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COVER

A two years old flowering *Carissa spinarum* Linn. Grown from stem cuttings at TAFORI Headquarters, Morogoro.

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ASSESSING STOCKING AND EFFECT OF ROOT BIOMASS HARVESTING FOR *Carissa spinarum* Linn. IN SAMUNGE VILLAGE, NGORONGORO DISTRICT, TANZANIA

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Abstract

Carissa spinarum Linn. (Syn: *C. edulis*) is a shrub growing up to 5 m high when supported by other trees. The tree has recently been famous for treatment of various ailments and attracted attention of the world's medical practitioners. The study was conducted at Samunge village, aiming at assessing the stock and impact of root biomass harvesting for the species. Stocking was found through inventory and root biomass through weighing roots (fresh weight) in the field and samples were taken to the laboratory and oven dried for biomass analysis. The results showed that there are very few trees of *C. spinarum* in Samunge Village Forest Reserves with an average of 2 clumps per hectare. Most of the *Carissa spinarum* roots used in Samunge for treatments of diseases were obtained from the near by village called Mgongomageri where the shrub has 33 clumps per hectare. It was also found that only few roots (30%) were removed from mother plants, therefore imposing minimum negative impact to the trees' growth. There was no fresh cut tree stumps observed in the forest reserves during resources survey. This implies that there was no effect to other trees found in village forests during the period of high population visiting Samunge for medicine. Germplasm materials were also collected for domestication purpose. Stem cuttings and wildings inserted to the polythene tubes sprouted well. These findings suggest that the species can be grown easily especially by vegetative propagation.

Keywords: *Samunge village, Carissa spinarum, Stocking, Root biomass, Ngorongoro*

Introduction

Carissa spinarum Linn. (Syn: *C. edulis*) *or* "Mrigariga local name in Maasai and Sonjo" is a spiny shrub/tree up to 5 m which occurs in savanna woodland, in thickets, forests, disturbed areas and on termites mounds at medium altitudes between 1,100-1,600m a.s.l. with rainfall between 1,000 -2,100mm. The species is commonly found throughout the drier parts of tropical Africa and Asia (Ruffo *et al.,* 2002). In Ngorongoro area *C. spinarum* is found in relatively higher altitudinal highland areas ranging from 1600 – 2000m a.s.l. The species belongs to the family Apocynaceae, and like other members of this family, *C. spinarum* has the milky latex. *Carissa spinarum* has edible sweet purple-black fruits (when ripe) ripening at different times but mostly in December. However, the shrub is widely recognized as a traditional medicinal plant for treating different diseases. In Ghana for example, the roots are used as an antiseptic while in Eastern and northern African folk medicine, it is largely used in the treatment of gonorrheae, syphilis, lumbago and other pains. Moreover, pharmacological studies in Kenya discovered that *C. spinarum* has significant effect against wild type and resistant strains of *Herpes* simplex virus (HSV) (Tolo *et al*., 2010). In Tanzania, *C. spinarum* has been used as a miracle traditional medicine alleged to cure untreatable diseases such as Diabetes, Cancer, HIV-AIDS and many others since early 2011 in Samunge village, Loliondo (about 400 km from Arusha City). The forecasted miracle capacity to treat various diseases has consequently caused thousands of people from around the world to flood to Samunge

Village in order to have a dose of the miracle cure popularly known as “the Loliondo cup”. This has resulted into massive *C. spinarum* roots extraction in the area to fulfil the high medicinal (the concoction) need of the patients.

This type of treatment is not uncommon in Tanzania. Traditional herbal therapy is widely practiced by communities in the country for control of both animal and human diseases. About 80% of the local communities in sub-Saharan Africa rely on traditional medicines (WHO, 2002). In this case, as for the *C. spinarum* and others sustainable utilization of local trees which are the main sources for traditional medicines is inevitable. Until to date the traditional miracle healing using *C. spinarum* Samunge village continues and this therefore calls for the need to collect enough information to see the impacts of roots extraction for this alleged healing to the stocking level and biomass. This study therefore entailed assessing the species abundance and extent of root extraction at Samunge village Ngorongoro district in Arusha Region, Tanzania.

Materials and Methods

Study area description

Samunge village is located in Ngorongoro District, some 50 to 70 km from Loliondo Town (depending on the road taken). The village can be accessed by more than two routes from Mtowambu Town. The first route runs from Mtowambu Town via Lake Natron, and the second route is via Waso where the Ngorongoro District Council is and the third one which is a bit rough runs via Loliondo where the offices of the District Commissioner and other government offices are stationed.

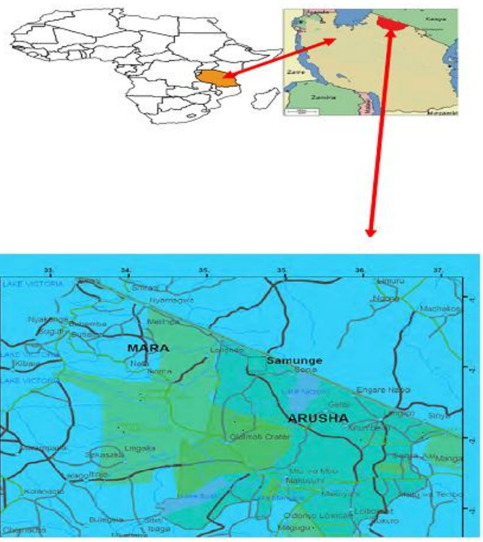


Figure 1: Location of Samunge Village Source: Senzota (2012).

The elevation ranges from 1344 to 1359 m a.s.l. Administratively, Samunge is divided into three sub-villages namely Samunge, Mijuti and Hahama with about 242, 106, and 114 households respectively. The sub-village of Samunge has a population of about 930 people of which 424 are males and 506 are females. Their main economic activities are farming and animal husbandry mostly cattle, goats and sheep (Village Statistics, 2010).

Location wise Samunge is a bit lower than Loliondo hence relatively warmer and tropical fruits like mangoes are grown. Some parts of this village where agriculture is practiced are fertile and wetter with permanent and seasonal streams flowing from mount Mwigaro.

Plate 1: View of hills covered with shrubs at Samunge village Ngorongoro district.

Plate 2: A clump of un-harvested *C. spinarum* in front of TAFORI researchers at MgongoMageri Village Loliondo

Tree species such as *Ficus vallis-choudae* and *Ficus sycomorus* which are indicator of warm lowland places can be found on streams banks. On the slopes of hills surrounding Samunge where *C. spinarum* is found, it is dry with shrubs and small trees of *Acacia* and *Croton species* interrupted with indicator plants of dry land areas like *Balanite aegyptiaca* and *Euphorbia spp* mostly *E. tirucalli* and *E. candelabrum*.

Data collection

Stocking level determination

Forest inventory was conducted to determine the stocking level of *C. spinarum* in the study area. This was done in the village forest found in hills that surround the village settlements in West, North and South sides. Nine transects were laid out from South to North for the forest situated in the northern side of the village and from North to South for the forest located in southern part of the village at a 3 km interval covering the whole forested area. A total of 35 quadratic plots (20 m x 20 m) were laid down along the transects systematically at 200 m interval. From each plot number of *C. spinarum* including other species were tallied. Each plot was given an identification code and a description of the main characteristics and landmarks was also recorded. Moreover, the number of *C. spinarum* shrubs whose roots were extracted and those which were not extracted were also recorded in a strip with 20 m wide during transect walk. Tree callipers were used to measure trees at the root collar diameter while crown diameters were measured using a measuring tape.

Assessing the effects of root biomass harvesting in the study area

The effects of root biomass harvesting in Samunge was evaluated on the basis of the differences in biomass content between the harvested versus the non harvested *C. spinarum* roots. Big, medium and small trees were selected from both extracted and intact trees and they were then extracted to compare for their root biomass. Green samples were weighed in the field and then taken to the laboratory for oven drying and hence determine root biomass.

Collection of planting materials (germplasm)

Cuttings from roots and stems of *C. spinarum* were prepared at Mgongo Mageri village and put in the buckets with water and then in soaked hessian bags and transported to Lushoto, Korogwe and Morogoro for propagation purposes.

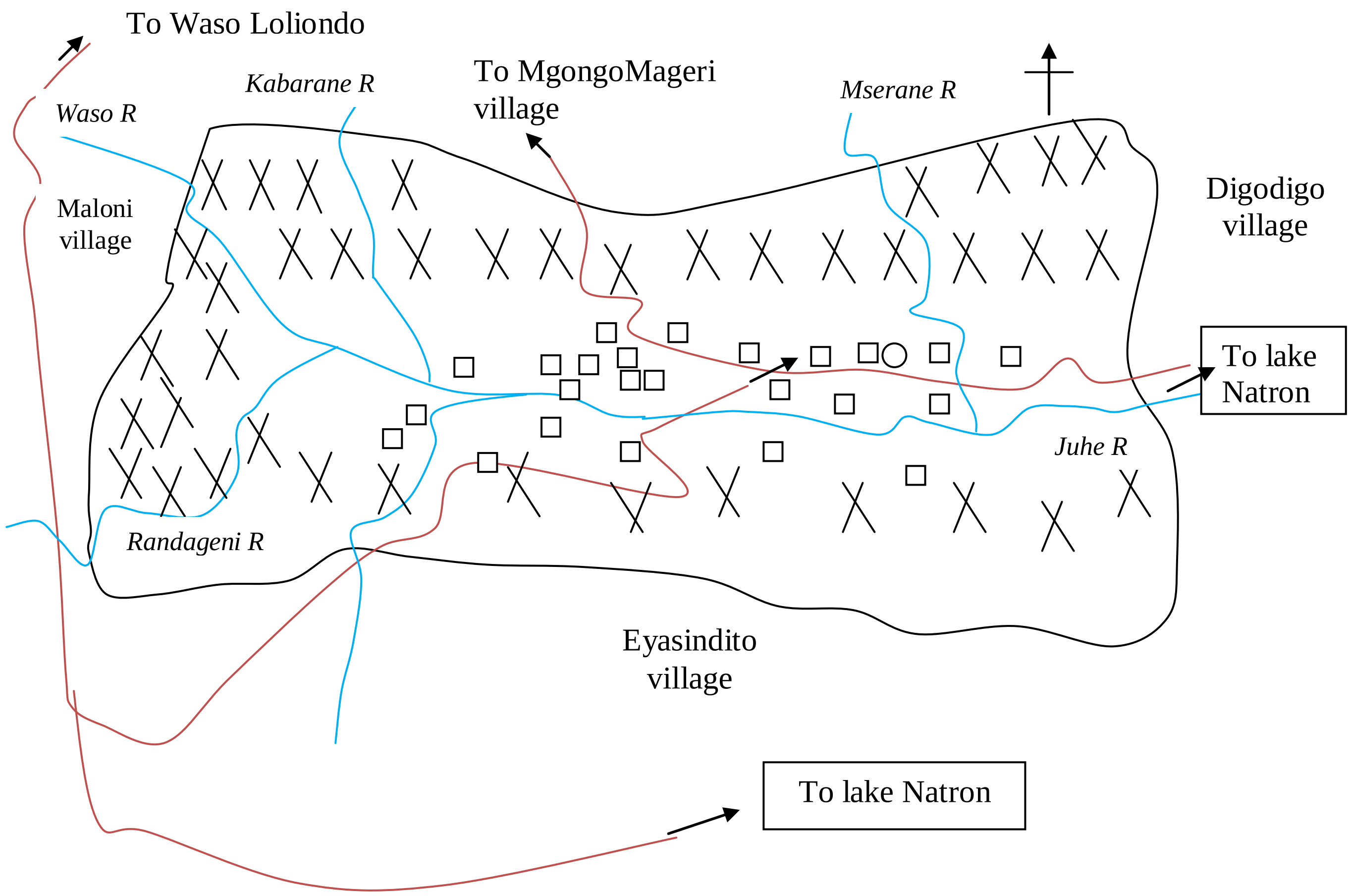
Data analysis

Inventory data (that was used to assess the impacts of roots biomass harvesting as well as *C. spinarum* stocking) was analyzed using Microsoft Excel.

Results and Discussion

Carissa spinarum stocking

The abundance of *C. spinarum* can easily be confused with the presence of *Acocanthera schimperii*. It is sometimes difficult to separate *C. spinarum* with *Acocanthera schimperii*, a strictly poisonous tree and an associate species of *C. spinarum*. Both *A. schimperii* and *C. spinarum* are abundant on the drier parts of Samunge towards Loliondo (Richard, 2011). However, results obtained from the two villages of Samunge and Mgongo Mageri showed that the shrub is more common in Mgongomageri as compared to Samunge village (Table 1).



Keys

Road
River

Village boundary
□ Residential area
X Hills with Forest
O Mwasapila area

Figure 2: Simple sketch of Samunge village in Ngorongoro District Arusha (not to scale)

Table 1: Carissa stocking at Samunge and Mgongomageri villages, Ngorongoro District, Tanzania

Villages	Stocking		Elevation (m a.s.l.)
	Number of clumps / hectare	Average number of stems / clump	
Samunge	2	6	1565 - 1713
MgongoMageri	33	4	1800 - 1822

On the other hand, those clumps found in Samunge have many stems per clump than at Mgongomageri. This is probably an altitudinal effect as the former subvillage is at a lower elevation than the later**.**

In Samunge the shrub is found in steep slopes of the marginal land in an elevation between 1565 and 1713 m. a.s.l.

Plate 3: *C. spinarum* plant in marginal land at Samunge steep slopes area

There are 2 clumps per hectare of the *C. spinarum* with an average of 6 stems per clump in the whole village (Table 1). The clumps assessed in Samunge village were not harvested but they were few in number though there are two clumps with large stems that could be excavated for root requirement. The reasons for *C. spinarum* not being excavated in Samunge area was that, the species is located in stony steep slope which hindered root excavation exercise (Plate 3).

Nevertheless, some of the available clumps were still immature with small sized roots. Immaturity of some of the Carissa shrubs in Samunge might be due to the hotter environmental condition in Samunge compared with the nearby villages like Mgongomageri and this is possibly what hinders the growth of this species according to the literature (Mbuya *et al.*, 1994).

It was observed that most of the roots used by the traditional healer Pastor Ambilikile Masapila were excavated from Mgongomageri village in the northern side of Samunge village. There are differences in areas where the species can be located in those villages. While it is found in hilly rocky areas at Samunge, the shrub is found in marginal lands at Mgongomageri village. The difference might also have been contributed to the number of stems per clump between the two villages (Table 1).

Root harvesting

The most used part of *C. spinarum* for decoction was the root. Root harvesting was done in a clump by selecting the mature roots. A study by Swier (2012) showed that harvest of roots for medicinal purposes is often done whenever and wherever people need. However, in most cases roots are said to be harvested during the dry season, as they will easily deteriorate e.g. by fungus, in the rainy season (Swier, 2012). In the assessed clumps, the quantity of roots taken off was about 30% of the total roots in a clump. Usually the harvested area is filled with soil to encourage other roots outgrowth. The observation made to the plants that has been excavated in past six months in Mgongomageri area indicated that new roots are emerging (Plate 4).

Plate 4: New roots regenerating following root extraction

Effect of harvesting to the root biomass

The measurement of roots was done to find total fresh weight and sample fresh weight at the field. The *C. spinarum* roots have an average total weight of 21.8 kg for big shrubs and 1.5 kg for small to medium shrubs when the whole roots are harvested. Average weight of root taken for medicine was about 7 kg (30%) of the total roots from big shrub (Richard, 2011). This was verified during this study were by roots harvested for medicinal and those harvested after excavate the whole *C. spinarum* clump weighed and found that in every 10 kg of fresh root excavated from the targeted clump, only 3 kg were taken out of the clump for medicine purposes. The root harvesting slightly affect the root biomass of the shrub since once excavated it will take more than a year to regain the lost roots (Plate 4). However, there was no effect observed physically in the harvested shrubs since the remaining roots have many simple roots with an ability to absorb water and minerals.

Effects to other tree species

The high population that visited Samunge village was expected to cause the degradation of forest in the area and other detrimental effects. The assessment conducted in the village forest indicated that no marked effect to the village forest in terms of tree cut for fire wood and charcoal since most of the wood energy used was from individual farms opened for agriculture and there were no fresh cut tree stumps in the village forest. Therefore according to local people most of trees used previously were cut from individual farms. Normally forest resource harvest data analysis involve the computation of forest variables in terms of stumps (N) and basal area (G) per hectare (Mbwambo *et al.*, 2012) but in Samunge Village forest there were no tree stumps recorded that means tree were harvested from particular individual farms.

Propagation of plant materials

Plant materials collected were cuttings from both roots and shoots. The 1100 cuttings were taken at different sizes and position in the shrub and root cuttings were 200 taken from different size roots. The stem cuttings sprouted well when inserted directly in the moist soil and in the polythene tube filled with soil mixture but soon after sprouting most of the cuttings died. The probable cause of death might be the time span from harvesting to the time the cuttings were inserted to the growing media, the variation in climatic condition, the type of soil used and the relative humidity required. Propagation by seeds and wildings was reported as the best option in Kenya and Uganda (Mbuya *et al.*, 1994; Katende *et al.*, 1995; Maundu *et al.,* 2005). The height of new stems from the survived cuttings during a period of six months was 45cm in Kwamarukanga Korogwe, and 55cm in Morogoro Kingolwira as indicated in plate 5. None have survived at Lushoto probably due to very low temperatures.

Plate 5: A polythene bag with a new stem of *C. spinarum* developed from stem cuttings at Morogoro site.

This implies that the species can be propagated using not only seeds and wildings as reported in other countries but also stem cuttings and can perform well in areas with high temperature and for areas with low temperature performance was poor though the origin of species where from low temperature areas. Cuttings from roots showed no sign of sprouting even when treated with a root stimulating hormone at Kwamarukanga Korogwe. Hence propagation using root part seems to be difficult. The wildings taken had grown well in Morogoro area so propagation using wildings is the best option for domesticating this species.

Conclusion

Carissa spinarum clumps in Samunge village forest reserves were few with an average of 2 clumps per hectare. Most of the *C. spinarum* roots used in Samunge for treatments were obtained from the near-by village called MgongoMageri where the shrub has 33 clumps per hectare. It was also found that only few roots (30%) were removed from mother plants, therefore imposing minimum negative impact to the trees' growth.

There were no fresh cut tree stumps in the village forest hence no marked effect to the village forest in terms of tree cut for fire wood and charcoal. The stem cuttings from *C. spinarum* sprouted well when inserted directly in the moist soil and in the polythene tube filled with soil mixture. Cuttings from roots showed no sign of sprouting even when treated with a root stimulating hormone hence propagation using root part seems to be difficult. The wildings of

C spinarum taken from Samunge showed good growth in Morogoro area; so propagation using wildings is proposed for domesticating this species.

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WOODLAND COMPOSITION, STRUCTURE AND TREE SPECIES DIVERSITY AT SAMUNGE VILLAGE IN LOLIONDO, TANZANIA

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Abstract

A survey was conducted to determine woodland composition, structure and trees species diversity of woodland within Samunge village - Loliondo. A total of 37 equidistant (400 m) quadrants (20 m x 20 m) were established within 8 equidistant (400 m) transects of different lengths laid from the village centre towards the village boundaries. Information on types of tree species, number, Diameter at Breast Height (DBH) (taken at the nearest 0.5cm) and tree height (taken at the nearest 1m) were recorded. All trees with DBH ≥ 5cm were considered for measurement. Descriptive analysis was done for all quantitative data by using totals and averages. Shannon Weiner's Diversity Index was used to obtain woodland's tree species diversity. A total of 43 tree species were recorded. The woodland had a density of 444 stems Ha^{-1}. The dominant species was *Croton dichoganus* Pax which occupies 18.7% of the total number of tree species found in the area. The woodland is dominated by trees of between 3 - 6 m high. Trees indicated inverse J-distribution where stems frequencies decreased with increase in DBH, a sign for developing and regenerating woodland. The woodland had a Shannon Wiener diversity index (SDI) value of 1.32. It is concluded that the present disturbance at the Samunge woodland has not reached a level of imposing a negative impact to the woodland.

***Keywords**: Samunge woodland, species diversity, height distribution, diameter distribution*

Introduction

Samunge village is located in the northern part of Tanzania close to the protected areas of Loliondo Game Reserve, Serengeti National Park and Ngorongoro Conservation Area. Samunge is dominated by Sonjo tribe with some traces of Maasai people found close to the boundaries. Sonjo are mainly herdsmen involving themselves with very little subsistence agriculture. In the recent years (2010) the village received very high attention as a result of healing operations conducted by the famous retired Reverend Ambilikile Mwasapile who provided the conventional healing traditional semi sic faith healing concoction made from *Carrisa spinarum* roots (famously known as kikombe cha babu) (Senzota, 2012). This attracted a lot of people from within and outside the country.

As a result of excessive entrance of large amount of people to the area more trees of *C. spinarum* were extracted for making the concoction and many other tree species were cut for the purpose of obtaining wood for construction of temporary settlements and for firewood. The coming in of the *Kikombe cha Babu* era was a surprise and experts were taken unaware of the woodland conditions in the area which might have led to unstable ecological condition. The unexpected habitat degradation and loss are the greatest threats to terrestrial species (Baillie *et al*., 2004 cited by Marshall, 2008). This in one way or another might have affected the woodland's structure, composition and tree species diversity. Forest ecosystems received attention in recent years as threats to their conservation have become recognized (Killen *et al.*, 1998). On the other hand it has implication for climate change, hydrology, nutrient cycling and natural resource availability. Vegetation degradation is expressed through changes in composition, structure, function (Kakembo, 2001) and reduction in species diversity (Dregne, 1986 cited by John, 2007).

The species diversity of an area is indicated to be related to a number of different factors, such as temperature, rainfall, soil fertility, age, isolation and habitat diversity interacting in simple or complex ways to produce the patterns biodiversity (Whiffin and Kikkawa, 1992). Normally woodland structure is made up of four vegetation layers (the canopy, shrub, herb and ground layers) in a spatial arrangement of components. These can tell about the biodiversity of the woodland and the type of habitat it provides. The influence of these controls means that not every vegetation or even parts of it will always have all four layers. The structure can change naturally through trees decaying, being blown down in a storm, lightning strikes, landslides or the actions of animals. In many cases human activities have a much greater influence on the woodland's structure. On the other hand diversity in the strict sense is richness in species, and is appropriately measured as the number of species in a sample of standard size (Whittaker, 1972). It is reported that tree species diversity in the tropics varies dramatically from place to place (Pitman *et al.*, 2002). This background pushed for the will to conduct a study to determine status of the woodland structure, composition and tree species diversity of Samunge village woodland to get the base for future research. This is because, in comparison to humid forests and savanna, detailed information on the structure, diversity and function of the dry forest ecosystems is relatively scant (Killen *et al.*, 1998) and results from this study tries to fill this gap.

Materials and Methods

Study area

Samunge village is located in Loliondo ward, Ngorongoro District, Arusha region, some 325 km from Arusha town (Figure 1). Geographically Loliondo is located at latitude -02^{o}05'00''S and longitude 035^{o}61'67''E

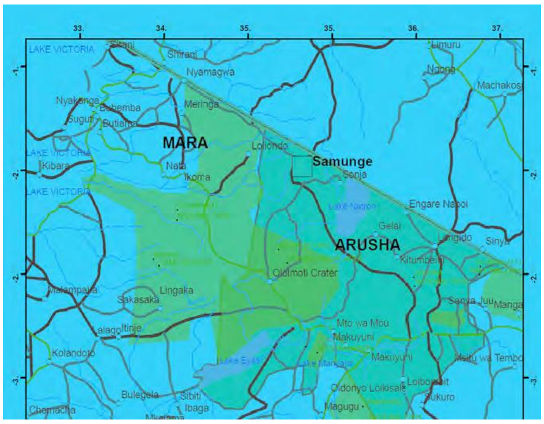

Figure 1: Location of Samunge village (Not to scale) (Source: Senzota, 2012).

The area is sparsely populated. Cattle keeping are the most predominant economic activity of the area. Some small petty businesses can be observed around the area and these have reached the present status as a result of peoples' influx in the area. Vegetatively the larger area is dominated by woodlands with scattered small diameter trees (Plate 1). Soils are mainly gravels poor for agriculture activities except for areas in valleys. Seasonal crops such as millet and maize are sometimes planted. There is no distinct permanent crop.

Plate 1: Appearance of the vegetation at Samunge village

Data collection

A total of 8 equidistant (400m) transects of different lengths were established from the village centre towards the village boundaries. This is because the village is located at the valley and surrounded by hills. A total of 37 equidistant (400m) quadrants of 20m x 20m (Lawton, 1978) were laid within transect. Information collected from established quadrants included number and type of tree species, Diameter at Breast Height (DBH) and tree height. Normal caliper was used in measuring DBH at the nearest 0.5cm, while height was measured at the nearest 1 m. As for buttressed trees DBH was measured just above the buttress (Kumar *et al*., 2006). Measurements were taken from all trees with DBH ≥ 5cm.

Data analysis

The data was analyzed for species composition and tree species diversity (Giliba *et al*., 2011). Descriptive analysis was done for all quantitative data by using totals and averages. Woody species density was derived from total number of trees recorded into per hectare. The most commonly used index in ecological studies (*https://biorich.wikispaces.com/file/view/Shannon+Diversity+Index.doc*) Shannon Weiner's Diversity Index (SDI) (Kent and Coker, 1992) was used to determine the trees species diversity. The formula is denoted as;

$$SDI = -\sum_{1=i}^{s} Pi \ln Pi \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:-

s = the number of species at that site

Pi = ni/N

ni = total number of individuals in the i^{th} species

N = total number of individuals of all species

The index (SDI) was used for each quadrant and averaged to get the community (woodland) value.

Results and Discussion

Woodland composition

Further identification was needed for the locally identified trees to come down to families. However, a total of 657 trees with DBH ≥ 5cm were counted comprising of recorded 43 species. Further, the woodland has a density of 444 trees Ha^{-1} and dominated by *Croton dichoganus* Pax which carries 18.7% of the total number of tree species found in the area. Other dominating species include *Combretum molle* (11.6%), *Acacia spp* (11%), *Mjorori* (Sonjo) (6.2%), *Dombeya bagshawei* Bak.f (4.6%), *Ficus vallis-choudae* Del (4.6%), *C. sarandensis* B.D Burtt (4.1%), *Ehretia sp* (3.2%), *Mroda* (Sonjo) (2.9%) and *Grewia bicolor*

Juss (2.3%). The ten least occurring species include *Steganotaenia araliaceae* (0.46%), *Mugumu* (Sonjo) (0.46%), *Embilia sp* (0.46%), *B. salicifolia* (0.46%), *Allophylus africana* P. Beur (0.46%), *Cleistanthus polystachyus* (0.3%), *Commiphora hornbyi* B.D. Burtt (0.15%), *Fagaropsis angolensis* (Engl) Dale (0.15%), *Ficus thoningii* BL (0.15%), *Kilemanyagu* (Sonjo) (0.15%), *Kitalambi* (Sonjo) (0.15%), *Msanganetu* (Sonjo) (0.15%), *Sclerocarya birrea subsp caffra* (0.15%) and *Steganotaenia araliaceae* (0.15%). The few number of tree species indicates that the Samunge woodland is a secondary forest/woodland as it is characterized by being less diverse and less tree rich (Kumar *et al.*, 2006). Of all the trees the fattest tree species was *Mgurumeti* (Sonjo) with DBH of 80cm. Trees within Samunge woodland have basal area of 6.78 m^2Ha^{-1}.

Woodland structure

Height distribution

Trees height distribution within Samunge woodland is as shown (Figure 2).

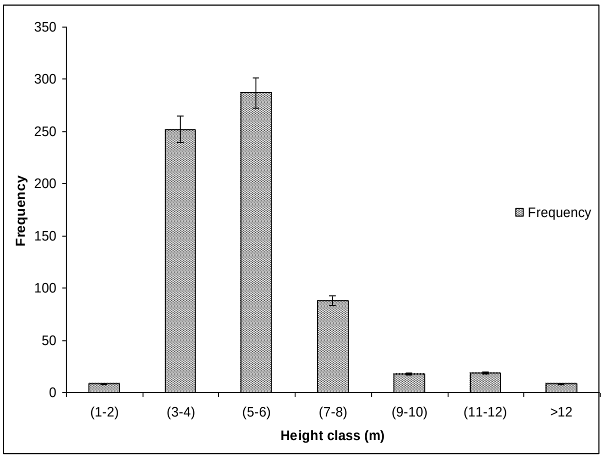

Figure 2: Trees height distribution at Samunge woodland

The woodland is dominated by trees of between 3 - 6 m high. There are very few short and tall trees which is an indication of good woodland. Very few trees are bellow 3m high and very few are above 12 m high. Variation in tree height is considered an important attribute of structure because stands containing a variety of tree heights are also likely to contain a variety of tree ages and species thereby providing a diversity of micro-habitats (McElhinny, 2002).

Diameter distribution

Trees diameter distribution of the trees within Samunge woodland is as shown (Figure 3).

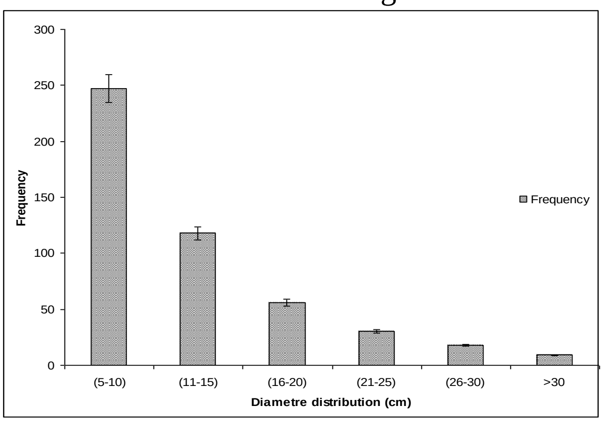

Figure 3: Trees diameter distribution at Samunge woodland

The woodland is composed of many small diameter trees and very few large diameter trees making an inverse J structure. The indicated inverse J-distribution showed stems frequencies decreasing with increase in DBH showing that the forest is developing and regeneration is taking place. This situation indicates a typically poorly disturbed forest which is characterized by the presence of smaller diameter stems (Singh *et al*., 1990; Smiet, 1992). This shows that human disturbance at Samunge woodland has not reached a point of having a serious negative impact. This also indicates the presence of natural disturbance, and the decomposition of woody debris (cycling of nutrients etc.), which are critical for the maintenance of biodiversity (Noss, 1990).

Tree species diversity

Results obtained from the study showed that, the Samunge woodland has tree species diversity of 1.32 as determined by Shannon Wiener diversity index (SDI). These results are far below the good diversity range of 1.5 - 3.5 recommended by Kent and Coker (1992). Usually the SDI value ranges between 0 and 4.6 *http://www.biorich.wikispaces.com/file/view/Shannon+Diversity+Index.doc*). The values closer to zero indicate that every species in the sample is the same while values closer to 4.6 indicate that the numbers of individuals are evenly distributed between all the species. The obtained results showed values which are far bellow the rich areas of tropical forests (Kumar, *et al*., 2006). This kind of reduction in species diversity is very common in poor soils (like those of Samunge) and generally the greater the habitat diversity the greater the species diversity when all other factors are equal (Whiffin and Kikkawa, 1992). On the other hand the tree species diversity within the area was expected to be low as the area is relatively dry. There is always a positive relationship between diversity and amount of rainfall the area receives (Pitman, *et al.*, 2002).

Conclusion

The results obtained from the study conclude that the trees diversity of Samunge woodland is far below the good diversity range. This means tree species are poorly distributed within the woodland. More research is needed to examine the status of *Osyris lanceolata* in Ngorongoro District and other medicinal plants.

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SOCIO-ECONOMIC AND INSTITUTIONAL FACTORS UNDERLYING POWER STRUGGLE IN SULEDO VILLAGE LAND FOREST RESERVE IN KITETO DISTRICT, TANZANIA

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Abstract

Contestation among stakeholders with varying interests is common in most rural areas involving mining of natural resources important for livelihood which often result into power struggles. The study intended to identify and assess socio economic and institutional factors underlying a dominant power struggle in the study area. The data were collected through PRA, household questionnaire surveys, key informants interviews and participants observation. Content analysis technique was used to analyze qualitative data while the quantitative analyses were performed using Statistical Package for Social Sciences (SPSS) Computer Programme Version 16. Socio-economic and institutional factors found to significantly ($P<0.05$) escalating power struggle between ZEC and SULEDO villages were wealth status, immigration, distance from homesteads to resource base, membership in VEC and political involvement while Education level, age, residence duration, farm size and household size were significantly ($P<0.05$) reducing the power struggle. It was concluded that Community Based Forest Management scheme remains a complex and contested arena, comprising many stakeholders with different powers, varied and conflicting interests.

Keywords: *Power Struggle, SULEDO Village Land Forest Reserve, Socio-economic, Institutional factors*

Introduction

SULEDO is the acronym for 3 wards namely Sunya, Lengatei and Dongo (Wily and Mbaya, 2001; Blomley and Ramadhani, 2006). SULEDO Village Land Forest Reserve was initiated in 1993, as a project which was under the Arusha Regional Forestry Programme (ARFP) supported by Swedish International Development Agency (SIDA). The project looked at different ways of managing forest areas jointly with local government authorities in a number of districts of Arusha Region. In 1994, SULEDO was formally established as a CBFM site through official transfer of administrative authority to the community (Blomley and Ramadhani, 2006). The change in tenure of SULEDO VLFR also resulted in changes in power relations at the local level, making a major impact on the institutions that determines people's access and control of the forest resources (Shackleton *et al.*, 2002). Institution factors are rules and structures that humans impose on human interactions that make and shape the performance of the societies in the management of natural resources (North, 1990). Socioeconomic factors are the social and economic experiences and realities that help mold one's personality, attitudes, and lifestyle in the management of natural resources (Borrini-Feyerabend, 1997).

There is a number of stakeholders in SULEDO VLFR with different powers and have now started to utilize the forest (natural capital) after many years of managing it. The situation has created a room for power struggles in the reserve which tend to lead into conflicts. The conflicts are both real and potential. Power struggles have been defined as an open clash between two opposing groups or individuals (Lukes, 2005). Power struggles can be manifested between different traditional authorities, political leaders and elected representatives who can disrupt community-based processes (Barrow *et al.*, 2002).

Each stakeholder with different power is competing to have a stake on the utilization and management of the forest resources. Finding a way to balance the power struggles so as to ensure equity in terms of sharing benefits, requires among other things in- depth analysis of socio-economic and institutional factors governing the entire process. Chapin (2004) and Benjaminsen *et al.*, (2008) documented the discrepancy which exists between the rhetoric of CBFM and problems that persist on the ground, as there is a substantial debate around the benefits of community conservation.

Despite the fact that SULEDO VLFR is important in supporting livelihoods of the adjacent local communities as well as economic development of the country at large, still there is inadequate information on socio-economic and institutional factors underlying the power struggle. This study is important because, it has been carried out at the time when SULEDO communities have started to utilize the natural capital after conserving it for quite sometime, hence a lot of power struggles have emerged among different stakeholders. The findings from the study aimed at contributing to the process of mitigating the problem of power struggles which tend to emerge among stakeholders in different parts of the country. Therefore, the findings of this study aimed at contributing to policy formulation for ensuring sustainable forest resources management in the study area and CBFM programme in Tanzania at large.
This paper reports socio economic and institutional factors underlying dominant power struggle in SULEDO VLFR.

Materials and Methods

Description of the study area

SULEDO Village Land Forest Reserve in Kiteto district, lies between 4^o and $6^o6'$ S and between $36^o15'$ E and $39^{\,o}$ E. The district area covers approximately 268 000 ha out of which 167,416 ha are under SULEDO Village Land Forest Reserve, shared by ten villages namely: Sunya, Asamatwa, Olgira, Lengatei, Lesoit, Olkitikiti, Engong’ongale Mturu, Mesera and Laiseri. According to 2002 human population census, Kiteto District has a population of 155,727 (URT, 2002).

The district annual rainfall ranges between 450 and 650 mm and occurs within the months of November/December and April/May. Average annual rainfall is 550 mm, particularly on the South eastern part of the district where SULEDO VLFR communities reside. Mean monthly temperature range between 15 and 22^0 C. SULEDO VLFR is situated at the high altitude of Manyara region; it lies at an altitude between 1,000 and 1,500 meters above sea level. Soils in the area are generally volcanic in origin and range from moderate to fertile soils.

SULEDO Village Land Forest Reserve is rich in miombo woodlands, the most dominant species are *Combretum molle* and *Dalbergia melanoxylon, Julbernadia globiflora* and *Brachystegia microphylla.* The dominance of *Combretum species, Dichrostachys cinerea and Acacia polyacantha* in some clusters is a signal that there was once degradation (Malimbwi, 2000).The main land uses in the study area include grazing, agriculture, settlements, forest conservation, beekeeping, timber harvesting, firewood and honey gathering (LAMP, 2005).

Traditionally, the Maasai and Kamba are pastoralists and all the remaining ethnic groups are agriculturalists. However, this division has become less clear-cut over the years. Partly due to land scarcity and the modern lifestyle which has restricted movements (Lissu and von Mitzlaff 2007).

Methods

Primary data collection

Qualitative data were collected by using Participatory Rural Appraisal approach, participant observation, semi structured and unstructured interviews. Tool used in the PRA was Focus Group Discussions. Quantitative data were collected by using structured questionnaires.

Secondary data collection

Secondary data were collected in published and unpublished documents from various sources including Sokoine National Agriculture Library, District Forest offices in Kibaya Township, village offices in the study area and from websites.

Data analysis

Qualitative and quantitative methods of data analysis were used in this study. Content analysis technique was employed to analyze qualitative data and information from the discussion with key informants and PRA groups. All the quantitative analyses were performed using Statistical Package for Social Sciences (SPSS) Computer Programme Version 16. Descriptive statistical analysis was used to explore data among others for distribution of responses, and multiple response analyses were also performed to ascertain responses and percentages. A logistic regression model was used to assess the likelihood of socio-economic and institutional factors underlying dominant power struggle in the management and utilization of forest resources.

Results and Discussion

Socio-economic and institutional factors underlying power struggle between ZEC and the ten villages surrounding SULEDO VLFR

A logistic regression model was employed to determine factors underlying power struggle between ZEC and the ten villages surrounding SULEDO VLFR. The dependent variable was household heads perception on occurrence of power struggle between ZEC and the ten villages surrounding SULEDO VLFR, namely Sunya, Asamatwa, Olgira, Lengatei, Lesoit, Olkitikiti, Engong'ongale Mturu, Mesera and Laiseri independent variables were age, Education level , Residence, Wealth , household size, farm size, Immigration ,distance from household to resource base, Membership in VEC and political involvement. Out of ten factors that have been analysed five factors have positive relationship to power struggle between ZEC and the ten villages surrounding SULEDO VLFR. The remaining five factors have negative relationship to power struggle between ZEC and the ten villages surrounding SULEDO VLFR (Table 1). The model has predicted correctly the cases by 80% with Chi-square value of 44.449. The high -2 Log Likelihood (68.687) indicates a high fit between the model and the data. The Negelkerke R squared = 0.545 implying that 54.5% of observed variation in the power struggle between ZEC and the ten villages surrounding SULEDO VLFR is explained by independent variables in the model.

Table 1: Socio-economic and Institutional Factors underlying power struggle between ZEC and the ten villages surrounding SULEDO VLFR

Factors X_i	β	S.E.	Wald	df	Sig.	Exp(B)
Wealth category	2.450	0.832	8.675	1	0.003*	11.589
Immigration	1.809	0.912	3.937	1	0 .047*	6.104
Distance to from household to resource base	0.617	0.681	0.821	1	0.365NS	1.854
Education level	-0.403	0.126	10.269	1	0.001*	0.668
Age	-0.086	0.039	4.977	1	0 .026*	0.917
Farm size	-0.038	0.060	0.404	1	0.525NS	0.962
Residence duration	-0.010	0.029	0.131	1	0.717NS	0.990
Family size	-0.049	0.141	0.122	1	0.727NS	0.952
Political involvement	19.184	2.190	0.000	1	0.999NS	2.145
Membership in VEC	0.304	1.146	0.070	1	0.791NS	1.355
Constant	6.594	2.135	9.537	1	0 .002*	730.965

Socio-economic factors escalating power struggle between ZEC and the ten villages surrounding SULEDO VLFR

i. Wealth category

Table 1 shows relative wealth of respondents to be positively correlated to power struggle with regression coefficient β =2.450 and statistically significant ($p = 0.003$). This positive correlation implies that increase in wealth of an individual increases strategic power in access and use of forest resources hence increases power struggle between ZEC and the ten villages surrounding SULEDO VLFR. The strategic power is based on financial or ability to raise capital necessary for harvesting and transporting products to markets. Another plausible explanation is that SULEDO VLFR is dominated by individuals with strategic and institutional powers that provide opportunities for utilizing the forest resources for personal gains. Therefore under such situation there is a possibility that increasing wealth heterogeneity increases the likelihood of power struggle between ZEC and the ten villages surrounding SULEDO VLFR. Agrawal (2001) argued that, rich households benefit more than poor households from the community forest reserve. Similarly, Mbeyale (2009) pointed out that, increasing wealth heterogeneity increase power imbalance due to income disparities among members of the community.

ii. Immigration

Table 1 shows that immigration was positively correlated to power struggle between ZEC and the ten villages surrounding SULEDO VLFR with regression coefficient $\beta = 1.809$ and statistically significant at (p=0.047). This indicates that the likelihood perception on power struggle between ZEC and the ten villages increases by a factor of 6.104 for every unit change in this variable. This indicates that immigrants tend to increase the village population consequently increases power struggle between ZEC and the ten villages surrounding SULEDO VLFR. This is because increase in population lead to increase pressure on farming lands resulting into encroachment to the Forest Reserve. Moreover, large herd owners tend to migrate to the area in time of pasture scarcity. This practice tends to increase pressure on forest resources. Herlocker (1999) argued that the pastoralists have for generations practised herd mobility which increase immigrants who tend to increase village population as well as power struggles in forest management resulting into forest resource-use conflicts. Galvin *et al*., (2001) reported high out migration of pastoralists from a drought prone Kakesio village into Mkata plain in Kilosa district consequently increased pressure on forest resources in the area.

The findings also concur with the report by WRI and UNEP (1992), which argued that increased demand for forest resources, which emanates from increased human population caused by increase of immigration to an area, has made forest resources use in rural areas unsustainable. McNeely *et al*., (1995) argued further that increased population growth due to immigration is strongly contributes to forest clearance at least in the tropics. Furthermore, Borrini-Feyerabend (1997) reported migration to be one of the main contributing factors to population dynamics and subsequently to power struggles and consequently forest resource use conflicts. Mbonile (2005) argue that migration has led to the convergence of pastoralists and farmers and to rapid population increases of both human beings and livestock in Pangani River Basin hence creating power struggle between villagers and Pangani River Basin Authorities over utilization of natural resources.

iii.Distance to resource base

Table 1 shows distance from household to resource base as positively correlated to power struggle between ZEC and ten villages surrounding SULEDO VLFR. Also with regression coefficient $\beta = 0.617$ and multiplicative factor of 1.854, but not statistically significant (p= 0.365) with power struggle between ZEC and the ten villages surrounding SULEDO VLFR. This implies that physical proximity of the communities to SULEDO VLFR increases occurrence of power struggle between ZEC and ten villages surrounding SULEDO VLFR, due to closeness to the resource base, hence more frequent visits to exploit the resources. Mayeta (2004) find similar results that reduction of distance from the reserve to homesteads increases the number of cases related to forest destruction in Kipengele game reserve.

Socio-economic factors likely to reduce power struggle between ZEC and ten villages surrounding SULEDO VLFR

i. Education level of respondents

Table 1 shows that the number of years spent in school was negatively correlated with power struggle between ZEC and ten villages surrounding SULEDO VLFR, with a regression coefficient $\beta =- 0.403$ and statistically significant ($p=0.001$), with a multiplicative factor of 0.668. This implies that increasing a year spent in school is likely to decrease likelihood of occurrences of power struggles. Level of education tends to create awareness, self-reliance, stimulate self-confidence, motivation and positive attitude. Increase in level of education also increases the willingness of local communities to participate in forest resource conservation. Involvement of local communities in conservation and management of forest resources reduces the chances of power struggles in forest resources management because the practice imparts a sense of ownership and benefit sharing at the local level. This in turn improves the relationship between local communities and the forest resource conservation and management authorities at the local level. Mayeta (2004) reported that increase in the level of education also increases options of respondents to meet their household needs and hence reduce power struggles and consequently resource use conflicts.

Katani (1999) reported that an increase in education level increases the level of awareness and thereby creating positive attitudes, values and motivating people to manage forest resources sustainably. Mbwambo (2000) argued that education has a direct influence on people's participation in natural resources management and promoted sustainable utilization of the natural resources in Udzungwa Mountains.

ii. Age of respondents

Table1 shows that age of the respondent in years has a negative regression coefficient ($\beta =- 0.086$) and statistically significant ($p= 0.026$). This implies that increase in age of a respondent reduces the incidence of power struggle between ZEC and the ten villages surrounding SULEDO VLFR, because older persons are assumed to have much wisdom related to forest resource use and in resolving power struggles through reconciliation committees. Usually power struggle occur between elders and young people as young people prefer harvesting forest resources including building poles for construction of their houses. Elders on the other hand do insist on conservation of the forest resources and in some situations urge young people to build their houses using modern and expensive materials. Kajembe and Mwihomeke (2001) in their study in Handeni District, Tanzania, reported that young generation always argued that it is unfair for anyone to prohibit them from obtaining poles because almost all homesteads in the villages started off being of poles and some built brick houses later as they became more settled. This struggle was caused by elders imposing what was perceived to be an "invented" tradition" of compelling the young generation to start from brick houses while most of them (i.e. the elders) started off with pole and mud structures. It is clear that even though the "invented" tradition has conservation rationality, the youth tend to object it.

iii. Farm size

Table 1 further shows that farm size was negatively correlated $\beta = -0.038$ with power struggle between ZEC and the ten villages surrounding SULEDO VLFR and not statistically significant ($p=0.525$). Farm size was assumed to reduce incidences of power struggle between ZEC and the ten villages surrounding SULEDO VLFR. The possible explanation is that when an individual own enough land resources he/she will be able to meet his/ her livelihood by allocating it for different uses and reducing dependency on forest resources than an individual who is not having enough land. During discussions with key informants it was revealed that individuals involved in power struggles were the ones who owned less than 8 hectares of land resources. FAO (2000) argued that land scarcity or ambiguous property rights contribute to grievances and power struggle; this is when forests contain valuable resources.

iv. Duration of residence

Results in Table 1 indicated that residence duration of a respondent has a negative regression coefficient $\beta = -0.010$ to power struggle between ZEC and ten villages forming SULEDO VLFR, but not statistically significant (p= 0.717). This implies that increase in duration of residence in years reduce the odd ratios of power struggles by a factor of 0.990. This is due to fact that when a person stays in a particular place for a long time is assumed to have accumulated enough land resources to meet his/her livelihoods than an immigrant to the area. This then reduces power struggle between ZEC and the ten villages surrounding SULEDO VLFR. In addition, the more an individual stays in the area is likely to be involved in forest resources conservation and resolving power struggle between ZEC and the ten villages surrounding SULEDO VLFR.

v. Household size

Table 1 indicates that household size is negatively correlated with power struggle between ZEC and ten villages surrounding SULEDO VLFR, with a negative regression coefficient $\beta = -0.049$ and multiplicative factor of 0.952. However, not statistically significant (p=0.727). The negative regression value indicates that an increase in household size lead to reduction of power struggle between ZEC and ten villages surrounding SULEDO VLFR. It was expected that household size would increase likelihood of power struggle between ZEC and ten villages surrounding SULEDO VLFR. This is because larger number of members in a household tends to increase demand of the forest resources. However, a plausible explanation for this is that bigger household size is self sufficient due to possibilities of diversification of livelihood activities as compared to small household size which depends on one activity. The study found households which receive remittances from family members who are living outside the villages. Similarly, Kisoza (2006) found negative correlation of household size with power struggles in Mkata plain, whereby family with many members were engaged in wage labour rather than depending on natural resources.

Institutional factors underlying power struggle between ZEC and the ten villages surrounding SULEDO VLFR

i. Involvement in politics

Table 1 shows that involvement of one member of household in politics has positive correlation $\beta = 19.184$ with regard to power struggle between ZEC and ten villages surrounding SULEDO VLFR, though not statistically significant (p=0.999). Involvement in politics has a multiplicative factor of 2.145. This implies that increase in one member in the household dealing with political activities tend to increase access to the forest resources, because politician tend to work hard in order to full fill their promises to people. Also politicians tend to increase power struggle between ZEC and the ten villages surrounding SULEDO VLFR due to the fact that they fear to loose their position in the coming years of election if they will limit people to access the forest resources. Hence this accelerates forest degradation and deforestation. Similarly, Stefan, (2008) argued that involvement of politicians in forest resources management increases power struggle between regulators and users, due to difference in interests.

ii. Membership in VEC

Table 1 shows that membership in VEC is positively correlated β =0.304 with power struggle between ZEC and ten villages surrounding SULEDO VLFR. Membership in VEC has a multiplicative factor of 1.355 and not statistically significant (p=0.791). This implies that increase in one member of household in VEC tend to increases power struggles between ZEC and ten villages surrounding SULEDO VLFR. The plausible argument is that memberships in VEC also give committee members institutional power on access to forest resources in SULEDO VLFR. Village Environmental Committee members were given direct authority on forest management and utilization therefore when they need forest resources it is easy for them to access thus increases power struggle between ZEC and the ten villages surrounding SULEDO VLFR. During discussions with key informants it was revealed that some of members in VECs were using their institutional power to harvest logs in forest for their own benefit. This increases power struggle between ZEC and the ten villages surrounding SULEDO VLFR. Similarly Heywood, (1992) reported that managers uses institutional power in overexploiting the natural resources hence causes misunderstanding between government administrative structures and local communities.

Conclusion

The study has shown that stakeholders' interactions under different socio economic situations and institutional settings are one of the most important aspects that influence power struggle in CBFM. Factors found to significantly escalating the likelihood of power struggle between ZEC and the ten villages surrounding SULEDO VLFR include wealth category immigration, distance from homesteads to resource base, membership in VEC and political involvement while age and education level while residence duration, household size and farm size significantly reduced the likelihood of power struggle. Generally speaking SULEDO VLFR remains to be complex and contested case of CBFM, comprised by different stakeholders underlined by power struggles and consequently resource use conflicts.

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ZONOCERUS VARIEGATUS (ORTHOPTERA PYRGOMORPHIDAE): A PEST OF ECONOMIC IMPORTANCE TO THE *PINUS PATULA* IN UKAGURU FOREST PLANTATION, TANZANIA

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Abstract
The study on determining the economic importance of *Zonocerus variegatus* on *Pinus patula* in Ukaguru Forest Plantation was carried out in April and May 2011. The major objectives were to study an outbreak, spread, damage and recommend an immediate control of the pest in the Plantation. Physical observations, experimentation, interviews, and the use of secondary data from plantation office were techniques used in data collection. It was found that the pest has spread to about the whole plantation and destroyed about 300,000 seedlings in the nursery, 4.8 hectares (ha) of 1 to 6 years and 2.9 ha of 17 years *Pinus patula* trees in the plantation. Cypercal D 15/120 UL (Cypermethrin 15g/l + Dimethoate 120 g/l. UL) pesticide was proved to be the best spray for controlling the pest among the other pesticides tested. The best time of insecticide application is when the pest is at nymph stage when they are incapable of jumping or before developing functional wing to fly. Silivicultural operations within the forest should be followed as it is directed in order to keep forest clean and tidy. Biological and Integrated pest management has to be worked on for the control of *Z. variegatus* as pesticides are not environmental friendly. Monitoring and studying on seasonality occurrence of *Z. variegatus* for the best time management is recommended.

Keywords: *Zonocerus variegatus; damage; chemical control; Pinus patula; Ukaguru Forest.*

Introduction
The exclusively African variegated grasshopper species, *Zonocerus variegates* (L) is the main grasshopper pest of crops in over twenty countries which occupy the extensive forest and savanna areas of West and Central Africa (Modder, 1994). *Zonocerus variegatus* is a destructive insect, native to the humid forest zone of West Africa (Modder, 1984). It belongs to the same order (Order: Orthoptera) as locusts. It is a polyphagous insect that defoliates and destroys the stem bark of a wide range of plantation, subsistence crops and horticultural plants at the end of the dry season (Balogun and Fagade, 2004). It causes great economic consequence to the African farmer, hence, *Z. variegatus* had been designated as a major pest of the agroecosystem by the National Agricultural Technical Committee of Nigeria since 1970 (Modder, 1986). Much of the information on the pest has been reviewed by Toye (1982), Modder (1986) and Chapman *et al*., (1986).

From the 1950s onward, extensive deforestsation and intensified Agriculture in West Africa have opened up habitats suitable for *Z. variegatus*, namely forest clearings in which subsistance crops including cassava, maize and leafy vegetables are grown. Subsistance crops are attacked because the agroecosystem is ideal for *Z. variegatus* (Modder, 1994). In the humid lowland forests, *Z. variegatus* is restricted to the sun-lit edges and clearings, and nymph and adults bask motionless in the sun for long periods. *Zonocerus variegatus* live and feed on about 300 host plant species (Chiffaud and Mastre, 1990). The geographical distribution of the pest in Africa includes; Angola, Burundi, Cameroun, Central African

Republic, Chad, Congo Republic, Ethiopia, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Spanish, Guinea, Sudan, Tanzania, Togo, Uganda, Upper Volta, Zaire.

The pest goes incomplete metamorphosis with Egg, Nymph (young grasshopper) and Adult stages only. The economically significant species of grasshoppers overwinter in the soil (about 15 - 18cm deep) in egg pods. The eggs for *Z. variegatus* can stay before hatched for period of 3- 9 months depending on the available condition (Roe, 2000). Elevation and exposure also affects egg hatch due to their relationship to temperature i.e. rising temperature shortened the incubation period of eggs (Koloud, 2011). Eggs are deposited in pods in the soil and each female may produce up to 25 pods with up to 100 eggs in each. There is usually only one generation produced each year. After each generation both male and female dies and it is estimated that the life span of *Z. variegatus* is 5 - 6 months (Roe, 2000). In early 2011, an outbreak of *Z. variegatus* was reported in Ukaguru Forest Plantation attacking both mature and seedlings of *Pinus patula*. More than 51% of the planted area has been planted by *P. patula*. The aim of this study was to determine the spread, damage and recommend immediate control of the pest in Ukaguru Forest Plantation.

Materials and Methods

Study site

Ukaguru forest plantation is one of the 19^{th} public forest plantations in Tanzania which is located in Milindo forest reserve in the Northern end of Ukaguru Mountain Range (Rubeho Mountain System) in Gairo District, Morogoro Region. The forest lies between $36^{0}8$'E to 37^{0}E and 6^{0}'S to $6^{0}5$'S. The plantation is surrounded by four villages namely Njungwa, Ikwamba, Mohe and Masenge (TFS, 2013). It is located at an altitude range of 1500 m with mean annual rainfall of 1300 mm with mostly deeply soil and weathered with a lot of mica (Ngaga, 2011). The total area of the plantation is 1700 hectares (ha) with an extension area of 400 ha. The plantation was established in 1954 in order to create softwood utility timber resources for the Central and Eastern regions of the country. The main tree species planted are *Pinus patula, P. carribea* and *Cupressus lusitanica.* The whole plantation was clear felled in early 1990s after overdue and second rotation was planted from 1994 on which up to now the area planted is only 600 ha being dominated by *P. patula*.

Data collection

Data were collected from Ukaguru forest plantation. The data were collected using the following techniques; physical observations, experimentation, interviews, and the use of secondary data from plantation office. Transect walk was done to survey the whole forest plantation in order to identify the affected areas and observe the intensity of damage in the plantation. Interviews with the Plantation Manager and other plantation staff was carried out to get information on the time of outbreak, spread, damage in acreage and number of individual trees/seedlings. Field control experimentations using known and available insecticides were done. The three insecticides that were used in the experimentations to control the pest were Benthanate, Dudu all 450 EC and Cypercal D 15/120 UL (Cypermethrin 15g/l + Dimethoate 120 g/l. UL). Data on the effectiveness and suitability of each insecticides were collected using transect walks with team of researchers and plantation staff.

Results and Discussion

Outbreak and spread of Zonocerus variegatus in Ukaguru Forest Plantation

Zonocerus variegatus was first noticed in the year 2006 in the area called Chiheta in Ukaguru Forest Plantation. At that time the grasshoppers were just in a small numbers and they were only feeding on grasses and not seen feeding on trees. Chiheta was one of squatters which were closed after harvesting operations which ended in early 2000's. It is assumed that the pest was brought unknowingly by transportation facilities and movements (mostly by weather lorries and donkeys) that were used to evacuate luggage from the squatters. At the end of dry season in February 2011, the grasshoppers erupted in large numbers and this time they were feeding on *P. patula*. At that time the grasshoppers had nearly finished consuming other agricultural crops and grasses nearby. From surveys that were done after pest eruption it was noted that the pest had spread to different parts of the plantation forest including; Tegeta, Maili mbili, Mbamba, Mandege Primary School, Rest House, Kambini, Dreva Street, Kwampoka, Nursery, Office compound, Manager's residential area and Sanjara. However, infestation rate varried between areas. In all affected areas in the plantation, a number of groups of *Z. variegatus* were observed on different areas like roadsides and field margins. The pest was causing damage to leaves and flowers of trees, agricultural crops, wild herbs and shrubs in different intensities (Plate 1). This is in line with Modder (1994) and Kekeunou *et al.*, (2005) who reported that cleared forest areas seem particularly suitable for the grasshopper. In all areas, grasshoppers were found in Nymph in 4th and 5th instars which are gregarious (dangerous) stage except in Kwampoka area where adult grasshoppers were seen (Plate 2).

Plate 1: *Zonocerus variegatus* at Nymph stages of growth (1st, 2nd, 3rd to 5th instars) feeding on grasses and agricultural crops in Ukaguru Forest Plantation.

Plate 2. Adult *Zonocerus variegatus* in Kwampoka area in Ukaguru Forest Plantation.

Damage/effect of the Zonocerus variegatus in Ukaguru Forest Plantation

Up to mid of 2011 the pest was reported to destroy 4.8 ha of 1 to 6 years, 2.9 ha of 17 years *P. patula* (by feeding on needles) and destroyed about 300,000 seedlings of *P. patula* in the nursery. This was a huge economical blow to the plantation as the seedlings were a selected germplasm (3Kg of seeds) bought from Zimbabwe which costed 400 USD/Kg (Sousa, personal communication, 2011). The pest cause serious effect during 4^{th} -5^{th} instars which is called gregarious stage. The aggregated early instars (1^{st} – 3^{rd}) prefer herbs off-farm while late instars and adults move to crops including trees (Modder, 1994). Adult grasshoppers jumps and flies to attack mature trees by sucking needles on which they cause serious destruction of trees (Plate 3) especially during dry season.

Plate 3: *Pinus patula* affected by adult *Z. variegatus* in Ukaguru Forest Plantation.

In Benin Republic, 90 and 30 % yield losses due to the infestation of *Z. variegatus* on cowpea and maize respectively (Langewald *et al.,* 1997). Over 50% of the cassava crop is estimated to be lost in years of high *Z. variegatu*s abundances in Southern Nigeria and Cote d'Ivoire in West Africa (Nwilene *et al*., 2009: Oku *et al*., 2011). The pest has also been reported to cause severe damage of Cabbage in Ghana (Timbilla *et al*., 2007). DeBrey *et al*., (1993) estimated that grasshoppers consume up to 25% of the available forage in West African countries annually. When grasshoppers' management is not attempted in areas of grasshopper outbreak, all available forage can be consumed. Niassy *et al.,* (2011) reported that in West Africa in 2004, over 300, 000 ha were treated with synthetic chemical costing around $ 1,550,000 and 4,301,000 for humanitarian and disaster assistance.

Recommended control of Zonocerus variegatus in Ukaguru Forest Plantation

All three (Benthanate, Dudu all 450 EC and Cypercal D 15/120 UL (Cypermethrin 15g/l + Dimethoate 120 g/l. UL)) insecticides were proved to kill *Z. variegates* at different rates. However, the best insecticide which shown the best result than others was CYPERCAL D 15/120 UL (Cypermethrin 15g/l + Dimethoate 120 g/l. UL). This is a systemic insecticide (double effect) with contact and stomach action. The rate of application is 1L/1-2.5ha depending on the speed of the wind. During windy time large area can be sprayed than unwindy time with the same amount of chemicals. The best time of insecticide application is after egg hatch is complete and before grasshoppers start jumping or before developing functional wing to fly. The application can be several times as eggs are not hatched at once. This is supported by Niassy *et al.,* (2011) who reported that the control strategies of *Z. variagatus* are classically based on the use of chemical pesticides. In Senegal, farmers mostly rely on chemical insecticides such as fenitrothion and Malathion for emergency situation. Grasshopper control insecticides available in the United State for homeowner use include formulations of acephate, Beauvaria bassiana, azadirachtin, bifenthrin, carbaryl, chlorpyrifos, cyfluthrin, deltamethrin, diazinon, dimethoate, lambda-cyhalothrin, malathion, permethrin, and synergized pyrethrins. Agricultural insecticides for grasshopper control include formulations containing the above active ingredients plus some formulations of azinphosmethyl, carbofuran, disulfoton, esfenvalerate, methyl parathion, Nosema locustae, parathion, phorate, and phosmet. With the exceptions of methyl parathion, parathion, and phorate, some insecticide formulations containing the active ingredients listed above are available for grasshopper control on ornamental flowers, shrubs, or trees (Roe, 2000). General cleanness and practicing Silivicultural operations as recommended is a sustainable option for controlling of the pest. It is advised to adopt cultural control method whereby the soil is disturbed so as to expose eggs to sun and other natural destroyers. This method is common in West Africa whereby digging up egg pods for desiccation at the soil surface is done and the method has given large reduction in grasshopper populations (Modder, 1986).

Conclusion and Recommendations

The study revealed that *Z. variegatus* has spread to about the whole Forest Plantation and cause some effects not only in forest sector but also agricultural crops grown in and near by the forest. The pest destroyed about 300,000 seedlings in the nursery, 4.8 ha of 1 to 6 years and 2.9 ha of 17 years trees of *P. patula* in the plantation. Cypercal D 15/120 UL (Cypermethrin 15g/l + Dimethoate 120 g/l. UL) has proved to be the best spray among others chemicals tested for killing grasshoppers. The best time of insecticide application is when the pest is at nymph stage when they are incapable of jumping or before developing functional wing to fly. Silivicultural operations within the forest should be followed as it is directed in order to keep forest clean and tidy. Biological and Integrated pest management has to be worked on for the control of *Z. variegatus* as pesticides are not environmental friendly and other health issues (risks) of intoxication to farmers and consumers). Monitoring and studying on seasonality occurrence of *Z. variegatus* for the best time management is recommended.

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REVIEW ON THE STATUS OF RESEARCH AND DEVELOPMENT OF EDIBLE INDIGENOUS FRUITS IN TANZANIA

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Abstract

Edible indigenous fruits trees (IFTs) are one of livelihood strategies from natural forests to meet with nutritional deficiencies and poverty reduction. These resources are underutilized due to low knowledge and they are rapidly declining due to high rates of deforestation. The study that was supported by the Association of Forestry Research Institutes in Eastern Africa (AFREA) and International Plant Genetic resources Institute (IPGRI) conducted to review on the status of research and development of IFTs in Tanzania. This article summarizes activities conducted by various key players which comprised Institutions, NGOs and International Organizations in the country. These included SADC/ICRAF Agroforestry programme that was based in Tabora, HASHI/ICRAF agroforestry project based in Shinyanga, Sokoine University of Agriculture, Tanzania Forestry Research Institute, Tanzania Tree Seed Agency (TTSA), HORTI – Tengeru, international Bioversity and World Agroforestry Centre (ICRAF). Activities included enthnobotanical surveys, domestication, nutritive values and suitability identification, processing and packaging, economic analysis and marketing. Enthnobotanical surveys identified about 79 and 131 IFTs species in the Miombo woodlands and for the whole country respectively. As initial step for domestication and commercialization purposes, priority IFTs species were tested for provenance screening, propagation, suitability, marketing and value addition. Currently, the scaling-up and adoption of the technologies are still on a moderate scale. Ongoing research and development for wider domestication, conservation of IFTs species and commercialisation of products should involve more valuable indigenous tree species to increase more knowledge and options for household nutritional security and income generation for poverty reduction.

***Keywords**: Indigenous fruit trees, research and development, promotion.*

Introduction

Tanzania is among biodiversity rich African countries. Other Countries include: Democratic Republic of Congo (DRC), Cameroon and Madagascar. This plant biodiversity in Tanzania has played major roles in human daily lives as sources of products such as timber, poles, fuel wood, fodder, medicinal, beeswax, honey and edible indigenous fruits (MNRT, 1998; Ruffo *et al.*, 2002; Swai and Kimata, 2005; URT, 2009).

Edible indigenous fruits as non-wood forests products (NWFP) have been used as source of food and income for rural communities, while also serving as strategic food reserves during season of food shortages (Kadzere *et al.*, 1998; Iddi, 1998). As most of them ripen at different seasons, thus they supplement in nutrient intake from green leafy vegetables and cultivated fruits (Lindström and Kingamkono, 1991; Hines and Eckman, 1993 and Kwesiga *et al.*, 2000). Indigenous fruit trees (IFTs) are economically more affordable and are rich of important sources of vitamins such as vitamin A, vitamin C, folic acid, minerals, proteins, carbohydrates, and fats (Ndabikunze *et al.*, 2000; Swai and Kimata 2005; Tuli *et al.*, 2010). Apart from being consumed as food, fruit tree species, have been providing also numerous uses such as livestock feeds, crafts, medicines, firewood, timber, charcoal, carvings, etc (Ramadhani *et al.,* 1998, Mbuya *et al.,* 1998; Ruffo *et al.,* 2002).

In view of the importance of indigenous fruit trees to peoples' livelihood, the existing moderate level of utilization and increasing deforestation due to human pressure on natural forests, efforts to conserve and fully exploit the potentials of these fruits have been mounted, though not in large scale. Therefore the aim of the study was to review and synthesise the work done on IFTs in the country in terms of research and development and provide emphasis on possible development.

Specific objectives of the study were to identify key players who have been involved in research and development work on IFTs, to document the status of research and development of IFTs, to analyse the production and marketing status of various IFTs species and to identify the research gaps in terms of research and development.

Materials and Methods

Study area description

Tanzania is located in Eastern Africa between Longitude 29 ^{0} and 41^0 East and Latitude 1^0 and 12^0 South with the total land area of 886,100 km^2 (URT, 2013). According to White, (1983) Tanzania's vegetations fall into five main phytogeographical regions, namely;

- Closed forests (Afromontane archipelago – like region centre of endemism,
- Zanzibar Inhambane regional mosaic (Mangrove forests),
- Forest – Grassland Mosaic (Somali Masai regional centre of endemism),
- Woodlands/deciduous woodlands/ Zambezian regional centre of endemism and
- Lake Victoria regional mosaic.

Since the main economic activity of most of Tanzanian people is agriculture, parts of this vegetation have been cleared out to allow for crop productions and residences which have lead into eradication or decrease in products of some species.

Data collection

The information was collected from secondary data, manuals, books, technical handbooks, reports and papers (published and unpublished) and websites. Other information obtained through personal communications with farmers and key players involved with research and development. Personal participation and experiences also complemented on the data obtained.

Data analysis

Data analysis involved case studies summarization and abstracting important observations from publications, manuals, books, technical handbooks, reports and websites' research papers and publications. It involved also synthesizing important discussions made with farmers and researchers.

Results and Discussion

Status of IFTs research and development by key players

Table 1 summarizes key players involved in research and development, their activities and achievement secured.

Table 1. Key players involved in Research and development of indigenous fruit trees

Institution/NGOs	Activities conducted	Status/Achievement
Southern Africa Development Countries (SADC)/ International Centre for Research in Agroforestry (ICRAF) in collaboration with ARI Tumbi in Tabora, Tanzania Forestry Research Institute (TAFORI) and HASHI/ICRAF project in Shinyanga which is now known as NAFRAC.	• Ethnobotanical surveys • IFTs priority species setting • Germplasm collection • Provenance trials • Germination trials • Development and testing processing recipes (protocols) • Training of women farmers on household level processing of some indigenous fruits of the Miombo woodlands • Marketing promotion • Establishment of field trials	• More than 83 IFTs and priority IFTs identified (*Parinari curatellifolia, Strychnos cocculoides, Uapaka kirkiana, Vitex mombassae, Vitex doniana, Tamarindus indica and Vanguelia infausta* (Swai 1999; Mbwambo and Balama, 2009). • Germplasm collection protocols developed and used for 5 priority IFTs (Swai, 1999; Swai 2003) • Five priority IFTs tested for germination (Swai *et al.*, 2002b) • Provenance trials of *Sclerocarya birrea, Vitex mombassae and Strychnos cocculoides* established (Swai *et al* 2002a; Swai 2003) • Field trials, Farmers' with IFTs farms established. • Processing protocol for five priority species developed (Swai *et al.* 2002a) • More than 200 farmers trained on processing indigenous fruits • Packaging and marketing of some indigenous fruits species done • Trials of *Vanguelia infausta, Vitex payoos* and *V. Mombassae* established on-station (Lubaga and Malya)
NAFRAC under the former project HASHI (A project for rehabilitation of degraded lands in dry land areas)	• Promotion of indigenous conservation practices known as "Ngitili",	• About five species of indigenous fruit species found to regenerate in ngitili farmers (*Tamarindus indica, Adansonia digitata, Ximenia caffra, Azanza garckeana* and *Vangueria infausta*) (MNRT and IUCN, 2005).
Sokoine University of Agriculture – SUA (Faculty of Forestry and Nature conservation) Food and Agriculture organization of United Nations	• Analysis of nutritive values and suitability juices and jams of some of edible indigenous fruits • Significance of indigenous fruit trees against exotic fruits indicated. • Germination trials in collaboration with TTSA	• Nutritive values of 18 species identified (Ndabikunze *et al.*, 2000) • Potentials of indigenous fruits have been elaborated • Comparable studies for IFTs suitability for juices and jams carried out (Tiisekwa *et al.*, 2002). • Functional characteristics required for jam manufacturing have been studied for *V. mombassae, U. kirkiana, S. birrea* and *A. digitata* (Ndabikunze *et al.*, 2011).
Regional land management unit (RELMA)	• Supported the identification and documentation of edible IFTs in Tanzania	• About 131 edible indigenous fruits were identified and documented (Ruffo *et al.*, 2002).
Tanzania Tree Seed Agency (TTSA)	• Conducted various studies on germination of indigenous fruits • Collection of IFTs germplasm • Developed a seed collection calendar • IFTs seed issue note provided	• Identified and documented best techniques for some indigenous fruit propagation methods (Msanga 1998; Msanga, 1999). • Developed seed collection calendar and seed issue notes for some useful IFTs species
Tengeru Horticultural Research and Training Institute (HORTI – Tengeru)	• Collection and field maintenance of some IFTs and exotic fruit trees • Development of processing protocols	• Collection of *S. Birrea* subspecies caffra, *Syzigium guineense*, *Poteria campechiana, Tamarindus indica* in place • Protocols for processing jams, juices, wines, chutney and pickles developed
International Bioversity in Collaboration with TAFORI	• Identification of the distribution, abundance and ecosystem of IFTs • Identification of IFTs suitability according to size, taste and shape • Identification of sites for promotion of IFTs	• Three IFTs studied (*V. doniana, T. indica and S. birrea*) (Mbwambo and Balama, 2009). • IFTs distribution, abundance and its ecosystems were identified • IFTs suitability according to size, taste and shape identified • Potential sites for promotion of IFTs identified

Some of research and development work conducted, involved development of propagation protocols and rising of seedlings as part of propagation effort for domestication purposes. Plate 1 shows seedlings of *Vitex doniana* that were raised by SADC/ ICRAF at ARI Tumbi Tabora.

Plate: 1 *Vitex doniana* seedlings at ARI, Tumbi, Tabora (Photo by Maduka, S.)

Production and marketing of various species

Number of farmers who mostly are women and children who collect IFTs has been increasing from 15% (Mumba *et al.,* 2001) to 66% (Bucheyeki, 2008) in Miombo woodlands areas. Some of farmers collect and process fruits into juices, beer and wine while others sale to retailer farmers who sale to end users in town. Likewise, the contribution of this enterprise to annual household income has increased from USD13.0 to 26.04 in Miombo woodlands (Mumba *et al*., 2001; Bucheyeki, 2008) indicating that indigenous fruit have the potential in contributing to household income and wealth greater if marketing channels and processing techniques are improved. Interestingly enough is also that these enterprises will also increase trees on-farm for ecosystem benefits.

The increase on the awareness on the importance of IFs have lead into more farmers to be involved into collection and processing which in future might outweigh their availability due to loss of vegetation as a result the ongoing deforestation and little IFTs replanting. Yet in peak seasons, handling and rudimentary processing technologies lead to spoilage of fruits (Swai and Kimata, 2005; Bucheyeki, 2008; URT, 2009). More than 79 edible indigenous fruits found to exist in Miombo woodlands of Tanzania which nearly occupy 90% of the total forest area or 13% of the land area. Mostly collected, processed and marketed IFTs include *V. mombassae*; *V. doniana, S. Cocculoides, Parinari curatelifolia, Sclerocarya birrea, Tamarindus indica* and *adansonia digitata* (Ruffo *et. al.,* 2002; Mapolu, 2002; Swai and Kimata, 2005; Bucheyeki, 2008; Mbwambo and Balama, 2009). From the Eastern Arc Mountains, all of the forests food reported, 54% about 69 are edible indigenous fruits, *T. indica*, *Saba comorensis*, *Annona senegalensis* being among them (Msuya *et al.,* 2010). Designing and introducing appropriate IFs processing technologies could processes and save more IFs during peak seasons and made available even during stress periods saving nutrition deficiencies as well as raising the income to farmers.

Plate 2: Vending of *Vitex mombassae* at Tabora Market (Photo by Maduka, S.)

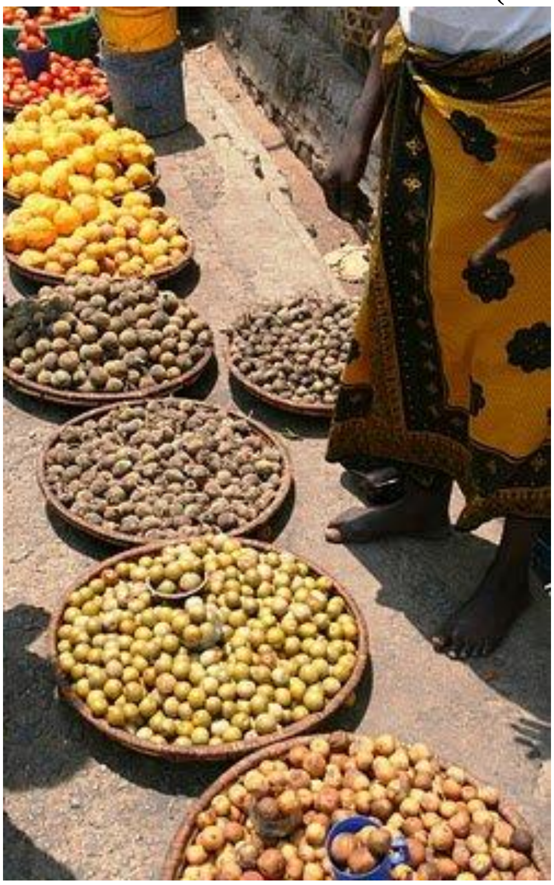

Plate 3. Selling of indigenous fruit trees in one of Miombo Woodlands market

Research and development gaps on indigenous fruit trees

Regardless of the effort conducted on research and development activities on IFTs in the country, still have however been limited to a few species only. Thus, there are still a lot to be done in the country including;

- Value addition and improvement of products through use of better processing equipments, packaging materials, labels with nutritive values and certification by the Tanzania Bureau of Standards (TBS) as well Tanzania Drugs and Food Agency (TFDA).
- Strengthening collaboration and networking among key actors (players) in order to avoid reinventing the wheel

- Community sensitization on IFTs cultivation and environmental conservation issues to increase individuals participation.
- Develop more propagation protocols on the existing potential species emphasising on using techniques like grafting, stem cuttings, budding, cloning and micro-propagation (tissue culture) which will assist in conserving the genetical resources and improve indigenous trees by shortening their fruiting periods, quality and productivity.
- Scaling up and out of the promising results of IFs interventions for wider adoption and meeting Millenium Development Goals (MDGs) by year 2025
- Group formation, training on financial, credit facilities support and market soliciting
- To study the current marketing practices like marketing channels, harvesting, storage and processing of the fruits and related products

Conclusion and Recommendations

Indigenous fruits as NWFP products have potentials to remarkably contribute to the nutrition status and economy of the country. In order to promote this vital food resource, individuals, the government, donors, NGOs and international agency should put more effort in conducting and supporting research and development activities. Networks of key actors need to be put in place to define roles for each and therefore catalyse wide adoption. Some of the existing technical information on propagation, nutritive values, processing and traits improvement on indigenous fruit species need to be reviewed, improved and made available to stakeholders.

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EXTRACTION OF INVASIVE SPECIES IN MATOGORO FOREST RESERVE TO IMPROVE WATER RECHARGE SERVICES

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Abstract
This study was undertaken in 2011 in efforts by the Ministry of Natural Resources and Tourism (MNRT) to improve management of Matogoro Catchment Forest Reserve (MCFR). The MCFR is a source of water for the adjacent populations saved by Ruvuma, Rufiji and Lake Nyasa Basins. The objectives were to come up with recommendation on the proper management including extracting invasive tree species, improvement on natural vegetation cover for improved hydrology. Methodologies used for data collection include key Informant Interviews, Rapid Inventory, observations and review of different documents. Data collected were analyzed using content analysis and excel Microsoft office computer programme. The study found that Eucalyptus trees have invaded over 350 ha of MCFR in different compartments with varying areas, age and intensity. The Eucalyptus trees have suppressed indigenous vegetation. About 90% of the areas previously under Pines has been cleared, however instituted large scale harvesting of Pines in MCFR left large open areas on MCFR steep slopes which are prone to runoff, soil erosion and landslides which affected water quality and quantity. On the other hand, insufficient implementation of silvicultural activities resulted in inadequate tending techniques to indigenous trees in the reserve. Chronic fire incidences have affected survival of planted indigenous trees. It is recommended that extraction of *Eucalyputs* trees be in rectangular coupes running along the contours, with directional felling to avoid damaging
indigenous trees and minimizing ground disturbances, District authorities should strengthen forest fires control measures, and sustainable management of MCFR needs a coordination and integration of different disciplines.

Keywords: *Water catchment management, soil erosion, rectangular coupes natural vegetation, landslides.*

Introduction
Matogoro Catchments Forest Reserve (MCFR) covering 3,723 ha was established in 1951 with the initial purpose to protect water sources. Later-on in 1970s about 867 hectares were converted into a forest plantation forest dominated mainly by pines to supply fuelwood and timber products in Songea region. Exotic tree species planted in Matogoro Catchment Forest Reserve included *Pinus patula*, *P. elliotii* and small plots of *Cupressus sp*., and *Grevillea robusta.* Boundaries demarcating exotic plantation from natural forest were planted with *Eucalyptus saligna* and *Eucalyptus maidenii*.

There was an outcry of stakeholders in Ruvuma Region with regard to the deterioration of hydrological characteristics of the Matogoro Catchment Forest Reserve (MCFR), the main watershed and only supplier of water for Songea Municipality and other down stream settlements. The main culprit being exotic trees planted in MCFR. In Early 2000, The Songea Urban Water and Sewerage Authority (SOUWSA) secured funding for water supply system project in Songea Municipality with the aim of improving water quality, water quantity and the protection of the Matogoro Hills catchment area. In the same period, the consulted Dorsch

Consult Company from Germany recommended the removal of all exotic tree species, as they were considered to have a negative effect on water quality and quantities in MCFR. In 2001, the Ministry of Natural Resources and Tourism (MNRT) made decision to change MCFR status to pure water protection forest Reserve. Then, large scale and speed harvesting of Pines was done leaving large open areas on Matogoro steep slopes which were prone to runoff, landslide and soil erosion and affected water quality. Indigenous trees were planted after removal of pines but frequent fires and poor tending of planted seedlings resulted to low survival. Furthermore, stimulation to vigorous germination of Eucalyptus seeds was supported by fires set by farmers within proximity of the MCFR especially from Mpingi village. Fire has boosted seeds from boundary trees of Eucalyptus to profusely colonize the reserve. It is from this situation, this study was carried out to come up with the design which will help to extract these saplings.

The MNRT through the Director of Forest and Beekeeping Division (DFoB) assigned Tanzania Forestry Research Institute (TAFORI) team to undertake research and provide advice on proper management of MCFR. This paper presents the status of MCFR and recommendation on the proper harvest of the invaded eucalyptus and general management of the reserve for improved hydrology.

Materials and Methods

Study area

Matogoro forest reserve consist of headwaters of perennial river including Ruvuma, Luhira, Lipasi and several small perennial streams which are sources of water for Songea municipality. The MCFR cover about 4,000 ha out of which about 900 ha were converted to industrial wood plantation in 1978 by the MNRT. Generally the geology of the area is comprised of Precambrian and early Proterozoic granites and granodiorites with gneiss and migmatitic basement rocks intruded by quartz and pegmatic veins. The terrestrial deposits on hilltops and flanks are comprised of clayey silt soils, brownish red or yellow soils.

Methods of data collection and analysis

Inventory and review of literature were the main data collection methods.

Inventory

Inventory data on Eucalyptus trees was done in the forest reserve compartments. The team assessed the current situation of forest reserve after harvest of Pines, regeneration of invasive exotic tree species (Eucalyptus) and indigenous species, water flow and slope of the affected areas. The team also took the measurements on distribution, abundance, and height of the Eucalyptus trees expected to be removed from the MCFR. The collected data by TAFORI team was important for determination of proper and safe harvesting methods of invasive exotic trees species at MCFR .

Inventory data was analysed by using Microsoft Excel Software to generate figures and tables. The DBH measurements were used to calculate the number of stems per ha (N). The number of stems per ha was calculated using equation 1 based on Philip (1994):

$N = \sum(n_i/a_i)/n$ ....(1)

Where:

N is number of stems (seedlings) per hectare
n_i is tree (seedlings) counts in the ith plot
a_i is area of the ith plot in hectares
n is total number of sample plots.

Review of different documents, office and field visits

The team members were able to access documents reports provided by Stakeholders. Most information was collected from SOUWASO, Ruvuma and Nyasa Basins Authorities, however Rufiji Basin was not visited though information was supplied by the MCFR Manager, Songea Natural Resources Advisor, District Forest Officers for Songea Urban and Rural and individuals. The following offices were visited: the office of District Commissioner, District Executive Director, SOUWSA Manager, Water Basins Authorities (Ruvuma and Nyasa). Informal discussions were carried out which provided input to this paper and familiazation process. Extensive field visit to the Forest Reserve, inlets and the new water treatment facility. The research team was accompanied by District authorities (Forest), Manager MCFR, SOUWSA Engineer and Technicians. During this visit, major discussion were on status of MCFR, history, problems of management of MCFR and suggestions on proper methods of management of MCFR for sustainable use of MCFR resources. The key informants information and data collected from field were analysed using content analysis and excel Microsoft office computer programme, respectively.

Results and Discussion

Results are presented based on the following four main items: Status of MCFR, estimation of the extent of Eucalyptus trees, identification of areas for wood processing and recommendation on proper management of MCFRs to enhance sustainable water recharge.

Status of MCFR

The catchment area for the existing and proposed intakes is predominantly forested hilly terrain with an altitude ranging between 1100-1577 m.a.s.l. The main drainage systems in the Matogoro East Forest reserve include the Ruvuma, Mkulumusi, Mowele, Luhira and Sindasinda systems. In the Matogoro West F.R. the Lihwena systems dominates the drainage.

Existing Vegetation type and distribution of MCFR is presented in Table 1. The natural vegetation that dominates the majority of the Matogoro Hills East and West Forest Reserves consists of typical Miombo woodlands, dominated by *Brachystegia, Albizia, Combretum, Julbernardia* and *Uapaca* species. The valleys are covered with rich vegetation in 20 to 50 wide strips on both sides of the streams. Distribution of standing stocks around intakes in MCFR is as presented in Figure.1

Table 2: Vegetation Cover for MCFR

Vegetation cover	**Area in ha**
Plantation Area in the Catchment	693
Open Area (earlier clear cuts)	60
Cleared Pine Plantations	633
Catchment Area outside the Forest Reserve	118
Natural Forest	659
Total Area	1,470

Source: Dorsch report, 2001

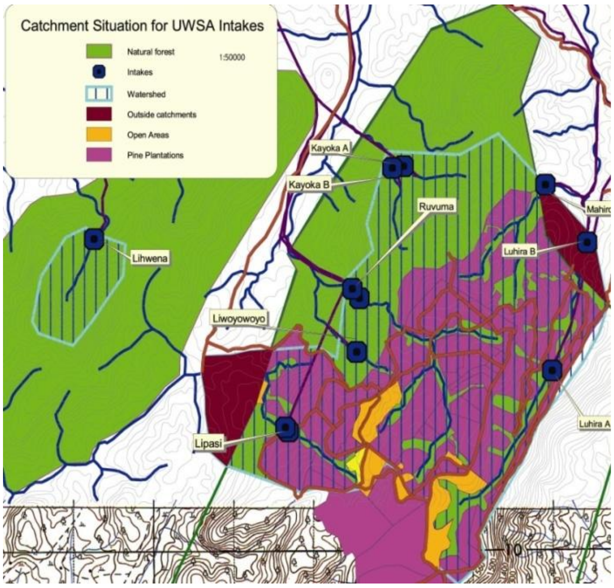

Figure 1: A map showing tree standing stock around the UWSA Intakes (Adopted and modified based on Dorsch report, 2001)

Extent of Eucalyptus Trees

The MFCR Eucalyptus trees in Matogoro are estimated to cover over 350 ha of the plantation in compartments 6, 7, 9, 10 and 11. Basically the Eucalyptus has taken over and suppressed the indigenous trees. Generally most trees are of smaller sizes, with diameter ranging from 1cm to 55cm. Average diameters ranged between 7.2cm and 14.0cm. The number of stems per hectare ranged between 2,700 and 5,700 stems per ha. This is quite dense plantation established naturally. Summary of the extent is presented in Figures 2 – 4.

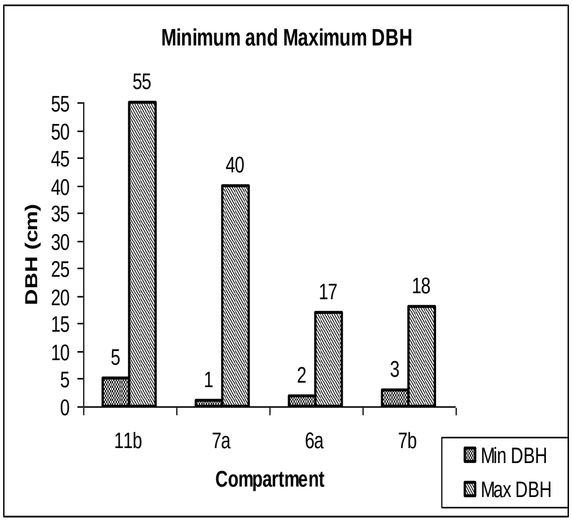

Figure 2: Minimum and maximum diameter of Eucalyptus trees in MCFR

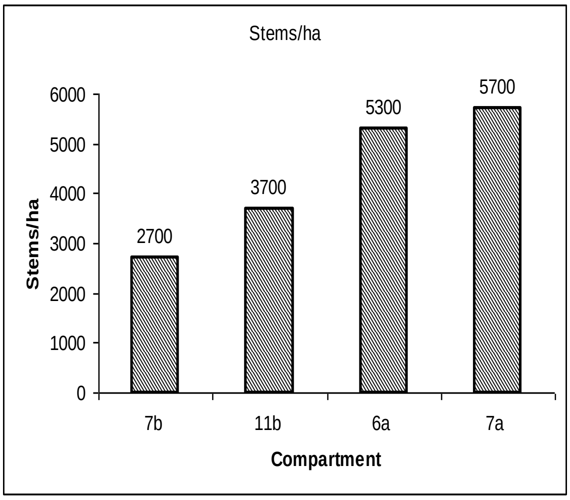

Figure 3: Number of stems per ha in surveyed compartments in Matogoro

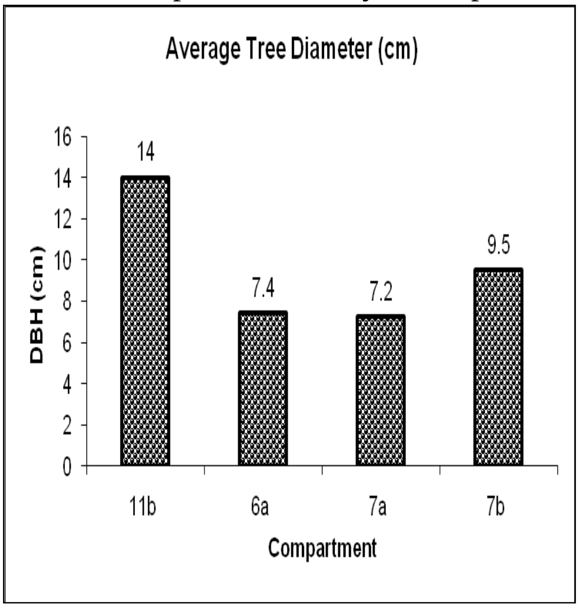

Figure 4: Average diameter of trees in surveyed compartments in Matogoro

Impacts of exotic trees on water recharge services

Most of the plantations were established in the catchments of the existing intakes for the Songea water supply. The total catchment area is estimated to be 1,470 ha, out of which 693 ha are exotic plantations and 659 are a natural forests. The rest of the catchment area is outside the forest reserve. The slopes draining into the Luhira and Mahiro intakes were predominantly covered by pines as well as the three arms of the Ruvuma River. On the Lipasi intake side, the Lihwena, Liwoyowoyo and Kayoka catchments are nearly fully covered by natural vegetation.

There were no long term measurements of water flow quantity and quality before and after the establishment of the Matogoro Forest Plantation so it was difficult for the researchers to say with confidence the impact of the exotic plantations on water quantity and quality in the catchments claimed to have been negatively affected by the exotic trees. The only water quality data based on data collected between May and July 2002, the Ruvuma and Luhira water intakes which drew water from a plantation covered catchment were found to provide poor quality raw water exceeding World Health Organisation (WHO) guidelines in terms of high acidity and turbidity. According to these laboratory test results, the high acidity was considered to be a result of the predominant pine cover and its sour leaf litter. High turbidity of the Luhira A is in direct connection with the large barren areas on top of the hills in compartment 9a which was clear cut in the early 2000. Furthermore, both existing stands as well as inappropriate treatments had influenced the soils and surface runoff negatively. Historically, according to an antiquity expert at Ruvuma Majimaji Museum, people started making iron tools from rocks locally found in Songea in 1800s. The acidity noted on the water may also originate from the soils as described in the geology of the area. However this needs more investigation. Currently, according to the SOUWASO Director (Person. communication, 2011) the water quality has improved and conforms to WHO standards as presented in Table 2.

Table 2: Three months Chemical parameter results for 2009-2011

YEARS		2011			2010		2009	
MONTHS	JAN	FEB	MAR	JAN	FEB	MAR	JAN	FEB
Parameters								
pH	7.9	7.4	7.1	7.6	7.7	7.6	7.47	7.84
TEM(°C)	21.6	20.4	25.4	22.6	22.8	22.3	21.9	20.9
COND(μs/cm)	39.9	33.8	32.4	47.8	41.8	36.7	45.05	41.45
TSS(Ml/l)	0.18	0.2	0.2	0.7	0.3	0.2	0.2	0.3
TDS(Mg/l)	19.9	20.3	16.4	22.6	20.4	17.9	27.03	20.9
NTU	37.1	28.32	29.2	204.6	21.19	19.39	25.29	29.71
Salinity(Mg/l)	-0.1	-0.1	0	0	0	0		
D.O(Mg/l)	92.2	90.6	95.2	88	11.3	96		
REMARKS	Water is turbid	water is turbid	water is turbid	water is turbid	water is turbid	water is turbid	water is normal	water is normal

Source: SOUWASO, 2011

The *Miombo* covered intakes of Lihwena, Kayoka A and B and Liwoyowoyo had better water quality.

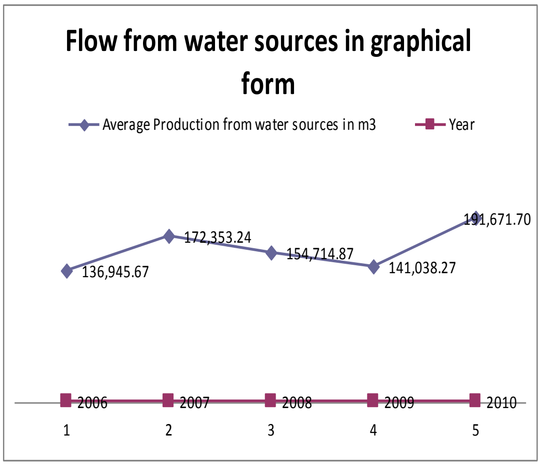

Figure 5: Water flow from sources Source: Songea Urban Water Supply Authority

Waterflow from Matogoro sources was assessed between 2006 and 2010 (Figure 5). However according to SOUWSA reports, water flow monitoring for the period 2005-2010 after the Pines were cleared to almost 90%, water quantity increased significantly on average from all intakes (person communication SOUWSA Director). This however leaves many unanswered questions because there are no data for the situation before clearing of the Pines. Furthermore, Rainfall data in the Matogoro hills was found to evenly distributed except for the year 1995 to 2000 which is attributed by low rainfall in the year 1997 (892 mm). This is as presented in Figure 6 which shows rainfall data.

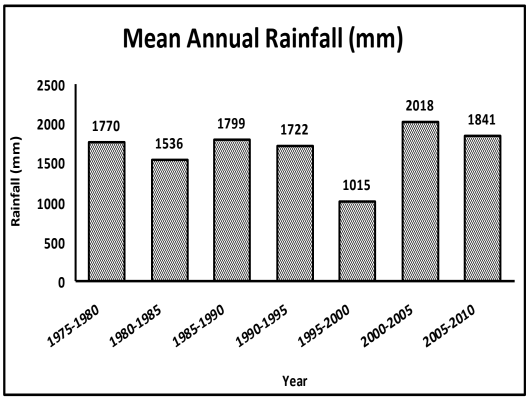

Figure 6: Rainfall data in Matogoro hills since 1975- 2010
Source: MFP Meteorological station

Furthermore, in terms of amount of water flow against the rainfall trend, a five year data was available and is presented in Table 3, This is based on SOUWSA water flow experiments. It is evident from the rainfall data that the area received substantial amount of rainfall between 2006 and 2010 which might have been a result of increased water discharge from the MCFR water sources.

Table 3: Water flow and Total rainfall in MCFR from 2006-2010

Year	Water flow (m^3)	Total Rainfall (mm)
2006	136,945.67	1,730.6
2007	172,353.24	1,846.1
2008	154,714.87	1,459.1
2009	141,038.27	2,176.5
2010	191,671.70	1,994.9

Figures 7 and 8 depict a pattern of rainfall and water flow indicating synergy between rainfall and water flow.

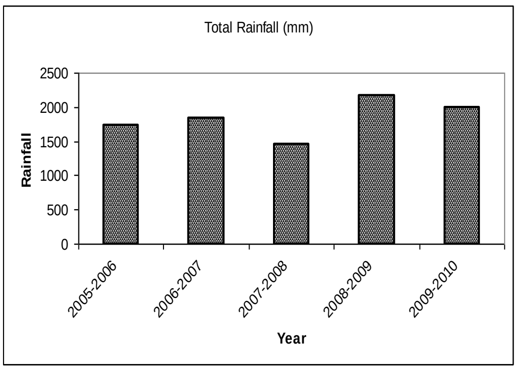

Figure 7: Total rainfall 2006 - 2010

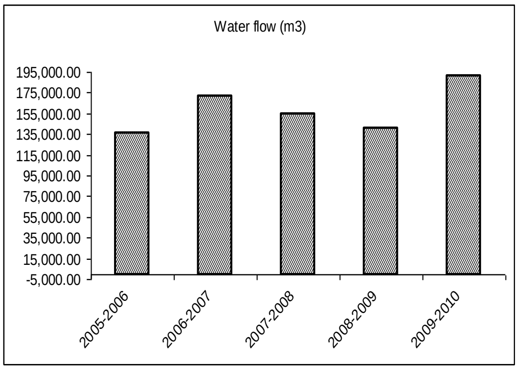

Figure 8: Water flow 2006 - 2010

Extraction of exotic tree species

Total clearing method system was used to clear-fell existing plantations. The method did not take precautions regarding the steep slopes and likely soil erosion in cases of heavy rains. According to the Forest and Beekeeping Division procedures, the customers of pine plantation coupes administer the harvesting, skidding and transport of logs from the forest for further processing. The forest officers assign the coupes to the customers, calculate the royalties and Logging Miscellaneous Deposit Account (LMDA) and leave the physical work to the buyers.

Observations in the field indicated that soils are easily eroded and can culminate into landslides if measures are not taken. The slope of the forest terrain ranged from 10 -35% due to steep slopes terrain, and limited harvesting technologies, logs were processed inside the forest using mobile sawmills. There is therefore a lot of saw dust, branches and slabs in the forest which are dangerous in case of fire outbreak. The influence of the Forest Plantation Manager on logging procedures under such situation is limited. Thus tree harvesting on the Matogoro hills went technically unsupervised. The exercise was therefore hurriedly done in clear cut system which generated large open areas with increased surface runoff and erosion. This contributed to the higher sediment load at Luhira A and B intakes. Ecological disadvantages of large-scale interventions in Matogoro plantation needed considerations on modest silvicultural interventions.

The TAFORI research team concurs with the Dosch Consult report (2002) which suggested that, any interventions within the Matogoro Forest Plantation have to minimise negative ecological effects, hence large scale harvesting is not suitable. *A "femel cutting system"* which is irregular group-selection system was proposed for opening the canopy in the compartments surrounding Lipasi and Luhira A intakes with coupes appearing like mini cuts not exceeding 0.5 ha in extent. This recommendation was accepted by authorities. The plantation management staff easily could follow these instructions. To the contrary large scale harvesting was instituted, leaving large open areas on steep slopes which were prone to runoff and soil erosion. The Matogoro Forest Plantation management needs to balance between the technical means of the wood customers and a sound catchment forest management. Based on the above observations the team recommends use of selective-alternate coupes harvesting technique which would lead to controlled soil erosion and protection of sedimentation of the water intakes.

Indigenous tree planting and natural regeneration of cleared plantations

Matogoro Forest Plantation staff started planting indigenous species on harvested exotic trees in 2001. Planted trees included *Acrocarpus flaxinifolius, Bridelia micrantha, Syzigium cordatum*, and three species locally identified as *Migwina* (Breonadia salicina) and *Ming'ong'oma (Afzelia quanzesis)* and *Mshai (Albizia gummifera)*. Very unfortunately poor tending techniques and forest fires have affected the planted indigenous tree seedlings causing failure in survival. Late planting was also claimed to be the reason for growth failure of the seedlings. Natural regeneration of indigenous species of plants in cleared compartments include; *Uapaca kirkiana, Vernonia myriatha, Albizia spp., Croton spp, Annona spp., Euphorbia spp., Protea spp., Terminalia spp., Cussonia spp., Vitex spp., Syzigium cordatum, Phylanthus spp., Breonardia salicia, Parinary curatelifolia, Diplorhynchus condylocarpon, Markamia obtusifolia, Markamia lutea, Trema orientalis, Flacourtia indica, Brachystegia boehmii, Brachystegia spiciformis, Julbernadia globiflora, Combretum spp.,* and *Dalbergia nitidula*. The undergrowth is dominated by the elephant grass, ferns and wild asparagus. Other plantations for instance compartment 6a, 6b, 7a, and 10 are dominated by regenerating Eucalyptus (*E. saligna* and *E. maidenii*) which were previously planted in the boundaries to mark the plantations. Forest fires following the harvesting of the compartments caused profuse regeneration of Eucalyptus and suppression of planted seedlings. It was very unfortunate that after planting the only tending operation which followed was "spot weeding". This technique is applicable only where the undergrowth is not highly competitive, otherwise a combination with slash weeding in the whole compartment could yield good results. This is because all unwanted trees could be cut back to allow desired species to grow. The exercise is however expensive compared to spot weeding alone because it is labour intensive. Meager budgets allocated to MCFR were limiting. The new water project for Urban Songea funded by KfW also did not set funds for the management of the water sources. Focus was only on the water infrastructure.

Identification of areas to be used for wood processing and recommend the extraction design

Most of the trees are smaller in size, unprofitable as timber. Thus, currently there will be minimal processing on site. Bigger trees >50cm are those which remained in the boundary since the establishment of Matogoro Plantations. The hilly slopes of the forest does not allow tractor skidding. Furthermore there are no extraction roads across the compartments. The practice has been to skid logs manually to a nearby processing site using mobile sawmills. Under the geographic features of Matogoro plantation and the fragile slopes in the area, this is the best option for timber extraction in the area. It minimizes soil erosion and damage on the under growth. Currently the product which can be extracted from the compartments invaded by Eucalyptus is poles for transmission and fencing with minimum timber extraction. To avoid problems related to soil erosion, "selective coupe system" is recommended. The coupes are to be laid along the contours in not more than 50 m width and length will depend on the width of the compartment along the contours. This activity must be carried very soon before the Eucalyptus overgrows. The coupes must be alternating down the slope to allow buffer zones to control any likely soil erosion and landslides as shown in Figure 9 and 10. All cut trees must be brought manually to the roadside ready for transportation. Directional felling should be applied to avoid damaging the buffer zone.

Coupe 1: Clear first year*
Coupe 2: Remain first year as buffer (Clear 2nd year)
Coupe 3: Clear first year
Coupe 4: Remain first year as buffer (Clear 2nd year)

*Clear felling should be followed by intensive suppression of all eucalyptus sprouts and seedlings to favour mergence of indigenous tree species.

Figure 8: Proposed alternate coupe system for extraction of Eucalyptus in Matogoro

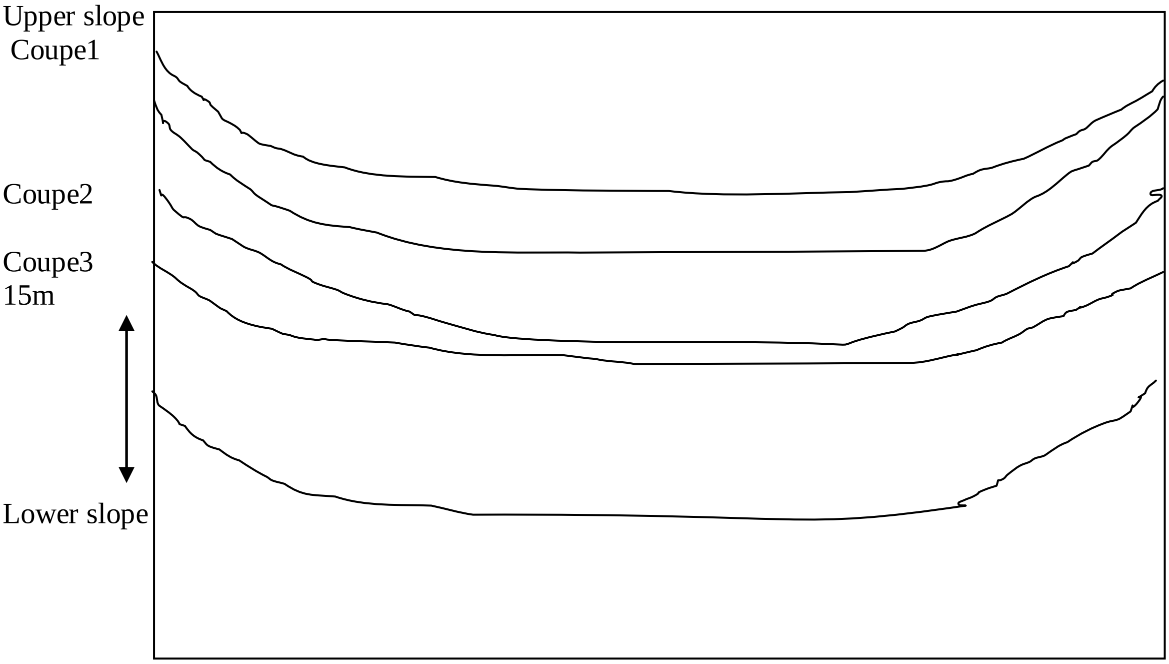

Figure 9: Proposed alternate coupes system following contour lines for extraction of eucalyptus trees and subsequent suppression of coppices

Joint management of Matogoro Forest Reserve by different stakeholders

The existing situation of MCFR institutional frameworks are neither integrated nor coordinated which predispose the MCFR resources to unsustainable management. Respective institutions regulating stakeholders' interest of the two sectors (water and forest) are disintegrated and lack coordination. Furthermore, there was lack

of formal integration mechanism among MCFR stakeholders including communities, Ruvuma basin, Nyasa basin, MFRM, SOUWSA and communication organizations (Vodacome, Airtel and Tigo). . Integration in management of MCFR resources has remained a problem due to sectoral focus in planning, policing and budgeting in Tanzania. Water and forest sectors were established to meet specific needs. Thus, the team recommends informal meeting between stakeholders at the ground which may have positive impact on the management of MCFR.

Conclusion and Recommendations

The MCFR needs to be transformed to a natural forest and potential catchment for water supply downstream to Songea Municipality and adjacent populations saved by Ruvuma, Rufiji and Lake Nyasa Basins. The challenge of how to remove the invasive tree species (e.g. Eucalyptus) without causing devastating ecological effects on the steep slopes of the MCFR terrain the study has the following recommendations: considerations on modest silvicultural interventions and harvesting invasive tree species using selective-alternate coupes technique to control soil erosion and protection of sedimentation of the water intakes. Matogoro Forest

Plantation management needs to balance between the technical means of the harvesting invasive tree species for market and a sound catchment forest management. For sustainable management of MCFR resources, integration among several line ministries and departments' having interest in MCFR resources is important and the management of the reserves should avoid sectoral focus in planning, policing and budgeting in Tanzania.

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PARTICIPATORY APPROACH POTENTIALS IN ADOPTION OF AGRONOMIC, LAND AND WATER MANAGEMENT TECHNOLOGIES IN SEMI ARID AREAS OF TANZANIA

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Abstract
The study was conducted to asses the potentials of Participatory Approach (PA) in enhancing adoption of improved technologies. Literature consists plenty of general information on Participatory Approach (PA) in Tanzania. However, it has inadequate scholarly information on the contribution of PA in adoption of improved technologies. Specifically, the study determined rates of technologies adoption. A cross sectional research design was adopted for the study. Methodologies used for data collection include Focus Group Discussions (FGD), questionnaires survey, Key Informant Interviews (KII) and participant observation. Questionnaire data were collected from 240 households selected randomly. Data from questionnaires were analysed using Statistical Package for Social Sciences. Content analysis was used to analyse information from FGD, KII, participant observations and document reviews. The results show that PA improved knowledge and skills of beneficiaries as most of respondents from Participatory Irrigation Development Programme (PIDP) schemes (61.3%) adopted improved technologies than respondents in Non-PIDP schemes (25%). The results further revealed that farmers using PA adopted more improved agronomic technologies as 63.7 % of respondents in PIDP adopted improved maize varieties while in non-PIDP were 22.5 %., Further more, 61.2 % of respondents in PIDP schemes planted trees while in Non-PIDP schemes were 24.4%. It was concluded that PA encourage large proportion of farmers to adopt improved technologies as farmer's ideas have been incorporated. The study recommends institutionalisation of the PA in tertiary agricultural and forestry institutions curricula and provision of PA training to farmers using PIDP training methods and approaches.

Keywords: *Participatory-management, technology-adoption, food-security, and PIDP*

Introduction

Participation of beneficiaries has gained popularity today because of past failure of top down approach in development projects in the third world countries. Development projects failed to achieve their objectives due to lack or minimum involvement of the beneficiaries in project problem identification, design and implementation which made beneficiaries consider projects as not theirs (White, 1994). Therefore, this calls for the need to involve beneficiaries in development projects including technology dissemination. The PIDP was the programme that declared involvement of farmers in all stages of irrigation scheme development projects. Despite a good number of studies conducted on PA, little is known about the impact of PA on use of improved technologies. Additionally, although there is an increased emphasis placed on the role of participation in development programmes, there is insufficient empirical evidence to support the claim that participation leads to positive project outcomes and impact (Cleaver, 2001). The PIDP was introduced in 2001 as a follow-up to Small Holder Project for

Marginal Areas (SDPMA), which performed poorly due to inadequate beneficiaries' participation in project activities. Thus, PIDP upgraded SDPMA irrigation schemes and introduced new schemes with emphasis on PA. In this study, new schemes were called PIDP while schemes that were introduced during SDPMA and up-graded latter under PIDP were called SDPMA schemes. The Non PIDP schemes were neither under PIDP nor under SDPMA selected as control group. In implementation of the PIDP activities the programme was emphasising PA in all stages of project cycle including technology dissemination activity. This paper, focus on potentials of PA in facilitating adoption of improved technologies in semi-arid areas of Tanzania. Specifically the study determines extent of use of improved agronomic, land and water management technologies disseminated to beneficiaries.

Materials and Methods

Study area

The study was carried out in three districts, Babati, Nzega, and Igunga, Tanzania. Babati District council is among six Councils of Manyara Region. The district lies between latitudes 3^0 and 5^0 South of the Equator and longitudes 35^0 and 37^0 East of the Greenwich. Nzega District is one of six districts making up Tabora Region, and covers an area of 9226 Square kilometres. The district is located between 32^o $30^{'}$to 33^o $30^{'}$ longitudes East of Greenwich and latitude 3^o $45^{'}$ to 5^o $00^{'}$ South of the Equator. Igunga District is one of the six districts of Tabora Region. It is located between latitudes 3°51 and 4°48 South of Equator and longitudes 33°22 and 34°8 East of the Greenwich. These districts were purposively selected since they were among the 12 districts of semiarid areas where the PIDP operated and consist of other types on schemes. These sites were also selected based on their long experience in implementing PA and few studies have been done in these areas (PIDP, 2000: SUA, 2000). The PIDP was selected as a case study because the programme emphasised on participation of various stakeholders in management of irrigation schemes while non-PIDP and SDPMA schemes were selected for comparison purposes.

Research design and data collection procedures

The study employed a cross-sectional research design which allows collection of data at one point at a time (Kumar, 2005). Purposive sampling was used to obtain districts and schemes. These are areas where PIDP, SDPM and non-PIDP schemes have been operating for a period of three years. Two schemes were selected from each district. List of WUA members from each scheme constituted the sampling frame from which 40 households were selected from each scheme using a simple random sampling method. A total sample of 240 respondents were selected from WUA, eighty respondents (80) were selected from different types (PIDP, SDPM and non-PIDP) of schemes. According to Bailey (1994) 30 respondents are enough to get information from the selected sample for statistical analysis. Two FGDs were conducted in each scheme with an average of 10 to 15 respondents in each group involved in the discussion. In each scheme 10 key informants were involved in the discussion including Councillors, Village Government Leaders, WUA leaders and Village Environmental Committee leaders. Participant observation, FGD and secondary data were used to supplement information from questionnaire. Secondary data were obtained by reviewing different literature from Journal papers, technical reports, books, the internet and websites. Other sources of secondary data were baseline studies and other documents from the PIDP Coordination office, district agricultural offices and the Ministry of Agriculture and Food Security Headquarters. The purpose was to have background information regarding the study area and the study topic.

Data analysis

Quantitative data from structured questionnaire were coded and analysed using the Statistical Package for Social Science (SPSS) version 12. Content analysis was used to analyse qualitative information collected from FGDs, KII, participant observations and document reviews. Analysis of Variance (ANOVA) was used to check the statistical significance of mean difference between and within types of schemes in selected variables.

Results and Discussion

The study found that more than (70%) of respondents from the study are received training and are aware on agronomic, land and water management technologies (Table 1). The training received under agronomic practices include improved seeds, use of fertilizers, line and space planting while technologies under land and water management practices were bund construction, tree planting, crop rotation and maintenance of irrigation infrastructures. In this paper the discussion concentrate in adoption of unproved seed varieties and tree planting technologies.

Land and water management technologies adopted by respondents

Respondents in all schemes received training on tree planting technologies. The number of trees planted was an important element in understanding whether the programme was successful in sensitising the beneficiaries in adopting water and land management.

Tree planting

The results in Table 1 indicate that more than half of all respondents planted different types of trees in different areas. It was further found that relatively higher proportions of respondents in PIDP (61.2%) and SDPMA (68.4%) schemes planted trees than respondents from Non PIDP schemes. However, through probing it was revealed that generally few respondents reported to have planted more than 10 trees. The evaluation study conducted by SDPMA project team found that, despite the fact that more than 80% of the farmers depend on wood for fuel and nutrient cycling, the average number of trees planted were still very low (SDPMA, 1993).

Table 1: Technology received and adopted under agronomic practice

Item	PIDP (n=80)	SDPMA (n=80)	NONPID Pn=80	TOTAL N=240
Respondents received training				
Yes	97.5	83.5	41.0	74.3
No	2.5	16.5	59.0	25.7
Types of paddy seed varieties used				
Local	77.5	53.7	95.0	75.4
Improved	18.7	41.3	3.7	21.3
Both	3.8	5.0	1.3	3.3
Types of maize seed varieties used				
Local	36.3	71.3	77.5	61.7
Improved	63.7	28.7	22.5	38.3
Overall high adoption rate	61.3	78.8	25	52.5
Overall low adoption rate	38.7	21.3	75	47.5

Through probing it was found that trees were planted around their homesteads, farms and along the rivers, roads and canals. Most of the fruit trees were planted around the homesteads and very few were planted in the farms. Trees which were mentioned to be planted in the farms and along the canal were: *Leucaena leucocephala*, Acacia species and *Grivellea robusta.* Trees like Eucalypts species were planted along the road, due to fear that they would destroy crops when planted in the farms. Wild fig trees (Mikuyu) and Acacia trees were planted along the canals and rivers. The reasons provided for most of farmers not planting trees in field were: lack of tree seedlings, lack of agroforestry tree planting skills, animal destruction, pests, diseases, drought, fear of reducing their farm size due to trees and the fear of inviting birds in the maize and paddy fields. The same was reported by Grandstaff *et al.* (1985) in a study conducted at northern Thailand. The authors reported that among the values of trees planted in the paddy fields, provide rats and birds habitat and food. Other reasons provided by respondents were: fear for the theft of planted seedlings; poor survival of the trees planted in the paddy fields due to too much

water; fear for creating shades which would affect their crops and that the roots of the trees can block canals. It was further revealed that, few farmers had woodlots due to the shortage of land and drought effects. According to Vityakon (2001) farmers make conscious to retain or planted trees when the net benefits are perceived as exceeding the costs.

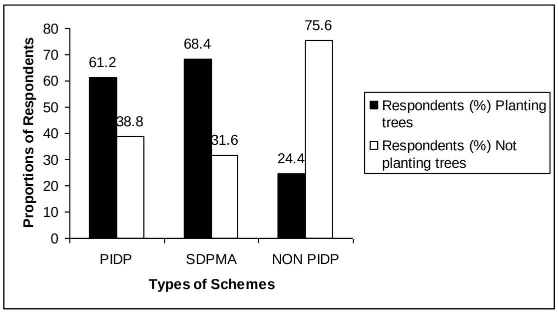

Figure1: Adoption of tree planting technology
Source: Survey data (2008/2009)

The results in Figure 1 indicate that respondents implementing PA approach (SDPMA and PIDP) had relatively higher proportion of respondents planted trees as opposed to the respondents in non-PIDP schemes. This is probably due to the participatory training provided by the programme to the WUAs members. These results are in line with the argument made by Pretty and Scoone (2006), who noted that people who are directly involved in the project activities are best placed to manage their environments and resources. Farming activities are known to have severe consequences such as land degradation, especially during land preparation. As land preparation activity is associated with tree cutting. Tree planting in the fields was emphasised by the PIDP programme using agroforest trees but, it was unfortunate that most of trees were planted around homesteads and not in their farms and woodlots. Some of the respondents reported that they do not practice agroforestry due to lack of agroforestry knowledge and fear of tree shed crops.. Generally, people in the study areas do not have the culture of planting trees but did a lot of tree cutting. This is partly attributed to the need for some livestock keepers to eradicate tsetse flies by using bush clearing method. The same finding were reported by Jordan (1986) that clearing of vegetations method is practised by livestock keepers to control tsetsefy despite that the method is not allowed by conservationist.

Agronomic practices

Training skills provided under agronomic practices components were line and space transplanting, fertilizer application and the use of improved seed varieties. Among the agronomic technologies, the most adopted ones were: line planting technique, space planting and improved seed paddy varieties. Positive impact on the use of these technologies encouraged farmers to grow paddy and maize using improved agronomic practices. This is due to the fact that the PIDP's concentration was on paddy and maize production in consideration of PA. Contrary to the practice used for crops such as sweet potatoes and sorghum where most of the respondents reported of not even knowing whether the improved varieties existed.

The respondents in the PIDP and SDPMA schemes preferred more improved varieties, than local varieties. Different varieties were planted in farmers' fields as on-farm trails and during farmers' field day the farmers were able to select the variety with good performance. This participatory evaluation process increased the adoption rate in the SDPMA and PIDP schemes on the utilization of improved varieties. As Abrol and Chopra (2007) report, in order to enhance agriculture, practitioners need to view farmers as partners rather than mere recipients of technology. When there is active community participation in research activities, it is likely that those involved would want to see more immediate benefits directed from within their own community and hence leading to high adoption rate (IDRC, 1991). The results in Table 1 further show that most of respondents (61.7%) used local varieties while few (38.3%) used improved varieties. Among the respondents who used improved maize seed varieties, majority (63.8%) where from PIDP schemes; few (28.8%) in the SDPMA and the rest (22.5%) from non-PIDP schemes. This could be due to the reason that the respondents in the PIDP involved in selection of best performing seeds.

The results in Table 1 indicate further that there were higher proportions of the respondents using improved varieties in the SDPMA (41.3%) than in the PIDP (18.8%) and non-PIDP (3.8%). During FGDs the respondents in the non PIDP reported on not using the improved seed varieties introduced by the Japanese because they did not know the performance of those varieties and the taste was bad. Japanese, under JICA project, provided 170 improved paddy seeds varieties to farmers at one of the non-PIDP schemes, but the seeds provided were not accepted by the community due to lack of PA during the introduction of those varieties. Olaka *et al.* (2006) found similar results, it was reported that the researchers forget about the involvement of farmers in the research process and at the end of the day they came up with technologies which farmers may not have been interested in. According to Berhanu (1999) the most important reasons that contribute to the low level of use of technologies is lack or minimal involvement of farmers in the planning process and inappropriateness of the technologies

The respondents were asked to explain whether they are using improved or local paddy seed varieties. Most of respondents (75.4%) from all schemes reported using more local varieties, despite that more than half of respondents had received agronomic practices training including the use of improved seed varieties. Few respondents (21.3%) used improved seed varieties and only 3.3% used both improved and local paddy seed varieties (Table 1). The reasons provided for few farmers using improved seed varieties were seeds unavailability and high price of the improved seed varieties. However, as Senkondo *et al.* (1998) argues farmers preferred more local varieties because a farmer is likely to adopt new technology if the utility of that technology is higher than the utility derived from traditional technology.

Table 2: Multiple comparisons in mean differences in overall technology adopted by respondents in schemes

(I) Selected scheme	(J) Selected scheme	Mean Difference (I-J)	Std. Error	Sig.	95% Interval	Confidence
SDPMA	NONPIDP	2.45000(*)	0.32750	0.000	1.8048	3.0952
SDPMA	PIDP	0.90000(*)	0.32750	0.006	0.2548	1.5452
PIDP	NONPIDP	1.55000(*)	0.32750	0.000	0.9048	2.1952

*The mean difference is significant at the 1% level
Source: Survey data (2008/2009)

The results in Table 2 indicate further that, there was a significant difference in the overall technology adopted by the respondents between and within the schemes. The difference identified was due to programme intervention emphasizing on the PA. Lutkamu e*t al*. (2006) reported that PA helps in utilization of improved technologies. Since both PIDP and SDPMA received PA training, the difference between them was due to the time of the project intervention In the SDPMA scheme the respondents received support for relatively a longer time than the respondents in the PIDP scheme. Thus, there was evidence that programme interventions had improved the knowledge and skills of beneficiaries. Higher adoption rate of technologies disseminated to farmers was evident to the PIDP (61.3%) and SDPMA (75 %) compared to farmers in non-PIDP (21.3%) schemes (Table 1 and 2.) Thus, the programme emphasising participatory approach had significant

contribution on utilization of improved technologies.

Conclusion and Recommendations

Programme interventions through PIDP and SDPMA had improved the knowledge and skills of the beneficiaries. Higher adoption rate of technologies disseminated to farmers was evident to the PIDP and SDPMA schemes compared to farmers in non-PIDP schemes. Thus, the programme emphasising PA had significant contribution on utilization of improved technologies. The study also reveals that PA contributed to building confidence among community members because some WUAs members who participated in training were able to contest for leadership positions at ward and village levels. Likewise, irrigation scheme infrastructures were in good condition in PIDP schemes than in SDPMA and non PIDP schemes due to PA training received during programme intervention. However policy makers and other development programmes staff tend to impose issues to farmers thinking that is important to farmers but in the ground is not working. The study recommends institutionalisation of the PA approach in agricultural and forestry tertiary curricula. It is also recommended that training on PA should be provided to farmers using good PIDP training methods and approaches.

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