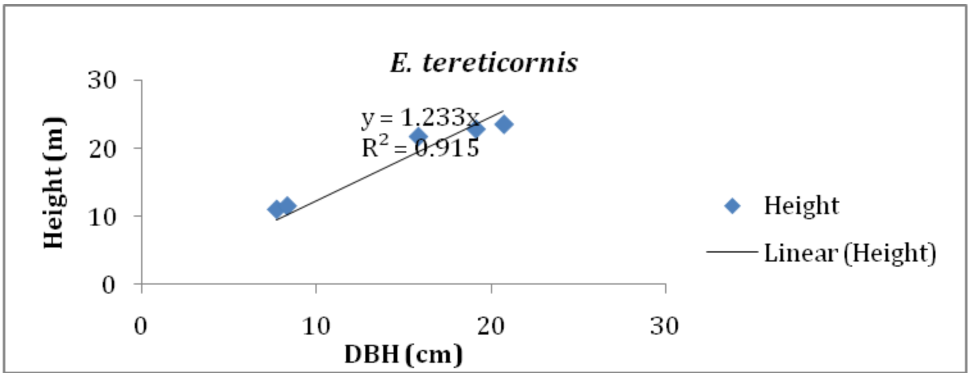

Figure 5: Correlation Between Mean Height and Mean DBH of *E. tereticornis)*

Mean dbh for red wattle (*Acacia crassicarpa)* was 6.7cm in year 2.5 and reached 26.8cm in year 9 (Table 11). This growth rate was lower than the one reported by Nyadzi et al. (2002) from a taungya system in Tabora. They measured 15.37cm and 18.68cm at the age of three and four years respectively. The differences may be attributed to climatic and soil conditions. There was also a strong linear correlation (r^2= 0.997) between mean dbh and age of red wattle (Figure 6). This relationship was presented by the equation y= a*x where: y= dbh of red wattle, *a* = a constant (2.98 in this study), x = tree age in years and r^2 = coefficient of determination, = 0.997 for *A. crassicarpa* in this study. By inserting any age in the equation you get the corresponding diameter breast height.

The red wattle started yielding withies within the first year (dbh = 2.2-4.9cm) and poles (dbh = 5-15cm) at the age of 2 to 4.5 years. The mean dbh increment for the entire 9 years did not vary much because it was 2.7cm in year 2.5 and 2.9cm in year 9 (Table 11). The red wattle woodlots have been planted by farmers mainly for timber harvesting. Therefore trees have not attained dimension for timber according to Bekker et al. (2004) classification. At the rotation age of 30 years for timber set by Bekker at al. (2004), the expected dbh will be 65.94cm.

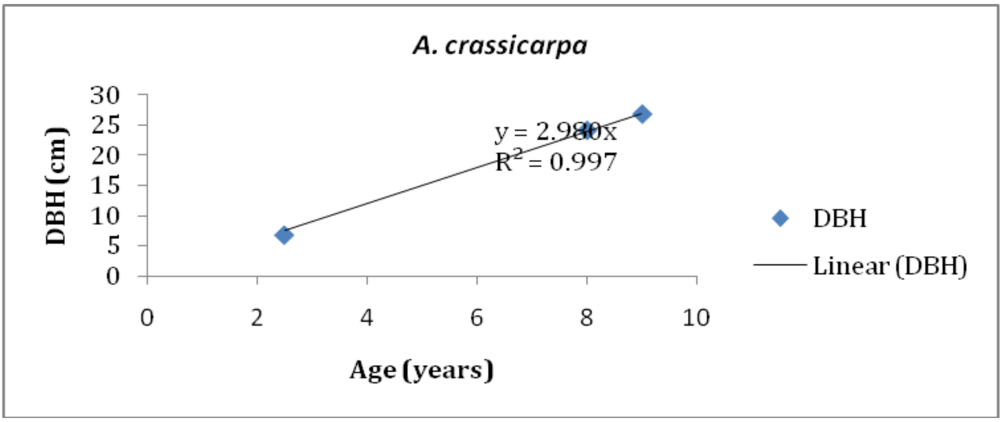

Figure 6: Correlation between DBH and Age of Red Wattle (*A. Crassicarpa)*

The mean height of red wattle was 10.3m in year 2.5 and 21.5m in year 9. This growth rate was higher than the one reported by Nyadzi et al. (2002) from a taungya system in Tabora. They reported mean height of 6.23m and 7.68m at the age of three and four years respectively. The differences may be attributed to climatic and soil conditions. Mean height increment showed a decreasing tendency from 4.2m per annum in year 2.5 to 2.4m in year 9 (Table 11). There was a strong linear correlation (r^2= 0.764) between height and age of red wattle (Figure 7*)*. It was represented by the equation y=a*x, where y= height in metres for red wattle (*A. crassicarpa),* a= constant (2.507 in this study), x= age in years of *A. crassicarpa* and r^2= coefficient of determination (0.764 for *A. crassicarpa*).

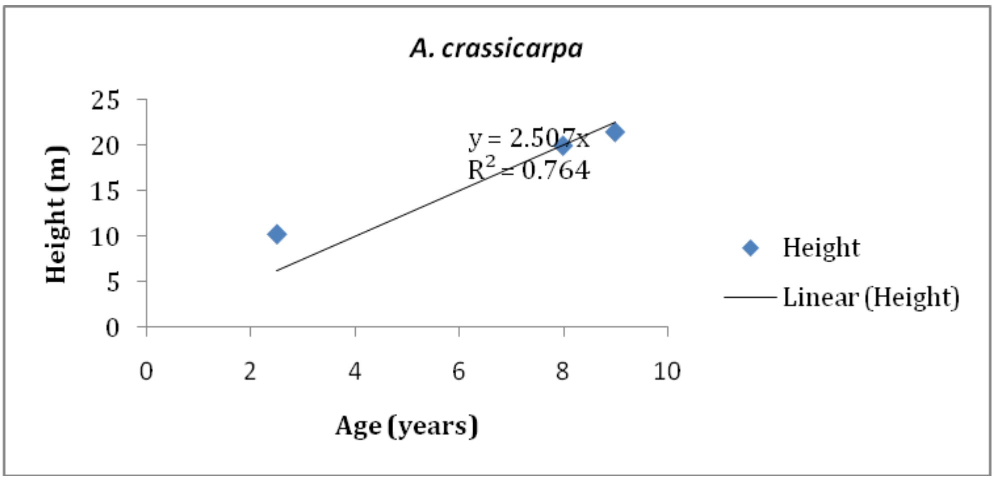

Figure 7: Correlation Between Height and Age of Red Wattle *A. crassicarpa)*

There was a strong linear correlation (r^2= 0.888) between mean height and mean diameter breast height of red wattle (Figure 8). This was expressed by the equation y= 0.936x, whereby y= mean height in meters and x= mean dbh in centimetre.

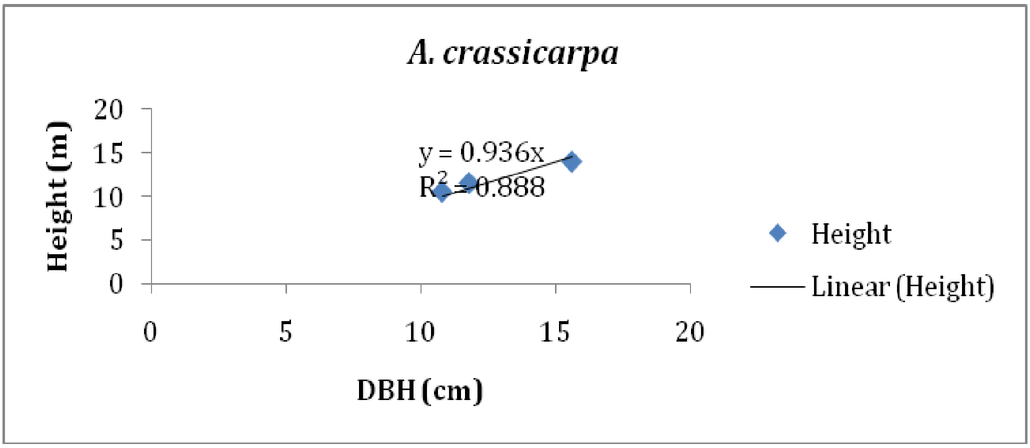

Figure 8: Correlation Between Mean Height and DBH of Red Wattle (*A. crassicarpa)*

The mean dbh of brown salwood (*Acacia mangium)* was 10.8cm in year 4.5 and 15.6cm in year 8 (Table 11). The growth of trees at Ruvu was less than that reported from Sumatra in Indonesia by Krisnawaki et al. (2011). Their data showed very rapid increase in mean diameter up to 15cm in only three years. Diameter began to level at 25cm by the age of 8. At Ruvu, the mean dbh increment was 2.4 in year 4.5 and 1.9cm in year 8. This was a decreasing tendency. Comparative data from Java showed that mean diameter increment was 4.4cm per annum at the age 4.5 and 2.6cm per annum at the age of 8 years (Krisnawati et al., 2011). The differences may be attributed to climatic and soil conditions. There was also a strong linear correlation (r^2= 0.743) between mean dbh and age (Figure 9). This relationship was presented by the equation y= a*x where: y= dbh of brown salwood, a= a constant (2.081 in this study), x= age in years and r^2 = coefficient of determination, = 0.743 for *A. mangium*). By inserting any age in the equation you get the corresponding diameter breast height.

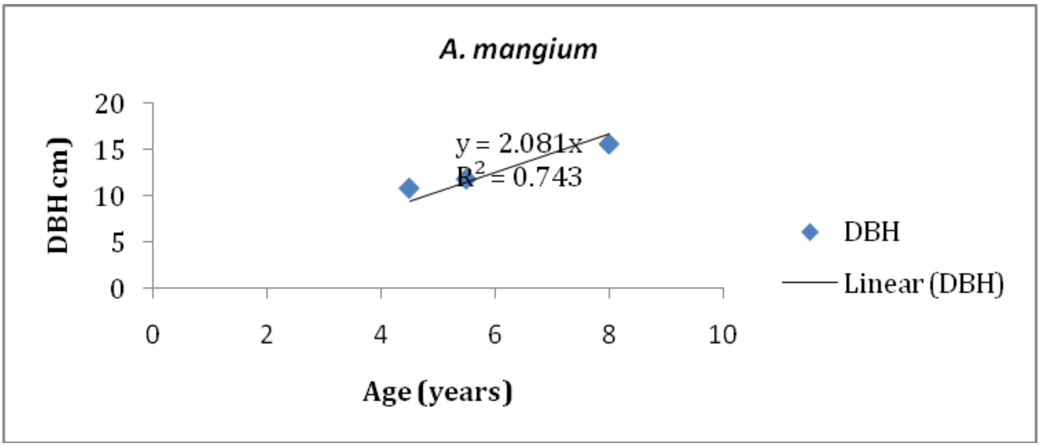

Figure 9: Correlation Between DBH and Age of Brown Salwood *(A. mangium)*

Brown salwood started yielding withies at the age of 1.5 years and poles at the age of 2.5 years. Brown salwood woodlots have been plated for timber harvesting by farmers. Therefore trees have not yet reached this dimension for timber according to Bekker et al. (2004) classification. At the rotation age of 30 years for timber set by Bekker at al. (2004), the extrapolated diameter breast height will be 62.43cm.

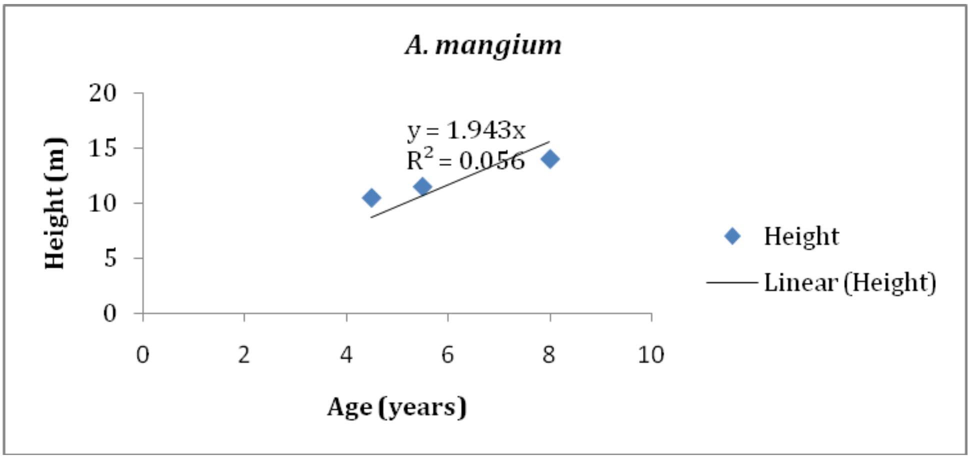

Figure 10: Correlation Between Mean Height and Age of Brown Salwood *(A. mangium)*

There was a strong linear correlation (r^2= 0.888) between mean height and mean diameter breast height of brown salwood (*A. mangium)* (Figure 11). This was expressed by the equation y = 0.936x, whereby y= mean height in meters and x = mean dbh.

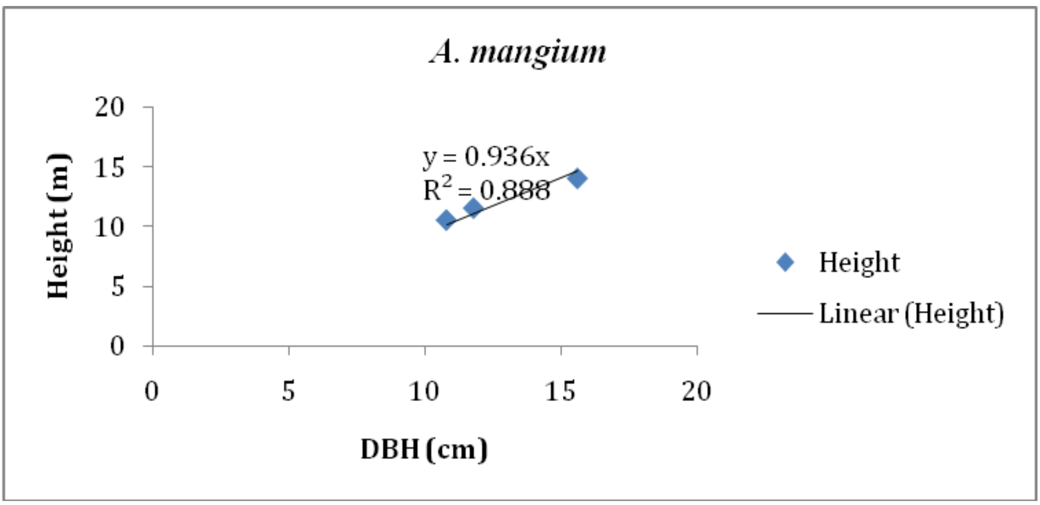

Figure 11: Correlation Between Mean Height and DBH of Brown Salwood *(A. mangium*)

Mean height of brown salwood was 10.5m at the age 4.5 and 14.0m at the age 8 (Table 11). The corresponding mean height increments were 2.3m at the age of 4.5 and 1.8m at the age of 8. Contrary to these observations, Krisnawati et al., (2011) reported from Java in Indonesia higher mean height of brown salwood of 15.6m at the age of 4.5 years and 18.6m at the age of 8 years. The corresponding mean height increment was 3.5m at the age 4.5 and 2.3m at the age of 8 years. The difference in height growth reported here may be ascribed to higher rainfall exceeding 2000mm in Java. There was a very weak linear correlation (r^2= 0.056) between height and age of brown salwood (Figure 10). It was represented by the equation y=a*x, where y= height in metres for *A. mangium,* a= constant (1.943 in this study), x= age in years of *A. mangium* and r^2= coefficient of determination (0.056 for *A. mangium*).

CONCLUSION

Households which participated in the shamba system of forestry management at Ruvu were 180 and 670 in the 1st and 5th year respectively. In total they planted 1.3 million trees and 0.7 million survived at an average rate of 58.2%. Households participated in tree planting because they needed land for growing agricultural crops. Before project their farms were very small (1 hectare or less) for growing sufficient food crops. They were also motivated by the ownership of the trees they planted. Currently 79% of the households are food insecure because they rely on forest plots to produce food crops. The woodlots occupy space and shade agricultural crops resulting in lower crop yields.

The farming households regard trees as their standing capital which they will pocket after selling the timber. The trees grew very fast and reached the size of withies and poles at the ages of 2.5 and 5 years respectively. Trees will reach the timber dimension of 60cm dbh in the next 20 years. The reluctance of the forest department in extending the management agreements has created a state of insecurity among participating farmers.

The forest department should act immediately to rescue the situation. The continuing delay in extending management agreement by forest department officials is indication of poor governance and has lowered their standing within the community.

ACKNOWLEDGEMENT

This work was sponsored by the Open University of Tanzania Small Research Grant. I wish to thank the Tanzania Forest Research Institute at Kibaha for providing staff and equipment for the measurement of tree woodlots.

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