TAFORI EXPERIENCE IN SOLVING FOREST DEFORESTATION AND DEGRADATION CHALLENGES IN TANZANIA

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ABSTRACT

Deforestation and forest degradation in Tanzania are the challenges noting deforestation rate of about 500,000 ha per year. Tanzania Forestry Research Institute (TAFORI) has gained vast experiences in solving deforestation and forest degradation. Experiences gained are from enhancing natural regeneration of degraded forests and woodlands, introduction and screening and multiplication of Eucalyptus hybrid clones, artificial propagation of indigenous trees (medicinal, timber and fruit trees), including application of tissue culture technology, enhancing availability of planting materials through the establishment of seed orchards and gene conservation stands. In meeting charcoal demands and sustainable utilization of available trees resources, efficient charcoal-making kiln (Casamance) has been introduced and disseminated through outreach programme. Regeneration techniques for 10 dominant tree species in Miombo woodlands of Tabora and three tree species within the Eastern Arc Mountains have been developed. Over 500,000 ha of *Ngitilis* and 20 tree species have been restored in Mwanza and Shinyanga regions. Through Tree Biotechnology Programme, improved Eucalyptus hybrid clones have been introduced and adopted by stakeholders. Morever, the new focus towards application of tissue culture technology will widen the range of benefits including mass seedlings production. Several publications on research findings and dissemination materials in user-friendly languages have been made and distributed to stakeholders. More studies, identification of new technologies and innovations are required to meet the growing demands of wood.

Keywords: *Natural regeneration, artificial propagation, charcoal-making, dissemination*

INTRODUCTION

Deforestation and forest degradation in Tanzania are the challenges noting a deforestation rate of 500,000 ha per year (MNRT, 2015). Unsustainable anthropogenic activities such as agricultural expansion, grazing, timber extraction, charcoal making and urbanisation have been reported all over the country as threatening the existence of natural forests (Blomley and Iddi, 2009; MNRT, 2015). For instance a study by Kashaigili *et al.* (2013) indicates that between 2000 and 2007 there has been a deforestation rate ranging from 0.14 to 0.61% per year, along the coastal areas of Tanzania, and which was trigger by various uses of the forest such as timber, building poles, withies, firewood, and charcoal making. In addition, Kazimzumbwi forest has been degraded and over 20,000 hectares of the Pongwe forest were lost through human activities (Kahyarara *et al.,* 2002). Similarly according to Masanja (2013), along with energy requirements for domestic use, vegetation losses in Miombo woodlands areas of Sikonge in Tabora region are reported to have been contributed by mainly agricultural expansion for tobacco and to some extent for cereal crops.

The Miombo woodlands whose part integrate with coastal forests and surround some of the Eastern Arc Mountains are known globally for the conservation of high levels of species richness and endemism (Milledge *et al.,* 2005).

Indigenous tree species of economic and social importance (endemic and rare tree species) are threatened to near extinction. Tree species such as *Pterocarpus angolensis*, *Khaya anthotheca*, *Allanblackia stulhmannii, Ocotea usambarensis, Olea capensis, Olea welwitschii, Milicia excelsa, Osyris lanceolata* and *Dalbergia melanoxylon* are threatened while others are on the verge of extinction due to selective over-exploitation (URT, 2009). Most of the vegetation in the country due to the on-going deforestation and land degradation are facing local extinction and genetic loss. There have been remarkably negative changes of forest cover between 1990 and 2010 where the area under forests decreased from 41,495,000 ha to 33,428,000 ha with the estimated deforestation rate of 403,000 ha per year (FAO, 2011). However, with the implementation of different management initiatives following the implementation of Forest Policy of 1998 and Forest Act of 2002, there has been a slight decrease of deforestation rate down to 372,871 ha per year (MNRT, 2015). This could be due to a decrease of illegal harvesting, encroachment, fire incidences and other unregulated activities (Hamza and Kimwer, 2007) and supplemented by an increase of awareness of tree planting activities, which reduce pressure and improve regeneration of forests.

Trees can regenerate naturally in natural forests or artificially through planting. Natural regeneration is the process whereby trees and woodlands are established naturally from seeds, coppices, root suckers produced and germinated *in situ* (Mugasha *et al.,* 2004; Rocky and Mligo, 2012). Natural regeneration under reduced disturbances is much easier than tree planting as native trees are well adapted within the site. However, natural recovery in areas which are subjected to intensive anthropogenic effects might be too slow due to soil degradation, recurring disturbance and isolation from microclimate of intact forests (Shono *et al.,* 2007). Hence, the introduction of fast growing tree species and the application of artificial propagation techniques are considered as alternative solution for improving the availability of wood products and services. Artificial propagation is a process of reproducing suitable planting materials either by seed (sexually) or vegetative (asexually) to achieve various products and services.

Best planting materials (whether from seed or vegetative part) depending on the type of the tree species, must come from the best sources from plus trees in natural forests, plantations, seed stands, clonal seed orchards or mother blocks (Mbora *et al.*, 2009). This will influence efficient establishment of the materials in the field and the achievement of the desired end products. Thus, it is important to conduct experiments to determine appropriate propagation methods with optimum conditions and requirements before large-scale propagation (Hartmann *et al.,* 2011). Under Plantation Forestry and Tree Improvement Programmes, TAFORI has been carrying out experiments and researches on tree improvement, breeding and management for both local/indigenous and exotic trees by evaluating their adaptation on-farms and in the plantations. The findings from various researches - for instance Eucalyptus hybrid clones propagation, utilization and its dissemination to stakeholders have been contributing to solving deforestation and forest degradation.

Furthermore, most of the charcoal producers use inefficient technologies of charcoal-making. This has contributed to the high removal of trees regardless of sizes particularly from dry Miombo woodlands and *Acacia* to savanna woodlands (Hartmann *et al.,* 2011). For example, to produce one ton of charcoal, an estimated 3.4 m^3 of solid wood must be used (Indufor, 2011). The utilization of this source of energy will not be avoided in 10 years to come due to high price of alternative sources of energy such as electricity and solar power systems (Mbwambo *et al.,* 2005). Thus, sustainable charcoal production techniques are required to reduce the rate of forest degradation. This can be done by providing training on how to produce charcoal using improved kiln such as Casamance to communities living adjacent to the forest

reserves. Unlike the Traditional Earth Mound Kiln (TEMK) methods, the improved methods of charcoal-making have an average carbonization efficiency ranging from 27% to 35%. The Casamance Earth Mound Kiln (CEMK) and Basic Earth Mound Kiln (BEMK) among others are the two varieties of the improved earth mound kiln. The CEMK that has originated from Senegal in West Africa has technically been proved to be the most efficient method of charcoal-making with a recovery rate of up to 31% (Kimaryo and Ngereza, 1989).

TAFORI EXPERIENCES

TAFORI has been carrying out research in various areas such as planting, growth, development, conservation and the use of. Research has also been carried out regarding pests and diseases associated to these local and exotic tree species. Since the Institute is mandated to do forestry research and development in the country, it has been involved in development of regulations, guidelines, policies and research master plan as tools of research, development, management and utilization of forest resources. The experiences mainly fall under six categories (i) Enhancing natural regeneration on degraded forests and woodlands (ii) Introduction of Eucalyptus hybrid clones and propagation (iii) Artificial propagation of indigenous tree species (medicinal and fruit trees) (iv) Tissue culture application technology (v) Enhancing availability of planting materials through establishment of seed orchards and gene conservation stands (vi) Dissemination of improved kilns for efficient charcoal making, and (vii) Dissemination of research findings through outreach materials.

Enhancing Natural Regeneration on Degraded Forests and Woodlands

Through trials in the Miombo woodlands in Tabora Region, the Institute has enhanced regeneration of 9 dominant Miombo tree species namely, *Afzelia quanzensis, Brachystegia boehmii, B. microphylla, B. spiciformis, Dalbergia melanoxylon, D. nitidula, Pericorpsis angolensis, Pterocarpus angolensis,* and *Swartzia madagascariensis*. Similarly, in the Eastern Arc Mountains the Institute has enhanced regeneration of *Cephalosphaera usambaransis, Newtonia buchananii* and *Ocotea usambarensis* (URT, 2011). The study of tree basal area increment using Permanent Sample Plots (PSP) which was established in the Miombo woodlands of Iringa Region, reported the mean annual basal area increment of 0.22 m^2 per ha and sustainable annual harvests of 2% of the basal area which is about 10 tree per ha after five years of its establishment. While the use of PSP in Kiteto Manyara Region reported the mean annual basal area increment of 0.12 m^2 ha^{-1} and sustainable annual harvests of 1.2% of the basal area which is about 5 – 8 tree per ha.

Furthermore, in collaboration with other stakeholders, the Institute conducted research on PFM which indicated improvement of forest quality. There has been an increase of biodiversity, regeneration, stand density, and growth (Blomley *et al.*, 2011; URT, 2011). Forests under PFM have been recovering as opposed to forests managed by the government alone, or forests under open access regimes (URT, 2008; Blomley and Iddi, 2009). In these areas, livelihood of the communities living near the forests has improved; also there has been an increase of biodiversity, which in turn, increased the area of forest reserves by 2,047,824 hectares (Hamza and Kimwer, 2007). According to a study by Piiroinen *et al.* (2008), grasses in the Miombo woodlands were found to be the major forestry regeneration factor, since when there is an intermediate suppression of grasses through intermediate grazing, tree regenerations are favoured. A similar observation was made on *Ngitili* practice in semi-arid areas of Shinyanga and Mwanza regions. Under *Ngitili* practice, there has been alternating periods of grazing and enclosures of the area, which favours regeneration of trees and grasses for household use, whereby over 500,000 ha of *Ngitilis* and 20 tree species have been revived (Pye-Smith, 2010). The *Ngitili* provides fuelwood, poles, timber as well as

fodder for livestock and bee forages. However, improvement of regeneration for vegetation is reported to have increased the cost of protection for crops due to increased wild animals that damage the crops (URT, 2008, Pye-Smith, 2010; Omary, 2011; URT, 2011).

Introduction of Eucalyptus Clonal Hybrids and Propagation

According to 2012 National Population Census, approximately 75% of the country's population lives in the rural areas with 92% depending on wood fuel, which is mainly collected from natural forests, as their main source of energy. This collection is reported to have a major impact on natural regeneration. The deforestation rate is estimated at 372,871 ha per year while the total wood annual growth at the national level is estimated at 83.7 million m^3; and about 42.8 million m^3 per year is available for sustainable harvesting (MNRT, 2015). The demand for wood products, mainly for household energy, in Tanzania is estimated to be 62.3 million m^3 and loss due to land area conversions represents a deficit of about 19.5 million m^3 per year. This deficit can be met by several strategies including the use of fast growing tree species such as Eucalyptus hybrid clones (to meet the needs of fuelwood, timber and wood production on a sustainable basis) and an increase of biomass yield from farm forestry and plantations. According to Patil *et al.* (2012), the mean annual increment (Diameter at Breast Height - DBH) of eucalyptus hybrid at seven years was 2.52 cm while that of Eucalyptus local landraces was 1.78 cm. What is interesting is that, the benefits from Eucalyptus hybrid clones can be throughout the growing period depending on the management objectives **(Table 1).**

Table 1: Benefits of Eucalyptus hybrid clones under various management objectives

Management objectives	Harvesting age (Years)	Number of rotations
Building poles	2	5
Fuelwood	3 and above	4
Pulpwood	6	3 – 4
Transmission poles	6	2 - 3
Timber	12 – 15	2

Source: TAFORI (2017)

In Tanzania, Eucalyptus hybrid clones were introduced from Mondi South Africa in 2003 (TAFORI, 2017). Tanzania is among partner countries in East Africa that transfer and apply Tree Biotechnology for wood products (for home, industry) and construction (Kilimo Trust, 2011; Pima *et al.,* 2016). Through TAFORI, the transfer started by testing adaptability of the introduced hybrid clonal materials in the Tanzanian environment and this was followed by their large scale multiplication. The adoption of the clone based on the promising growth performances of the clone according to agro-ecological conditions. The introduced hybrid clones were *Eucalyptus grandis* x *E. camaldulensis* (GC), *E. grandis x E. urophylla* (GU) and *E. grandis x E. tereticornis* (GT) which has the combination of the desired traits for growth and drought tolerance, disease resistance and rooting ability (Pima *et al.,* 2016; TAFORI, 2017). The extensive trials showed that hybrid clones performed well in different agro-ecological zones of Tanzania, while others were site specific **(Table 2).** Due to their short rotation, wide adaptability, production of better wood quality and uniform stands, the species have the ability to meet various wood demands such as transmission and building poles, pulp, fuelwood and timber within the shortest period.

Table 2: Suggested Eucalyptus hybrids basing on agro-ecological growth performances

Ecological zones of Tanzania	Sites	Altitude (m.asl)	Rainfall (mm)	Eucalyptus hybrid
Lake Zone	Bukoba and Mwanza	1200 – 1600	800 – 1500	GC 15, 167, 514, 584, 785, 940 and GU 21.
Semi-arid	Dodoma and Shinyanga	200 – 1500 m	500 – 800	GC 15, 167, 522, 581 and 548,
Miombo		1000 – 1300	600 – 1200	GC 15, 584 and 940
Coastal	Kibaha and Lindi	Below 300	750 – 1200	GC 15, 167, 514, 584, 940 and GU 21
Lowlands	Korogwe and Mombo	Below 1000	800 – 1200	GC 15, 581, 584, 940 and GT 529
Highlands	Lushoto, Mafinga, Iringa, Tarime and Arusha	1000 – 2500	1000 - 2000	GC 15, 514, 522, 581, 584, 940, GU 125, 608 and GT 529

Source: Kilimo Trust (2011); Pima *et al.* (2016); TAFORI (2017).

In the mentioned ecological zones in **Table 2**, Eucalyptus clones can be planted on degraded areas which are exposed to soil erosion and with low soil fertility, water logged areas and saline soils. They can also be planted as shelter belts and wind breaks for large scale farms management. However, clones should not be planted in riparian areas (along rivers as stipulated in the Environment Management Act, No. 20 of 2004); areas around the lakes, ponds, swamps and any other bodies of standing water), irrigated farmlands and in areas with less than 400 mm of rainfall (TAFORI, 2017). These precautions are against the reported calamities of drying water sources caused by Eucalyptus. However, a strike of balances between the environment security and the demand for more wood resources should be observed (Kilimo Trust, 2011).

Eucalyptus hybrid clones have been multiplied at Kwamarukanga (Korogwe District) and Lushoto (Lushoto District) in Tanga Region, Kibaha (Pwani Region), Mufindi (in Iringa Region) and Kingolwira, Morogoro. For the growing season of between 2015 and 2017, about 920,072 of Eucalyptus hybrids were propagated by TAFORI and sold to various stakeholders. Depending on survivals in the field, these clones may have covered 575 ha at a spacing of 2.5 x 2.5 m contributing to the reduction of deforestation rate by 0.15%. For instance, Sao Hill Forest Plantation managed to plant about 300 ha of Eucalyptus hybrid clones between 2015 and 2016.

Artificial Propagation of Indigenous (Medicinal, Fruit and Timber Trees)

The on-going deforestation and forest degradation have been decreasing the availability of medicinal trees for curing various human and livestock (Dery *et al.,* 1999). Following this deficit, under the partnership with Hifadhi Ardhi Shinyanga (HASHI) or the World Agroforestry Centre (ICRAF), the study was initiated in order to identify tree species used for traditional medicine and later an ethno botanical survey was carried out to identify their availability. The study involved traditional healers, agro-pastoralists, farmers, and forestry experts. The study aimed at incorporating indigenous medicinal trees into farmlands using agroforestry systems. From the study, about 300 trees species were found to be used in traditional medicine for curing 100 human diseases. Eleven priority medicinal trees were selected and collected from areas where they are still available, especially from Miombo woodlands for propagation and silviculture studies. The priority traditional medicinal trees used included *Securidaca longipenduculata, Cassia abbreviate, Entada abyssinica, Turrea fischeri, Albizia anthelmintica, Entadaphragma bussei, Combretum zeyheri, Zanthoxylum chalybeum, Terminalia sericea, Kigelia africana* and *Harrisonia abyssinica*. After germination study, part of medicinal tree seedlings were established on-station at the Natural Forests Management

and Agroforestry Centre (NAFRAC) formerly known as HASHI/ICRAF in Shinyanga Region; others were established at Igwata Forest Reserve (IFR) at Malya in Kwimba District, Mwanza Region, and the rest were provided to farmers in Shinyanga Urban. Except for *S. longipenduculata,* the growth performances of the rest have been encouraging and recommended to be planted by farmers through agroforestry practice.

Furthermore, under the partnership with ICRAF Tabora, a similar survey was conducted whereby 79 Indigenous Fruit Tree species (IFTs) in the Miombo woodlands and 131 across the country were identified. As the initial step for domestication and commercialization purposes, priority IFTs species were tested for provenance screening, propagation, suitability, marketing, and value addition (Maduka *et al.,* 2013). Priority species used were *Parinari curatellifolia, Strychnos cocculoides, Uapaka kirkiana, Vitex mombassae, Vitex doniana, Tamarindus indica* and *Vanguelia infausta* established in Tabora while *Vitex mombassae, Vitex doniana, Tamarindus indica* and *Vanguelia infausta* at Lubaga in Shinyanga. The growth performances of these IFTs have been encouraging and have been recommended to be established by farmers through agroforestry practice.

On other hand, the indigenous timber tree species from natural forests have been depleted and need to be artificially propagated due to their poor natural regeneration under natural conditions. The tree species that have been prioritized for artificial propagation included *Afzelia quanzensis*, *Pterocarpus angolensis*, *Milicia excelsa*, *Olea welwitschii* (**Plate 1**). Propagation protocols through stem cuttings have been developed for *O. welwitschii* (Maduka, 2016; Maduka *et al*., 2017). However, similar studies are required for other tree species.

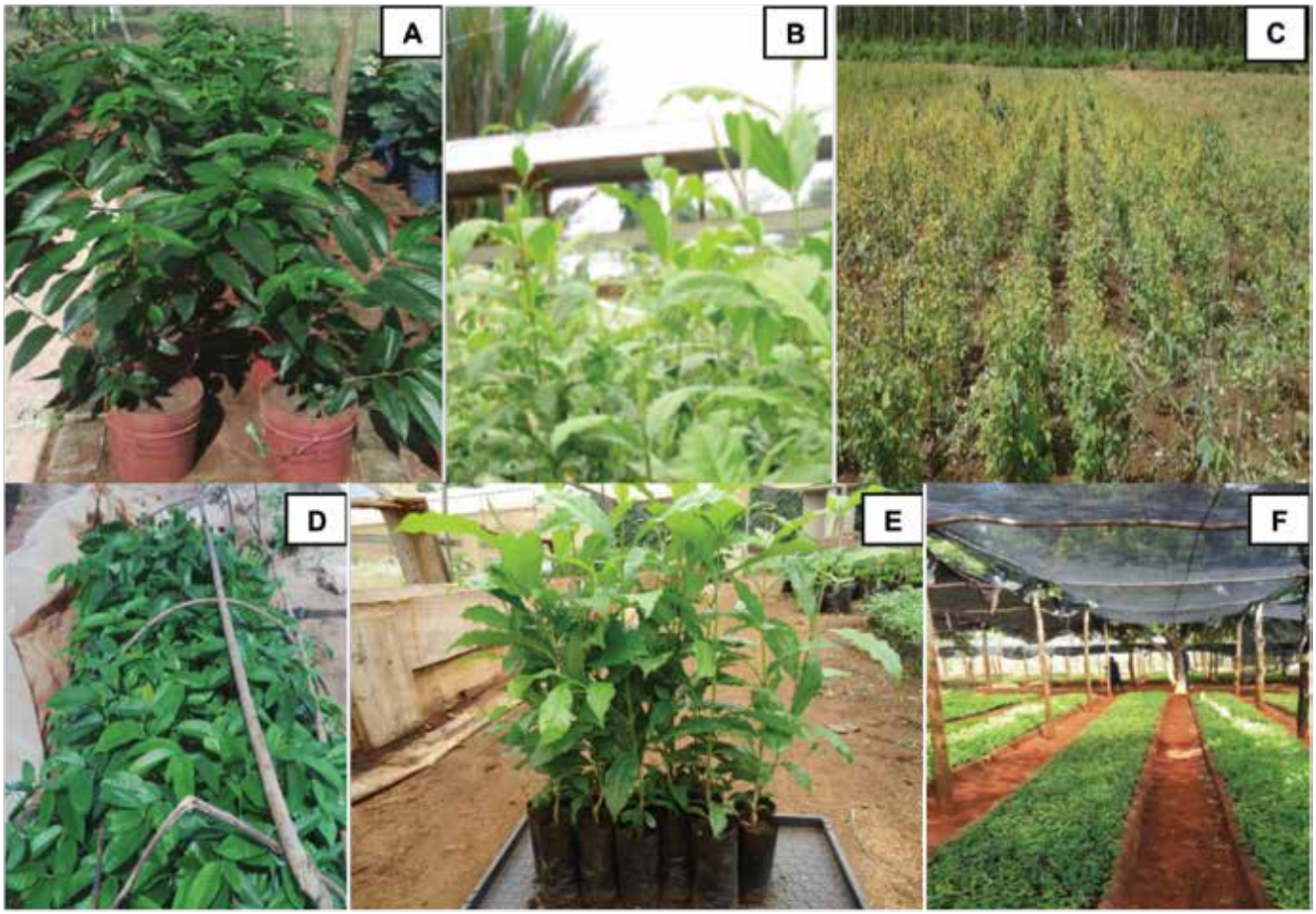

Plate 1: A, B, and C mother blocks for *M. excelsa, O. welwitschii* and Eucalyptus clone hybrids and D, E and F cuttings regenerated artificially through stem cuttings from mother blocks, respectively.

Tissue Culture Technology Application

Forestry development is still facing different challenges namely; propagation, rareness, seed dormancies and poor quality of planting materials. The priority indigenous tree species are threatened and are under both loss of genetic diversity and habitat destruction. Furthermore, the on-going deforestation due to socio-economic activities has resulted to poor natural regeneration that complicates the selection of plus trees of high value timber tree species. In this case, the use of micro-propagation or tissue culture is inevitable. In solving these challenges, TAFORI has developed propagation protocols using tissue culture technologies, namely the *in vitro* multiplication protocols for *O. welwitschii* and *Tectona grandis*. However, to improve the working condition, TAFORI is currently strengthening her laboratory by adding more infrastructure and facilities. The tree species regenerated may be useful for timber production, medicinal, resins and gums, and cosmetics.

The use of tissue culture in plant propagation is popular nowadays yet it is at an infancy stage for Tanzania forests development. Tissue culture or *in vitro* propagation is a technique which is used for mass production of plantlets or seedlings from plant tissues, cells, and somatic embryos in aseptic and artificial environment (Iliev *et al*., 2010; Hartmann *et al.*, 2011). It is an important process especially where conventional seedling production rate is low. Unlike seeds, plant vegetative parts such as shoots from managed mother plants may be available all year round for collection of explants for *in-vitro* micro-propagation. The *in-vitro* has been used in massive propagation of specific species or clones of specific desirable characteristics and high economic importance, in the production of pathogen free plants, in germplasm preservation especially of endangered species and in plants that have been improved (Kane, 2000; Hussain *et al*., 2012).

Establishment of Tree Seed Orchards and Gene Conservation

The achievement of afforestation programmes, among others, also depends on sustainable supply of planting materials. TAFORI has been involved in the establishment of seed orchards and gene conservation both for priority indigenous and exotic tree species. According to FAO (1993), seed orchard is a plantation or a stand of selected clones or families which is isolated or managed to avoid or reduce pollination from outside sources, and is managed to produce frequent, abundant and easily harvested crops of seed. On the other hand, gene conservation is the collection of plant genetic resources, with the overall aim of long-term conservation and accessibility of plant germplasm to plant breeders, researchers, and other users.

TAFORI in collaboration with Tanzania Forest Services Agency (TFS) and Tanzania Tree Seed Agency (TTSA) have identified plus tree for *T. grandis* (Teak) from superior stands from Mtibwa, Longuza and Kihuhwi plantations for seed collection and establishment of seed orchard at Mtibwa Forest Plantation. Planting materials were collected from 100 plus trees (families) for the establishment of clonal seed and seed seedlings orchards. Furthermore, the Institute participated in the identification of plus trees for indigenous trees species namely, *Afzelia quanzensis, Milicia excelsa* and *Khaya anthotheca* for seed collection and seed orchards establishment at Mtibwa Forest Plantation. These orchards will save as the gene conservation stands as well as reliable seed sources improvement and production of planting materials for the establishment of plantations and woodlots.

At the same time, TAFORI - Moshi Timber Utilization Research Centre at Kilimanjaro has managed to establish seed orchards for *Pinus radiata* and *P. patula* from Zimbabwe, *Eucalyptus cloeziana, Grevillea robusta* and *P. patula* from Muguga Kenya. Likewise, Malya Afforestation Research Centre in the Lake Zone has managed to establish *ex-situ* gene conservation stands of lesser known fast growing tree species for *Melia azedarach* and *Gmelina arborea*. The tree species have the ability of growing fast in semi-arid areas of the Lake Zone and meet the demands for timber while the gene conservation stands will save as reliable seed sources and will also be used for further improvement works. At Mufindi Centre,

the Institute has established seed orchards for *E. grandis* and *P. patula* with the support from TaFF, seed orchard for *E. pellita* and *E. urophylla* and gene conservation stand for *P. maximinoi* under partnership of Central American and Mexico Coniferous Research (CAMCORE). Similarly, Lushoto Silviculture Research Centre in Tanga has established clonal seed orchards of *P. patula, Cupressus lusitanica*, *ex-situ* gene conservation of *E. tereticornis*, seed stands of *G. robusta, E. saligna, E. grandis* and *C. lusitanica,* seedlings seed orchard of *P. patula* and seed orchard of *T. grandis* under CAMCORE partnership.

Dissemination of Improved Kilns for Efficient Charcoal Production

TAFORI has initiated the programme of disseminating improved charcoal production technology to charcoal producers. The introduced technologies were Casamance Earth Mound Kiln (CEMK) and Basic Earth Mound Kiln (BEMK). The technologies have a relatively higher recovery rate when compared to conventional methods. Further, TAFORI has conducted demonstrations to farmers at Kileo Forest Reserve Mwanga District in which five earth kiln designs were tested, and at Kahe village in Moshi Rural District where two earth kiln designs were tested **(Table 3).** Similarly, demonstrations were conducted at Kihangaiko villages in Bagamoyo District, Pwani Region and at Gwata and Lubungo villages in Morogoro Region **(Table 4).**

Table 3: Recovery rate for CEMK and BEMK at Kahe, Moshi Rural District, Kilimanjaro Region

Kiln type	Wood/logs weight (Kg)	Volume of logs (m^3)	Average stalk density (Kg/m^3)	Weight of charcoal (Kg)	Number of bags (Kg)	Recovery rate (%)	Duration of burn (days)
CEMK	2,457.8	4.4137	454	578.8	20	23.55	6
BEMK	2,420.7	4.4509	454	428.05	15	21.18	6

Table 4: Charcoal production using CEMK and TEMK in Bagamoyo and Morogoro sites

Attribute	Kihangaiko Village site		Kwang'andu Village site		Gwata Village site		Lubungo Village site	
	CEMK	TEMK	CEMK	TEMK	CEMK	TEMK	CEMK	TEMK
Amount of wood (m^3)	4.5	4.5	9.0	9.0	1.8	1.8	2	2
Days to complete charcoaling process	8	10	12	14	5	7	4	4
Debris and ashes (kg)	15	25	25	35	23	29	6	13
Quantity of charcoal produced (28 kg bag)	33	20	132	80	15	8	13	5
Tree species used	*Acacia nigrescens* (Mkambala) and *Xeroderris stuhlmanii* (Mnyinga)		(*Acacia xanthophloea*) Mkongowe		*Acacia nigrescens* (Mkambala)		*Acacia senegalis* (Mkongowe)	

From the above demonstrations **(Tables 3 and 4),** the Casamance Earth Mound Kiln (CEMK) has proved to be the most efficient among the three designs. This kiln is recommended to be disseminated to more charcoal-makers, technicians, Council natural resource officers and other stakeholders in order to reduce the number of trees which are used by the Tradition Earth Mound Kiln (TEMK) and contribute to the reduction of deforestation and forest degradation in Tanzania.

Enhancing Dissemination of Research Findings to Stakeholders

TAFORI has been making sure that research findings and technologies are disseminated to different stakeholders through development of outreach materials. The aim is to ensure that sufficient knowledge and technologies are available to solve deforestation and forest degradation in Tanzania. Several scientific articles have been published in newsletters, national and international journals, proceedings, books and chapters in books. Dissemination materials such as fliers, posters and booklets have been translated in user-friendly languages and distributed to stakeholders. Different directives in technical orders, guidelines and manuals have been developed as well.

CONCLUSION AND RECOMMENDATIONS

Tanzania Forestry Research Institute for many years accrued significant knowledge and experiences in tackling deforestation and forest degradation in Tanzania. The achieved experiences contributed a lot to reducing deforestation and forest degradation in the country. The available information is useful to researchers, academicians, decision makers, and the general public at large. To make sure that the efforts made are not lost, and more is done, partnerships and collaboration with other stakeholders need to be strengthened. More infrastructures, capital and human resources are required to catalyze further execution of more researches and the delivery of findings and innovations throughout the country.

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