



KENYA FORESTRY RESEARCH INSTITUTE



Annual Report and Record of Research

2017 - 2018

KEFRI is ISO 9001:2015 QMS certified



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BOARD OF DIRECTORS



Mr. Robinson Ngethe
Rep. Chairman KEFRI Board



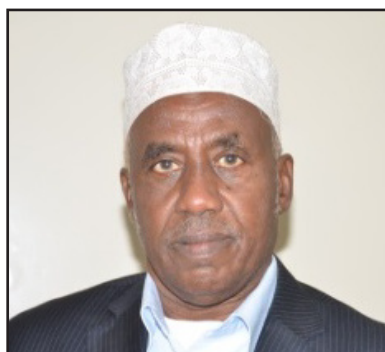
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Acronyms

ASALs	Arid and Semi-Arid Lands
BVQ	Bureau Veritus Consultant
CADEP (SFM)	Capacity Development Project for Sustainable Forest Management in Kenya
CAJ	Commission of Administration Justice
CPTs	Candidate Plus Trees
CBOs	Community Based Organizations
CERP	Coast Eco-region Research Programme
CHERP	Central Highlands Eco-region Research Programme
CIAA	Codex General Standard for the Labeling of Food Additives
EMS	Environment Management Systems
DERP	Drylands Eco-region Research Programme
DBH	Diameter at breast height
DGL	Diameter at ground level
FY	Fiscal Year
GCA	General Combining Ability
IMS	Integrated Management Systems
ISTA	International Seed Testing Association
ISO	International Organization for Standardization
ISSN	International Standard Serial Number
JICA	Japan International Cooperation Agency
KALRO	Kenya Agriculture and Livestock Research Organization
KEBS	Kenya Bureau of Standards
KFS	Kenya Forest Service
LVBERP	Lake Victoria Basin Eco-region Research Programme
MoU	Memorandum of Understanding
NACOSTI	National Council of Science Technology and Innovations
NARC	National Agriculture Research Centre
NFP	National Forestry Programme
NRF	National Research Fund
NGOs	Non- governmental Organizations
NWFPs	Non - Wood Forest Products
OSHA	Occupational Health and Safety Act
QMS	Quality Management Systems
SGS	Standard Global Services
RVERP	Rift Valley Eco-region Research Programme
NaHCO₃	Sodium bicarbonate
MTP	Medium Term Plan
UoN	University of Nairobi

SERVICE DELIVERY CHARTER

No	Service/Good	Requirement	Cost	Time line
1	Develop forest technologies	Research based stakeholder needs	Depends on the technology	Depends on reporting period
2	Disseminate forest technologies	Communication to stakeholders	Depends on format or channel of communication	Continuous on daily basis
3	Supply of high quality tree seed	By order	As per Tree Seed Catalogue	<ul style="list-style-type: none"> On order Depends on seasonal availability
4	Supply of high quality tree seeds	By order	As per Tree Seedlings Catalogue	Depends on seasonal availability
5	Training in forestry	On request	Nature of training	Quarterly
6	Wood, plant and soil analysis	On request	As per Analytical Catalogue	After contractual agreement
7	Provision of timber and non—timber products	By order	As per Catalogue	Immediate (Depends on number of items)
8	Advice on landscaping, tree establishment and management	On request	Depends on nature and duration of course	Immediate
9	Provision of training and conference facilities	On request	Depends on nature and duration of course	Response within 4 working days
10	Attachment of students	Application plus cover letter from the Institutions	Personal insurance cover	Response within 4 working days
11	Picnic sites for recreation and video	On request	As per catalogue	Immediate (After booking)
12	Consultancy in forestry	Call for consultancy	Depends on the nature of consultancy	Immediate (After contractual committee)
13	Resolution	Launch of specific complaint	After verification	One week

We value and welcome feedback and comments to enable us serve you better.
Complaints, compliments and suggestions should be sent to:

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Remarks by the Representative KEFRI Board of Directors



In 2017/2018, KEFRI continued to play its significant role in research and development of technologies, as well as sharing information for sustainable management, conservation and development of forests, which is key contribution to national and international agendas.

KEFRI Board of Directors through its constituted committees deliberated on requisite policy matters and carried out its leadership role to direct, control and ensure strategic objectives were attained and performance monitored in respect to performance contracting of Institute's targets for the year under review.

I am delighted to report the Institute's performance and share achievements realised during the Financial Year 2017/2018.

The Board ensured the Institute mandate was realized through implementation of the 5th Strategic Plan (2013-2018) and relevant development policies as ascribed in the National Forestry Programme (NFP), Third Medium Term Plan (MTP III) of Vision 2030, the Science, Technology and Innovation Act 2013, and Kenya Constitution 2010.

Consequently, the Institute contributed to the increase in national tree cover to 7.2 percent through: establishing 24 ha of seed stands; producing quality seeds from various commercial tree species across the eco-regions; raising planting materials for tree species that are difficult to propagate; dissemination of forestry technologies through organized forums; setting up demonstration model for forest technologies and resilience to climate change, as well as development of 6th Strategic Plan (2018 – 2022) which focus on enhanced performance and impacts for improved livelihood and environment resilience.

KEFRI also continued with building capacity of both staff and partners as well as decentralization of services to the Counties by constructing research facilities at Ngelenyi in Taita-Taveta County, as well as maintenance of research facilities and infrastructure in all regional centres countrywide.

The Board, in respect to Mwongozo Code of Governance, engrained corporate governance as pivotal institutional framework to promote efficiency in engagements between the board, management and regulators, donor, partners, and to ensure accountability in the management of public resources.

I take this opportunity to thank the Government of Kenya, through the Ministry of Environment and Forestry, development partners and my colleagues in the Board for the immense commitment and support during the year ending June 2018.

On behalf of the Board of Directors and myself, I commend KEFRI management, entire staff and other stakeholders for the support which has enabled successful achievement of the targets set for the fiscal year 2017/2018.

Mr. Robinson Ng'ethe
For: KEFRI Board of Directors

Foreword by the Director KEFRI



During the Fiscal Year 2017-2018, KEFRI implemented the activities derived from the 5th Strategic Plan 2013-2018 and approved by the Board of Directors. The priority activities, aligned to the National Forest Programme, were carried out within thematic areas namely: Forest Productivity and Improvement; Forest Biodiversity and Environment Management; Forest Products Development; Forest Economics, Policy and Governance; Technical Support Services; and Corporate Affairs & Quality Assurance.

Notable flagship project achievements realized during the reporting period include; development of forestry technologies geared towards enhancing tree productivity, efficient use of forestry resources as well as supporting forestry based climate change adaptation and mitigation initiatives. Collection of approximately 12 tonnes and distribution of 4.5 tonnes of various tree seed from 82

different species was achieved, establishment of 24 ha of seed stands and 21.4 ha of seed orchards. Tree seedlings for the drylands and for higher rainfall areas totaling 4, 417 of difficult to propagate species and superior genetic materials, and 200,000 of assorted tree species were raised in nurseries across the eco-regions and sub-centres.

Other achievements included; development and perfection of propagation protocol for Sandalwood (*Osyris lanceolata*), *Melia volkensii*, indigenous bamboo; screening of commercial plantation tree provenance for seed production; and establishment of progeny trials for tree species - *Grevillea robusta*, *Milicia excelsa*, *Moringa oleifera*, *Tectona grandis*, and *Terminalia spinosa*; silvicultural management for Eucalypts, *Melia volkensii*, *Gmelina arborea*, *Terminalia brownii* among other selected tree species; and assessment of the performance of a natural forest rehabilitation; market chain analysis, value addition to products and linkage to market.

Donor funded projects activities for European Union-WaTER Tower Project, KEFRI JICA-Capacity Development Project for Sustainable Forest Management in Kenya (CADEP-SFM), National Research Fund (NRF) and Climate Adaptation Change Fund boosted the Institute's finances and research activities were accomplished accordingly.

The Institute shared research findings and relevant information through the 5th KEFRI Scientific Conference, 31 diverse publications, and 26 Outreach fora carried out as exhibition, in-house trainings, mass media, internet and social media, collaboration with various partners and institutions in building capacity for; scientists, students from universities and tertiary colleges.

Despite challenges of budget cuts, inadequate policies, and limited land for research and development, the institute implemented the ISO standards and staff capacity development to enhance skills for service delivery, devolved services to the counties by constructing green houses at Eco-region centers and four refurbished green houses at the headquarters.

On behalf of KEFRI management and myself, I thank the Board of Directors for its leadership, the Ministry of Environment and Forestry, national as well as the county governments, development partners and all other stakeholders for their cooperation and support during the year under review. I also extend our gratitude to staff, our clients and service providers for their continued support and loyalty, which made KEFRI achieve the objectives for the fiscal year ending June 2018.

Jane W. Njuguna (PhD)
Director-KEFRI

Background

Kenya Forestry Research Institute (KEFRI) is a State Corporation established in 1986 under the Science and Technology Act (Cap 250) which has since been repealed by the Science, Technology and Innovation Act No. 28 of 2013 to undertake research in forestry and allied natural resources and generate and promote improved technologies for sustainable development.

Vision

A centre of excellence in forestry research for development

Mission

To conduct research and provide information and technologies for sustainable development of forests and allied natural resources for socio-economic development

Mandate

- Conduct research in forestry and allied natural resources
- Disseminate research findings
- Establish partnerships and cooperate with other research organization and institutions of higher learning in joint research and training

Core Values

- Professionalism
- Creativity and Innovation
- Team work
- Integrity
- Partnership
- Clean and healthy environment

1.0 Tree Seed Development and Production

Forestry plays a key role in the socio-economic development of Kenya. It contributes about 3% to the country's GDP and 10% of the non-monetary economy. Further, it is estimated that the formal forest sector employs about 50,000 people directly and about 600,000 indirectly, making it an important source of employment particularly in the rural areas. Forests and trees supply over 90% of the rural and peri-urban energy needs and provision of ecosystem services that include protection of water catchment areas, soil protection and carbon sequestration, and are home to many organisms.

One of the key areas for forestry research and development is provision of high quality germplasm, which plays a major role in forestry development to meet the demand for forest products and services. Development, production and conservation of tree germplasm are continuous and involve establishment of seed stands and seed orchards of highly demanded tree species. The activities are implemented within five eco-regional programmes i.e. CERP, DERP, CHERP, RVERP and LVBERP. The activity aims to meet the Government target of achieving at least 10% tree and forest cover as well as requirements of numerous tree planting programmes within the country and beyond.

1.1 Establishment of tree seed sources

KEFRI is mandated to produce high quality tree seed. To achieve adequate production of high quality seed, KEFRI continued to establish tree seed sources i.e. seed orchards and seed stands.

1.1.1 Establishment of seed orchards

During the year 2017-18, KEFRI established nine seed orchards comprising different tree species including *Cupressus lusitanica*, *Eucalyptus grandis*, *Gmelina arborea*, *Grevillea robusta*, *Moringa stenopetala* *Pinus patula*, in the various eco-regions as shown in Table 1.

Table 1: Seed orchards established by KEFRI in different Centres / sites in 2017 - 18

Species	Eco-Region	Centre / Eco-region	Hectares (ha)
<i>Gmelina arborea</i>	CERP	Gede	1.0
<i>Grevillea robusta</i>		Taita	2.0
<i>Cupressus lusitanica</i>	CHERP	Muguga	2.0
<i>Grevillea robusta</i>		Muguga	1.0
<i>Pinus patula</i>	RVERP	Masaita 2T	3.0
<i>Cupressus lusitanica</i>		Masaita 2R	3.0
<i>Eucalyptus grandis</i>		Turbo - Nzoia forest station	4.4
<i>Moringa stenopetala</i>		Mogotio, Baringo County	2.0
<i>Various species</i>	LVERP		3.0
Total			21.4 ha

1.1.2. Establishment of seed stands

During the year under review, 2017 – 18, the Institute established 24 ha of seed stands of various species including *Eucalyptus camaldulensis*, *Eucalyptus citriodora*, *Eucalyptus maculata*, *Eucalyptus urophylla*, *Gmelina arborea*, *Grevillea robusta*, *Melia volkensii*, *Milicia excelsa*, *Moringa oleifera*, *Tectona grandis*, *Terminalia spinosa* in the different eco-regions as shown in Table 2.

Table 2: Tree seed stands established by KEFRI in different Eco-regions in 2017 - 2018

Species	Eco-region	Location	Hectares (ha)
<i>Gmelina arborea</i>	CERP	Malindi Prisons	2.0
<i>Melia volkensii</i>		Gede and Lamu	2.0
<i>Terminalia spinosa</i>		Gede	2.0
<i>Milicia excelsa</i>		Gede and Lamu	3.0
<i>Tectona grandis</i>		Gede	3.0
<i>Eucalyptus urophylla</i>	CHERP	Muguga	1.0
<i>Eucalyptus camaldulensis</i>	DERP	Nyanya Secondary School, Kisayani	1.0
<i>Gmelina arborea</i>		Utoo Primary & Secondary School	1.0
<i>Moringa oleifera</i>		UoN	1.0
<i>Eucalyptus maculata</i>	RVERP	Buru site - Muhoroni Sugar Co. Estate	1.0
<i>Eucalyptus citriodora</i>		Buru site - Muhoroni Sugar Company	1.0
<i>Grevillea robusta</i>		Bangalow A site - Muhoroni Sugar Co. Estate	3.0
<i>Various species</i>	LVERP		3.0
Total			24.0

1.2 Seed collection, processing and distribution

One of the key areas for research and development is provision of high quality tree seed, which plays a major role in forestry development to meet the demand for forest products and services. KEFRI through the Kenya Forestry Seed Centre is the principle supplier of high quality tree seed both nationally and within the region. It has a capacity to supply adequate quantities of tree seeds to raise 200 - 400 million seedlings annually.

KEFRI through the Kenya Forestry Seed Centre collects tree seed from selected and established seed sources and seed orchards. The seed activities are undertaken through 9 field stations covering all the ecological regions of Kenya. These activities are undertaken at; Muguga, Nyeri, Kibwezi, Gede, Kitui, Londiani, Turbo, Maseno, and Kakamega. All the seed that was collected was processed and subjected to quality tests before any distribution to clients. The seed testing was done following International Seed Testing Association (ISTA) rules that require determination of; moisture content, purity, germination and seed weight (number of seed per kg) for every seedlot. Seed testing was done for fresh seed as well as retrials for seed that had been in storage for more than 6 months.

In the Fiscal Year 2017 - 18, KEFRI collected 12,104.5 kg of seed from a range of 82 species (Table 3). The Institute distributed seed of various tree species to stakeholders including; Kenya Forest Service, schools, individual farmers, Non Governmental Organizations (NGOs) and private companies.

Table 3: Summary of tree seed production and distribution in 2017-2018

Station	Amount collected (kg)	Number of species	Remarks
Muguga	1071.5	17	KFSC Muguga also receives seeds collected from other centres for processing, testing and storage or distribution
Nyeri	1712.6	17	All seed delivered to KFSC Muguga
Kibwezi	1259.4	12	-do-
Gede	908.7	11	-do-
Londiani	2295.2	6	
Kitui	706.4	12	-do-
Turbo	832.3	16	-do-
Maseno	862.8	7	The station also receives seeds for sale from KFSC, Muguga
Kakamega	1548.7	21	All seed delivered to Muguga
Suppliers	907.08	3	
Total	12,104.5		



Figure 1: Preserved seeds of various tree species and seed packed for dispatch to clients

2.0 Production of Planting Materials

KEFRI supports afforestation and conservation of tree genetic resources through production of planting materials for various categories of tree species. In the year 2017 - 18, the Institute continued to raise seedlings for: species that are difficult to propagate (Table 4); superior genetic quality some of which KEFRI uses in raising high quality seed sources (Table 5); and assorted tree species to meet demand by various stakeholders.

Table 4: Seedlings raised in one year - 18 for species that are difficult to propagate

Species	Site	Number of seedlings produced
<i>Terminalia spinosa</i>	CERP	3148
<i>Gmelina arborea</i> grafts		1500
<i>Melia volkensii</i>		873
<i>Bamboo</i>		6158
<i>Osyris lanceolata</i>	DERP	3434
<i>B. vulgaris</i> (giant bamboo) and <i>Oxtenanthera abyssinica</i> (solid bamboo)		6,000
<i>Melia volkensii</i>		Kitui - 12,588 Kibwezi - 1,250
<i>Ocotea usambarensis</i>		
<i>Osyris lanceolata</i>	CHERP	206
<i>Bambusa vulgaris</i> (green bamboo)	RVERP	
<i>Bambusa vulgaris</i> var. <i>striata</i> (yellow bamboo) and <i>Dendrocalamus asper</i> (Giant bamboo)		Londiani - 2684 Marigat - 2400 Turbo - 1400

Table 5: Planting material raised in year 2017 - 18 for superior genetic quality some of which KEFRI uses in raising high quality seed sources

Species	Site	Number
<i>Gmelina arborea</i> grafts	Gede	1500
<i>Pinus patula</i> grafts	Londiani	750
<i>Cupressus lusitanica</i> grafts		1,250
<i>Grevillea robusta</i> grafts	Muguga	1,185
<i>Cupressus lusitanica</i> grafts	CHERP	1,750
<i>Ocotea usambarensis</i>	Muguga	206

In addition, KEFRI raised more than 200,000 seedlings of various species in its nurseries across all its centres. These seedlings were planned for establishing plantation within the Institute, sales and free issues to the public and relevant institutions. Seedlings of species raised in the nurseries for the high rainfall areas during the year included: *Bambusa vulgaris*, *Croton megalocarpas*, *Dovyalis caffra*, *Eucalyptus grandis*, *Grevillea robusta*, *Kigelia africana*, *Maerua decumbens*, *Octotea usambarensis*, and *Senna spectabilis*.

The tree species of seedlings raised for the drylands included: *Acacia mellifera*, *Acacia senegal*, *Acacia tortilis*, *Aloe spp*, *Azadirachta indica*, *Carica papaya*, *Dalbergia melanoxylon*, *Delonix regia*, *Mangifera indica*, *Melia volkensii*, *Moringa oleifera*, *Senna siamea*, *Sclerocarya birrea*, *Syzygium cuminii*, *Tamarindus indica*, *Terminalia mentalis*, and *Vitex payos*.



Figure 2. Assorted tree seedlings being raised at the nursery and in greenhouse at Kitui

3.0 Development of Forestry Technologies

KEFRI plays an instrumental role in generating technologies for forestry development to improve forest productivity, increase forest cover, rehabilitation of degraded forests and woodlands, supply for domestic and industrial use, and development of forest products for improved livelihoods. In 2017 - 2018, the institute developed technologies for: propagation of difficult to propagate tree species; breeding tree species for improved yields; and silvicultural management of tree species. KEFRI also developed wood and non-wood forest products.

3.1 Propagation of Difficult to Propagate Tree Species

3.1.1 Propagation of *Osyris lanceolata* (East African Sandalwood)

Osyris lanceolata is a shrub or a small tree growing to a height of six meters. It grows at an altitude of between 800-2550 m above the sea level. It is important for cosmetics, red dye, smoking milk containers, and use of bark powder to heal wounds, treating stomachache, tonsils, diarrhea, ulcers, snakebites and rashes.

KEFRI in the recent past has undertaken research work associated with *Osyris lanceolata*. Several sources have been identified for seeds collection. A seed collection, handling and germination protocol has been developed. Further, seedlings propagation methods namely Marcoting (air-layering) has been developed as an alternative to seed propagation methods. Moreover, nursery experiments have been undertaken to ease seedling production. KEFRI has raised *Osyris* seedlings by developing protocols to ease the shortage of planting materials. DERP Kitui raised a total of 3,434 seedlings which were hosted by *Desmodium* species, *Tithonia* and lemon ball. The majority of the seedlings were not hosted.

3.1.2 *Osyris lanceolata* Demonstration Plots at Wii and Muguga

A demonstration plot for *Osyris lanceolata* was planted in November 2017 at Wii in Kitui County. A total of 84 seedlings hosted by *Croton megalocarpus*, *Acacia kirkii*, and *Calliandra calothyrsus* were planted at the site.

KEFRI has also established a trial plot in form of a demonstration plot at Malale within KEFRI Muguga estate, near KALRO NARC-Muguga main gate, as the first step of developing silvicultural practices for the species. The first planting in the demonstration plot was done in May 2011 and has been under-going expansion to the current size of about 0.3 ha. The seedling were raised from seeds and marcots and hosted by various species such as *Acacia senegal*, *Calliandra calothyrsus*, *Carissa spinarum*, *Rhus natalensis* and *Casuarina species*.

The plantlets raised through marcots have started seeding and the demonstration plot is being used as a seed source. Based on the seedlings planted in 2017, a monitoring protocol for the seedlings has been developed to monitor effect of host plants on growth rate of Sandalwood. It is also proposed that silvicultural treatments be imposed on Sandalwood saplings planted earlier to investigate the impact this will have on productivity of the trees.



Figure 3: Two year old Sandalwood plantation at Muguga and *Osyris* ripe fruits



Figure 3.1: Rooting branch raised through marcot (air layering) , seedlings hosted on *Calliandra* plant (centre) and mature Sandalwood tree growing in the wild

3.1.3 Propagation of *Euphorbia tanaensis* an endangered species at coastal Kenya

The Coastal region of Kenya supports a large number of endemic species, which are mainly found in the forests, dry bushlands and grasslands. With increase in demand of wood and non-wood products, some of the important trees have been overharvested which has severely reduced their population. *Euphorbia tanaensis* is one of the species that has been threatened by extinction. *Euphorbia tanaensis* is a medium-sized succulent tree of genus *Euphorbia*. The tree can grow to height of 30 meters with a single trunk attaining a diameter about 50 cm.

In order to effectively stop plant population losses and to conserve *Euphorbia tanaensis* species, KEFRI set out to develop propagation technologies with an objective of providing planting materials for re-introduction into the original habitats. Branches from selected *Euphorbia* trees were harvested to provide cuttings. The branches were carefully cut into several pieces, treated with root inducing hormone and planted directly in containers potted with soil. The propagated seedlings were out planted within the ecosystem in which the species was found to ensure conservation. Growth and survival of the trees planted as well as conservation status of the species will be undertaken.



Figure 3.1.2: *Euphorbia tanaensis* tree in the wild, collection of *Euphorbia* branches for propagation in the nursery, and *Euphorbia* plantlets ready for planting in the field

3.1.4. Development of vegetative propagation protocols for production of *Ocotea usambarensis*

Ocotea usambarensis, commonly known as East Africa Camphorwood, belongs to the family lauraceae. In Kenya the species occurs in the wet montane forests and grows naturally between 1375 and 2600 m above the sea level. The tree can attain a diameter at breast height (dbh) of 2 m and maximum height of 45 m with a clear bole of 9-15 m. This species is classified as threatened due to high exploitation pressure and difficulties in natural regeneration. It seeds once in eight to ten years but majority of seeds are dropped pre-maturely due to attack by gall-insects and birds. The seeds of *O. usambarensis* remain viable for few days even under most favourable conditions.

In order, to save this species from extinction other means of propagation need to be developed. Vegetative propagation through rooted stem cuttings is the most viable alternative. Experimentation on how best to root the *Ocotea* stem cuttings have been initiated but availability of suitable vegetative propagules has been an impediment. The objective of the current work is to establish extra sources of juvenile stem cuttings for research and production and to test the effect of different soil types (pH) on rooting of juvenile stem cuttings.

Cuttings were established at Muguga research nursery using soil collected from forest and tea plantation at Kangaita. Soil of different pH levels was collected from 0-30cm depth (top soil) acidic in nature while 30-60 cm depth (sub-soil) was alkaline. Cuttings were obtained from young seedlings of at least one year old. The seedlings were cut into 15 cm lengths with nodes and sterilized in sodium hypochlorite before inserting into the soil. The experiment was incubated in a non-mist propagator.

Assessment for rooting was done on 84th and 114th day. Parameters recorded were: number of cuttings with callus; number of cuttings with roots; number of roots; and length of the longest root (cm) per rooted cutting. For the purpose of raising source of cutting material, seeds were collected from the hedge established at Muguga and seedlings raised. By the 84th day, at least 74% of the cuttings were shooting. Survival was 81%. Higher callusing and some rooting were observed in cuttings under pH 6.1 and 6.3 an indication of success under these pH levels.



Figure 3.1.3: Seedlings of *Ocotea usambarensis* for cutting hedge establishment. Cuttings incubated in a non-mist propagator



Figure 3.1.4: Monitoring the development of cuttings, (centre) formation of callus, and (right) rooted cuttings

3.2 Technologies for Breeding Tree Species for Improved Yields

3.2.1. Grafting of Improved Material of *Cupressus lusitanica* and *Pinus patula* for Seed Orchard Establishment

Cupressus lusitanica (Cypress) and *Pinus patula* (Pine) are the main industrial plantation species in high potential areas of Kenya. The demand for seed and quality seedlings is high due to increased national effort in reforestation. However, there is inadequate supply of seeds of these species due to insufficient seed sources in terms of seed stands and seed orchards from which high quality seeds can be obtained. Raising Cypress and Pine plantations using seeds collected from certified sources increases growth and productivity of industrial plantations. The planting material for establishing seed orchards are raised through a difficult process that involves cloning of the selected mother trees so that their superiority is transferred to the next generation of trees. KEFRI embarked on raising improved planting material of Cypress and Pine through grafting which will be used for establishing seed orchards of the two species.

The process of raising Cypress and Pine propagules for seed orchards development involves collection of scions from selected superior trees for subsequent grafting. From the previously selected superior plus trees 40 scions were collected from each tree and grafted onto 8 month old seedlings (root stocks) of the same species in the nursery. The grafted plants were maintained under shade in a non-mist propagator by regular opening for watering, weed removal and general inspection after every 2 weeks. After 3 months in the non-mist propagator, the graft union on most of the seedlings had healed and seedlings continued to be nursed in the nursery. Once materials are ready for out planting they will be used to establish seed orchards.



Figure 3.2: Grafted seedlings of *Cupressus* and *Pine* hardening up

3.2.2. Establishment of Progeny Trials of *Cupressus lusitanica* and *Pinus patula*

Cupressus lusitanica and *Pinus patula* are the dominant industrial plantation species in high potential areas of Kenya. Most of these plantations are raised from seeds. However, there is inadequate tree seed sources especially seed orchards from which high quality tree seeds can be sourced. Seed orchards established using selected superior trees can provide high quality tree seeds. The planting material for establishing seed stands are obtained through a process of collection of seeds from selected mother trees so that their superiority is transferred to the next generation of trees. Establishment of progeny trials is a strategy of multiplication of superior mother tree traits in seed sources.

During the year under review, 2 hectares progeny trials of *C. lusitanica* and *P. patula* were established. The process of raising progenies for seed stand development involved collecting of seeds from selected superior trees and subsequent raising of seedlings in the nursery. For the two species planting was done at a spacing of 3 m by 3 m. Planting materials was carefully marked with specific clone numbers and booked as per the layout. For *P. patula*, 1460 seedlings were planted from 38 progenies while for *C. lusitanica*, 1,055 seedlings were planted from 19 progenies. It is recommended that re-selection of plus mother trees be prioritized.

3.2.3 Range-wide Progeny Trials of *Melia volkensii* and their Implications in Genetic Improvement of the Species

Melia volkensii is one of the most important indigenous species in the drylands of eastern Kenya, and probably the only timber tree species that can be grown on commercial scale in these areas. The breeding strategy for the species involved initial selection of candidate plus trees (CPTs) in both remnant natural stands and on-farm populations. One hundred plus trees were selected between 2010 and 2013, and their scions collected and used for establishment of clonal seed orchards in Tiva and Kibwezi. After two years, seed was collected from the orchards and seedlings raised for establishment of progeny tests. Four (4) main progeny tests and 4 sub-progeny tests were established in sites spanning *Melia* occurrence range in Kenya. The main sites were located on institutional land and the sub-sites on farmers' land. Planting was done in December 2015 at a spacing of 4 m x 4 m, in a randomized block design and single tree plots with varying number of trees per block. Pit size used was 45 cm x 45 cm x 45 cm. For the 4 main progeny sites, 3 blocks were used whereas for the sub-sites, 2 blocks were used.

Objectives of the progeny tests were: To compare the parent trees (CPTs) used as sources of desirable germplasm; to rank the parent trees according to the performance of their progenies; to estimate heritability of traits assessed and the General Combining Ability (GCA) of the female parent trees for a range of characteristics. Tree height, diameter at breast height (DBH) and diameter at ground level (DGL) and at 50 cm above ground (D50) were assessed at 6 and 12 months of age. Analyses of variance showed highly significant differences among progeny for all traits assessed. Ranking of the progenies showed that the best parents were 43, 26, 53 and 49. Calculated family heritability was moderate, 0.44, 0.24 for height and DBH respectively at 12 months and 0.52 and 0.41 for height and DBH at 6 months, suggesting a potential for transmitting desirable characteristics to operational commercial forest plantations.

Thirty seven of 76 female parent trees used showed a positive GCA for height and DBH respectively. The results indicated substantial variation among the selected trees of *Melia volkensii* and therefore further genetic improvement is possible.

The information collected will be used in improving the existing seed orchards of *Melia volkensii*. Future directions in improvement of the species will therefore aim at establishing controlled crossings of the best material and establishment of multiple breeding populations.



Figure 3.2.1: Candidate plus tree (CPT)

Overall results show that at 6 and 12 months of age, the progenies showed significant differences in height and DBH, and DGL at 6 months with moderate heritability values being realized for these traits. The progeny tests give the following indications to guide the future management of a *Melia volkensii* tree improvement programme:

- There is considerable, though not significant Genotype x Family interactions which may not be good for improvement of the species. However, subsequent assessments will give a clearer picture.
- At age one year, and a rotation of 12-15 years, it is still early to make conclusive recommendations.
- Heritability of the various traits was moderate but future assessments will give a better picture.
- Heritability estimates for *Melia volkensii* for traits associated with productivity indicate that the genetic improvement achieved can be transmitted and captured in operational plantations in the country. Immediate gain in plantation productivity can be achieved through rogueing the Melia seed orchards

For the long-term gain, sufficient seed orchards should be established using the best available material. The next step in improvement of the species will be controlled crossing of desirable plus trees and determination of specific combining ability of the parent trees.

3.3 Management Technologies for Selected Tree Species

3.3.1. Production of bamboo culms for power transmission poles

Bamboo is found in all regions of the world and plays important economic, environmental and cultural roles. Bamboo is becoming popular as an excellent substitute for wood as its uses include; crafts, housing, pulp, poles, paper, panels, boards, flooring, roofing, fabrics, and fuel. Bamboo is fast growing plant and can be harvested annually without depletion. It can grow on marginal land that is not suitable for agriculture or forestry. Cultivation of bamboo can be done on farms where it is more easily managed.

In Kenya, bamboo utilization is still at infancy. Development of the bamboo sector in Kenya has had a number of constraints that include availability of markets. Recently, Eco-Pole Factory Kenya Ltd, situated in Limuru, began manufacturing poles from bamboo culms (stems). Bamboo is considered as a cheaper alternative to using eucalyptus or concrete for power transmission poles. The Eco-pole factory is targeting to source bamboo from farmers in Kenya for the production of light weight Eco-poles for power transmission. The factory requires culms of 10 - 12 m in height.

KEFRI therefore undertaken a survey to assess two Community Based Organizations (CBOs) that have successfully sold their bamboo to Eco-pole Factory. The survey generated relevant information from the two case studies on the establishment, management, age, selection and harvesting of the requisite standard size and height for bamboo pole production. This information will be used to guide bamboo farmers on best practices to produce bamboo poles as per the standards set by Eco-pole Ltd.

Data collected revealed that bamboo on farm was planted at a spacing of 6 m by 6 m. Eco-Pole Company provided a market for bamboo from farmers. Standard size of bamboo required by the company was straight culms that were 10 m in height. However, no specifications were given for diameter. Bamboo culms that was sold to the factory took about 2 - 3.5 years to attain maturity and the required height for sale. Bamboo was extracted through clear felling or selected cutting.

The study recommended that; farmers be sensitized on production and management of bamboo for pole production, specifications of bamboo standards required for pole production i.e. in term of height. There is need to expand the area under bamboo production in order to sustain the expanding bamboo demand for industrial use.



Figure 3.3: Giant bamboo clump growing on farm and on established plantation

3.3.2. Recruitment of New on-Farm Tree Species for Increased Genetic Diversity in the Coast Region

There is limited diversity of tree species in many farms in coastal Kenya. Whereas there are many varieties of indigenous species on-farm, exotic species account for many of the trees planted on farms. There is therefore need to enhance tree species diversity on farm for diversification of incomes from tree products; increased stability and productivity of farms, and enhanced conservation of biodiversity.

Past initiatives favoured cultivation of fast growing high yielding, commercial exotic tree species. Indigenous tree species growing was neglected due to their perceived slow growth rate and low monetary returns.

However, introduction of indigenous trees on farm is now acknowledged to be a major step to conservation of tree diversity. KEFRI undertook a study at Kilifi and Kwale Counties to identify emerging on farm trees species and identify factors that constrain indigenous tree conservation at farm level.

The study revealed that the most preferred tree species were exotic. Factors that demoralized indigenous tree species growing were identified as slow growth rate, lack of seedlings and delayed economic returns. The

most preferred indigenous tree species in the study areas were:

Terminalia prunoides (Mwanga), *Lannea scheinfurthii* (Mnyumbu), *Dobera glabra* (Mkulu), *Grewia bicolor* (Mkone), *Berchamia discolor* (Mnago), *Artocarpus heterophyllus* (Mfenenesi), *Azelia quanzensis* (Mbambakofi), and *Milicia excelsa* (Mvule).

Economic consideration is a major driving force in determining the kinds of trees farmers prefer to plant. The highly preferred trees were those that can produce timber, fuelwood, poles, fruits and fodder. These trees provide income, household food security, energy generation and environmental conservation.



Figure 3.3.1. *Casuarina equisetifolia* established on farm



Figure 3.3.2. *Terminalia prunoides* and *Melia volkensii* woodlot

3.3.3. Performance of *Terminalia brownii* in the drylands of Eastern Kenya

Terminalia brownii is one of the species with high potential for domestication. The tree is semi deciduous and grows to a height of 7-13 m. It is a drought tolerant and termite resistant species. The species is mainly used for firewood, charcoal, construction timber, poles, posts, bee hives, tool handles, utensils (mortar and pestles), water troughs, human and veterinary medicine, fodder, shade, ornamental, mulch, soil conservation and improvement and dye. Research on management practices such as spacing and pruning regimes is essential, as this will provide information towards the domestication of *T. brownii* in the drylands of Kenya. A study was undertaken to determine the optimum escapement for *T. brownii* for timber production, assess pests attack, proposes the control measures, and determine the pruning regime for good tree form.

Growth performance of the species established at 3 m x 3 m, 4 m x 4 m, 5 m x 5 m and 6 m x 6 m continued to be monitored. Results at 5 ½ year showed trees had an average height of 4.5 m with a growth rate of 0.81 m per year. Trees spaced at 6 m by 6 m had the largest diameter at breast height (DBH, i.e. 1.3 m above ground) of 6.32 cm while those spaced at 3 m by 3 m had lowest DBH of 5.08 cm.

Terminalia brownii was found to exhibit positive interactions with vegetation underneath indicating its potential in having positive rather than competitive interaction with crops under agroforestry systems.

3.3.4. Techniques for Rehabilitating Degraded Natural Forests

KEFRI recognized that failure to rehabilitate degraded natural forests has the potential to negatively affect socio-economic growth, employment creation and poverty reduction strategies as forests have great impact on key sectors of the economy. KEFRI therefore initiated forest restoration studies in western Kenya to develop suitable technologies to support ecosystem restoration efforts. The research plots were established in Wire in 2007, Gwassii in 2009, South Nandi and Maragoli hills in 2010.

Objectives of the study were to; determine the rehabilitation needs of different levels of forest degradation, determine appropriate spacing under active forest restoration methods and establish demonstration plots to showcase forest restoration technologies.

Both passive and active forest restoration techniques were employed. Passive restoration techniques entailed site protection using enclosures to facilitate natural regeneration. Active restoration techniques included aided regeneration, which involves planting appropriate tree species at wide spacing e.g. 5 m, closely-spaced planting at between 2 m and 3 m, and dense planting at between 0.3 m and 1 m. Parameters assessed included; woody species types within restoration areas, stem diameter at breast height (DBH) and tree canopy height.

Preliminary results from South Nandi indicated presence of wide variety of woody species in the protected areas. Natural forest regrowth sites had more woody species than plots under active restoration.

Site protection caused a significant increase in woody stem DBH. Woody species in the unprotected site did not attain large DBH due to repeated incidences of disturbance such as grazing. Within the protected site, plots under natural regeneration recorded larger DBH than those under active forest restoration techniques. Dense planting at 0.3 m had trees of larger DBH than dense planting at 1 m or aided regeneration at 5 m.

Trees in the protected site were significantly taller than those in the unprotected site. Within the protected site, trees planted at 0.3 m spacing were taller than those growing through natural forest regrowth. Nonetheless, trees under natural regrowth were significantly taller than those planted at 5 m and 1 m spacing.

The following observations can be deduced from preliminary results on natural forest restoration technologies:

- Site protection is important for successful forest rehabilitation
- Dense planting is suitable for degraded sites with no capacity to support natural regeneration, such as open fields and bare soil.

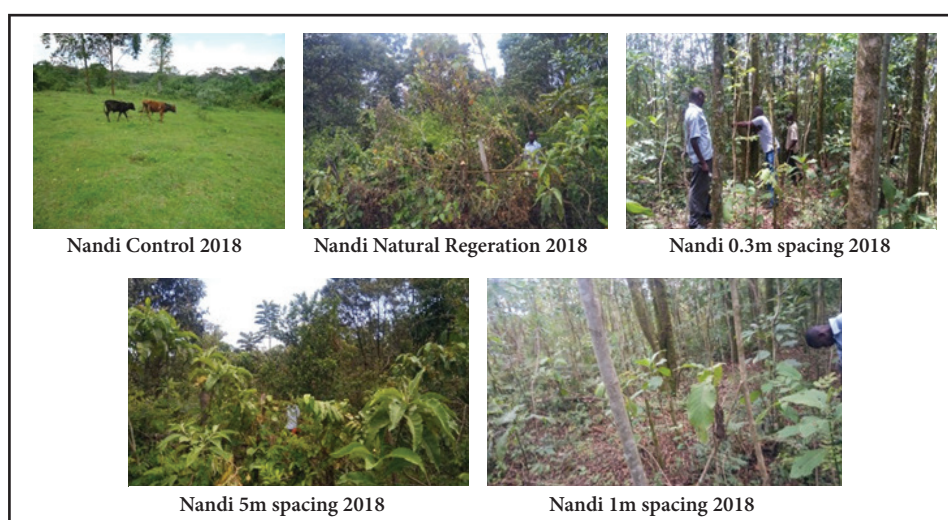


Figure 3.3: Photos show improvements in vegetation cover in degraded forest sites following restoration interventions at South Nandi

3.4 Bamboo as an Alternative Source of Biomass Energy

Bamboo is a perennial grass and is one of the strongest and fastest growing plants. The plant can reach maturity within four years and can be harvested for over 40 years without replanting. Depending on the species the culms (stems) range from a few centimeters to over 40 meters in length.

Kenya has only one indigenous species *Oldeania alpina*, formally known as *Yushania alpina*, which grows mainly in high altitudes. In the late 1980s - and early 1990s, over ten exotic bamboo species were introduced in the Kenya, mainly from Asian. These species can do well both in high rainfalls areas as well as low lands with as low rainfall as low as 400-800 mm per annum.

Over 70% of Kenyans depend on biomass energy as the main energy for cooking and heating. This calls for search for alternative sources of feedstock for biomass energy production as wood from preferred tree species cannot meet the ever increasing demand. Bamboo, a renewable resource, has potential as biomass energy and can be utilized for charcoal and briquette production.

KEFRI undertook studies on bamboo fuel properties in order to determine potential of selected bamboo species as alternative feedstock for biomass energy production. Bamboo species tested included; *Bambusa vulgaris*, *B. chungii*, *B. tulda*, *Dendrocalamus giganteus*, *D. strictus*, *D. brandisii*, *D. asper*, *D. membranaceus* and *Oldenia alpina*.



Figure 3.4: Harvesting *Dendrocalamus brandisii* bamboo species in Kakamega County and testing moisture content before carbonization

The results indicated calorific values of all the exotic bamboo species were high ranging between 8.2029 Kcal/g and 5.3457 Kcal/g with a mean of 5.6447 which was higher than the indigenous species which had 4.8319 Kcal/g and comparable to most of the preferred species.

Despite most of the bamboo having high fixed carbon, most of the exotic species reported low ash content of between 2.82 to 5.62 % (allowable ash content is 2-5%) hence suitable for establishment as potential alternative feedstock for fuel production.



Figure 3.4:1: Bamboo culms arranged in kilns ready for carbonization(left) and the carbonized bamboo charcoal

It was also evident that due to its short burning durations, bamboo may not be preferred as fuel where other source of fuelwood is readily available. However, due to its low bulk density, this study recommended that bamboo charcoal should be made into briquette for it to have a prolonged burning period.

4.0 Refinement, Protocols Development, and Linking Tree - Products to Markets

KEFRI recognizes that commercialization of tree based products is an important activity for improvement of communities livelihood, creation of employment and a motivation for conservation of trees and plant species with potential for product development. Development, refinement, and protocol development of tree-based products also contribute to the government Big 4 Agenda on food and nutritional security, health and manufacturing. During the Financial Year 2017 - 2018, KEFRI developed Marula jam, refined Opuntia concentrate; developed processing protocol for food flavour from *Vitex payos* and linked Syzygium fruit jam to markets.

4.1 Development of New Tree Products

4.1.1 Development of Marula Jam

Marula (Sclerocarya birrea) fruit is used as food in many communities in Africa. The ripe fresh fruit, which has high vitamin C content is edible, fermented or processed fruits can make alcoholic beverage such as Amarula, while boiled juice is used to flavour or sweeten porridge. The fruit can also be processed to make jam, thereby extending the fruit shelf life and consequently avoiding postharvest losses.

To prepare Marula jam, ripe fruits are cleaned, peeled, and de-pulped to separate from kernels. The pulp is blended while adding water.

Sodium bicarbonate (NaHCO₃) solution is added to adjust pH to 3.2. The mixture is then heated for 15 minutes. Pectin and sugar are also added to the mixture. The mixture is brought to boil while constantly stirring to give a uniform mixture. The jam is put into storage glass jars and sealed immediately. The Marula jam KEFRI developed showed a score of 67% °Brix, which is consistent with the KEBS standards of a minimum of 65% °Brix. The consistency of the jam compared very well with commercial brands.



Figure 4. Heating Marula jam

4.2 Refinement of New Tree Products

4.2.1 Refining of Opuntia Juice Concentrate

A number of *Opuntia* species, commonly known as Cactus, were introduced in Kenya in the 1950's and grows widely in arid and semi-arid regions. The prickly cactus is edible and has two different sections: the pad, which can be used as a vegetable, and the pear that bears the fruit. The fruit is rich in minerals; iron, calcium, potassium, sodium, magnesium, and vitamin C. It has low saturated fat and cholesterol and is a good source of dietary fiber. Freshly harvested fruits are highly perishable leading to nutrient and quality losses. KEFRI developed protocol for processing juice concentrate from *Opuntia ficus* in order to add value and prolong storage period.

The processing of making juice involves;

- Harvesting ripe *Opuntia* fruits
- Washing the fruits
- Extracting pulp by removing seed and skin fiber
- Pre-heating pulp between 65 to 70°C
- Standardizing pulp by adjusting pH, Brix, acidity, color, flavor, taste, texture
- Sterilizing juice by heating at 105 to 106°C for 90 seconds
- Aseptically cooling the juice
- Putting juice into containers
- Storing in dry place between 25°C and 30°C



Figure 4.1: Ripe *Opuntia* fruits

4.3 Protocols for Producing Refined Tree Products

4.3.1 Protocol on Food Flavoring from *Vitex payos*

This protocol specifies the information needed for production of *Vitex payos* fruit flavouring. The protocol follows the CIAA Guidelines on the Regulation.

Flavorings are products that are added to food to impart, modify, or enhance the flavor of food. *Vitex payos* fruit flavoring is produced from *Vitex payos* whole fruit pulp. The flavoring is prepared by suitable processes, which maintain the essential physical, chemical, organoleptical and nutritional characteristics of the flavoring of the fruit.

Processing steps include: Collection of ripe fruits, de-pulping, high accuracy and precision of weighing, processing raw materials that comply with quality standards, and freeze drying to produce solid product. The protocol also dictated that; the flavoring be packed in suitable materials that will not allow in moisture or its contamination. Labeling of flavorings should be in accordance with the requirements of the Codex General Standard for the Labeling of Food Additives when sold as such.

4.4 Linking New Products to Markets

4.4.1 Linking of Syzygium Fruit Jam to Markets

Syzygium cordatum fruit is highly valued for its pleasing flavour and its several medicinal properties. Syzygium jam has excellent market potential, with a good acceptability. KEFRI build capacity of Asili Self Help Group with the necessary knowledge and skills on sustainable harvesting, post-harvest handling, and processing of Syzygium fruits as well as value addition of Syzygium fruits into jam. Syzygium jam KEFRI developed was linked to markets using; farmer to domestic trader, and farmer to retailer linkages. Marketing by Asili Self Help Group was targeted to school activities and sales during market days.



Figure 4.2: Group members preparing Syzygium jam

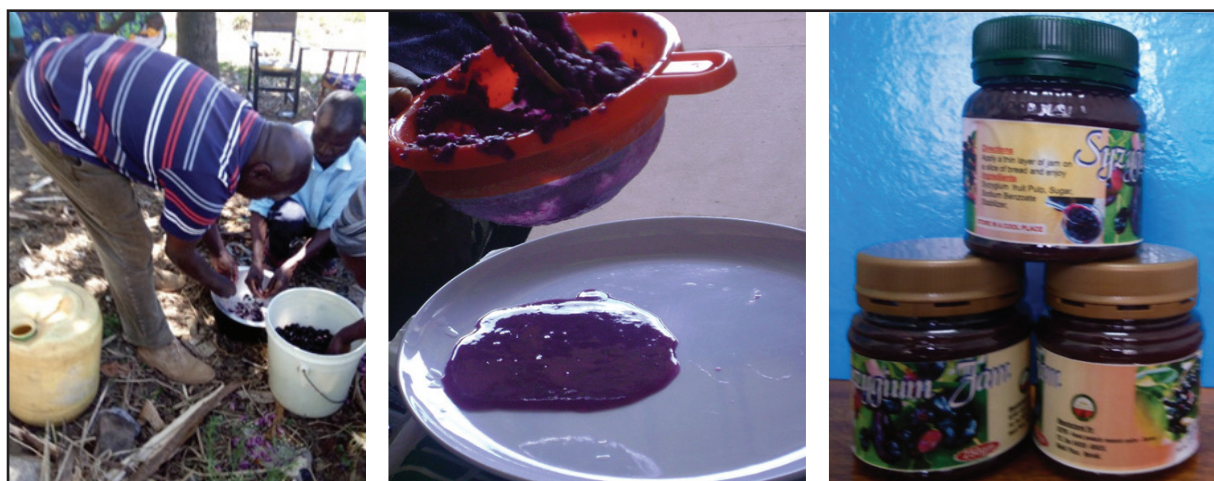


Figure 4.3: De-pulping of Syzygium fruits, (centre) extracting the jam, (right) packed jam ready for market

5.0 Dissemination and Publicity Activities

During the year under review, KEFRI continued to disseminate information and technologies for conservation, management and sustainable utilization of forestry and allied natural resources for socio-economic development. The information and technologies were disseminated through various channels that included; Field days, Open days, exhibitions at ASK shows, and mass media. The Institute also conducted capacity building of partners through interactive trainings, seminars and workshops.

5.1. Field days

KEFRI organized a total of 34 field days at various Eco-region Research Programmes. The major technologies and practices demonstrated during the field days included;

- Agroforestry technologies
- Bamboo propagation, establishment, management and utilization
- Climate change mitigation strategies
- Energy conservation and sustainable charcoal production using improved kilns
- Sustainable Briquette production techniques using biomass and agriculture waste
- Propagation, establishment and management of various high value tree species; *Osyris lanceolata* (E.A. Sandalwood), Eucalyptus, *Cupressus lusitanica*, *Gmelina arborea*, *Moringa stenopetra*, *Ocotea usambarensis*, *Makhamia lutea*, *Terminalia brownii*, *Tectona grandis*, *Euphobiceae tanaensis*, *Melia volkensii*, *Casuarina equisetifolia*, and *Vitex payos*
- Conservation and rehabilitation of degraded forests, mangroves, riverine, riparian areas and rangelands
- Tree nursery establishment and management
- Value addition to wood products (WPs)
- Value addition to non - wood forest products (NWFPs): aloe, gums and indigenous fruits
- Demonstration of timber processing on-farm

5.2. Open days

The Institute conducted one Open day in each of its six eco-region research programmes. The Open days featured research technologies being conducted at each specific region, products and relevant information on forestry and allied natural resources.

5.3. Radio talks

The Institute presented 15 talks and interviews at national and regional radio stations. The talks covered a wide range of topics including: Intensification and diversification of on-farm tree production for improved and sustainable livelihoods in Kenya; propagation and conservation of *Osyris lanceolata* and *Vitex payos*. In addition, 18 articles on research and corporate events featured in different print media.

5.4. Agricultural Society of Kenya (ASK) shows

KEFRI exhibited in 12 Agriculture Society of Kenya show countrywide. The exhibitions were held at; Machakos, Nakuru, Kitui, Kisumu, Kisii, Kakamega, Mombasa, Nyeri, Nairobi, Kabarnet, Migori, and Kitale. The institute show-cased forestry technologies and services that promote innovation and technology in agriculture and trade, which was the show theme.

5.5 Raising KEFRI Profile

In an effort to raise the Institute's profile, KEFRI choir made presentations at national events, forestry functions including; national tree planting, world environment day and international day of forests.

5.6. Production of Publications

A total of 23 publications, plus the Annual Report Fiscal Year 2016/2017 were produced by the Institute during the year. The publications comprised of; 12 peer reviewed journal papers, 3 technical/research notes, 6 Guidelines/extension materials and 2 policy briefs (Appendix I). The publications were distributed to various stakeholders through KEFRI Eco-region Research Programmes.

5.7. Building capacity of KEFRI partners

KEFRI through the Social Forestry Training Centre (SFTC) disseminated research findings through interactive training courses and seminars. Target participants were mainly KEFRI partners from national and county governments as well as international level institutions involved in forestry and allied natural resource management. During the year 2017-2018, SFTC designed and implemented the following trainings.

Table 6: Capacity building forums undertaken during the fiscal year

Course/Seminar Title	Course/Seminar Objective	Target group	Duration
4th Regional Training Course on Adaptation to Climate Change in Africa through Social Forestry	Enhance capacity of participants to climate change through implementation of participatory social forestry extension methodologies	Natural resource managers in East, Central and Southern Africa	5 weeks
Capacity Development Project for Sustainable Forest Management (CADEP-SFM)	Provide a platform for participants to; familiarize, discuss and understand application of CADEP-SFM tools for collecting, documenting, storing and sharing good practices in Natural Resources Management (NRM) for combating desertification	KEFRI Dissemination staff Participants from 7 countries in the Horn of Africa	1 week 2 weeks

5.8. Building capacity of KEFRI Scientific

KEFRI held its 5th scientific conference between 17 and 19th April, 2019. The 3-day conference themed 'Contribution of Forestry Research to Sustainable Development' was attended by scientists and stakeholders across the east African region.

6.0 KEFRI Partnership and Resource Mobilization

Partnership and Resource Mobilization (PRM) section is mandated to establish and strengthen synergies and complementarity with strategic partners for research and development, as well as initiating fundraising efforts from development partners. The section undertakes its activities based on the 4 specific objectives: enhance linkages and partnerships with stakeholders, increase revenue, improve resource mobilization, and operational efficiency. The section accomplishes this by forging partnerships with institutions such as Government Ministries, state corporations, universities, international organizations, donor agencies, private sector, Non-governmental organizations (NGOs), Community based organizations (CBOs), youth groups and other partners with mutual interest in forestry and allied natural resources.

In the Fiscal Year 2017/2018, KEFRI planned to sign 4 Memorandum of Understanding (MoUs). The section signed 3 new MoUs, renewed 6 old ones with strategic institutions, established 9 new partnerships, and updated database which has a total of 86 strategic partners.

6.2 Enhanced linkages and partnerships

KEFRI renewed old partnerships with Tinder Limited and signed new MoUs with, Laikipia County Government, and the Centre for Ecology and Hydrology (CEH).

KEFRI also established new strategic collaborations with Konza Techno-polis city, Techno Serve, KENNECT/KEFRI/GIZ, KDI-NGO, Natural Environment Council, NGARA, INBAR on Bamboo development, The Nature Conservancy (TNC), Food Agriculture Organization (FAO) on GEF5, NORAD on improving framework conditions and skills for private sector development in biofuel value chain in Kenya, Kaimosi TTC, Council of Governors and Life Skills dotcom.

6.3 KEFRI - KFS Partnership

KEFRI continued collaboration with Kenya Forest Service (KFS) as guided by a Memorandum of Corporate Collaboration (MoCC). Under this 5 year memorandum, the two institutions hold directorate policy level meetings twice a year, and quarterly technical level meetings to discuss forestry policy matters.

In the concluded year, three (3) meetings were held by KEFRI /KFS Taskforce on Asset Sharing, two (2) Technical and one (1) Policy liaison committee, three (3) Technical Liaison Committee task force meetings were also held and four (4) technical reports produced.

6.4 Resource Mobilization Strategy

The section also developed a Resource Mobilization Strategy for 2018 - 2022 as well as 15 proposals of which 3 had a positive response. The funded programs realized in the fiscal year were:

- Kenya's Water Tower Protection and Climate Change Mitigation and Adaptation Water, 5-year European Union funded Program.
- Integrated Programme to Build Resilience to Climate Change and Adaptive Capacity of Vulnerable Communities in Kenya, KEFRI - NEMA project in Loitokitok area.
- CSSF call-'Economic Empowering Youth in Lamu County to Deter Radicalization to Violence in Lamu County in Kenya' - funding for a period of 3 months.

7.0 Human Resource, Administration and Workplace Environment

During the year 2017-2018, the KEFRI Human Resource Division undertook recruitment and selection of staff, training and development of staff, performance management, reward management, employee relations, welfare and wellness, as well as personnel administration.

7.1 Staff Strength

In the year under review, as at 30th June 2018, the Institute had 946 employees of which 856 were on permanent and pensionable terms and 90 on contract terms as presented in Table 7.

Table 7: Staff strength as at 30th June 2018

Cadre	Number
Scientists	101
Technologist/ Technicians	92
Foresters	24
Supply Chain officers/Storemen	31
Accountants	37
Human Resource	4
Pension officers	2
Secretaries/ Copy typist	30
Clinic	2
Drivers	72
Clerical officers	57
Administrators	17
Auditors	7
Information Officers	23
Enterprises/PRMO	8
Artisans	13
Other Professional support	9
Subordinate staff	417
Total	946

7.2 Recruitment and Selection

The Human Resource Division (HR) facilitated recruitment of twelve (12) staff out of which eight (8) are on permanent terms of service and four (4) on annual contract terms. All the positions were competitively recruited either from internal or external sources.

7.3 Internship

The HR Division also recruited a total of fifteen (15) interns who were posted to various centres/sub-centres.

7.4 Training and Development

During the year under review, 2017/2018, the division facilitated training of various staff at various levels. Trainings undertaken included 11 PhDs, 13 attended senior management courses and other ongoing external trainings.

7.5 Awareness Creations

Various forums were organized at centres and sub-centres, to sensitize staff on various statutory requirement for the workplace as summarized in Table 8.

Table 8: Summary of Awareness Creations seminars

Title	Facilitators	Remarks
Public complaints	CAJ staff	Created awareness to 30 members of staff on the institutes public handling and the service charter in Marigat and Turbo sub-centre
Disability /Gender mainstreaming	NCPWD	Created awareness to 81 members of staff in Kibwezi and Gede on management of persons with special needs
Fire Marshalls and Drill training	Nairobi County Fire Brigade	Trained 28 staff in Kitui centre
Awareness on Terrorism	Anti-terrorism officers /NIS Kitui	Created awareness for 63 members of staff in Kitui centre
HIV/AIDS awareness	Health Officer	Created awareness on HIV/AIDs to 80 members of staff in Migori and Turbo
Values and Principles of Governance	Internal	Sensitized staff at Turkana Forestry Research sub-centre
Gender mainstreaming training	Internal	KEFRI staff at Kibwezi sub-regional centre



Figure 5. KEFRI staff at Lamu sub-regional centre undertaking a training on public relations and customer care

7.6 Infrastructure Development

During the financial year 2017-2018, the Administration division undertook development of infrastructure, and general maintenance of buildings, motor vehicles, generators and water pumps. Other services include; provision of security, janitorial, secretarial services, overseeing main and secret registries including the archives and transportation services. The following infrastructural projects were undertaken in support of research and development.

7.6.1 Acquisition of Land for Research

A follow up on acquisition of titles deeds for 1.78 ha of land for Lamu sub regional Centre, Taita Taveta (10 acres), Lodwar (1.3 ha) and Rumuruti (30 acres) was on-going. Preparation of part of development plans was done and gazetted by the various Country Governments.

7.6.2 Infrastructural Developments and Facilities

The following infrastructural projects were undertaken during the reporting fiscal year; construction of an office block, laboratory and farmers resource centre at Ngerenyi in Taita Taveta County, and construction of a Kitchen and Dining hall at Mukowe, Lamu County.



Figure 5.1: Kitchen and Dining hall at Lamu sub-Centre



Figure 5.2: Office block at Ngerenyi, Taita Taveta County



Figure 5.3: Fitting of fire extinguishers and bells at Kitui regional centre



Figure 5.4: Construction of greenhouse and control room at Muguga- CHERP



Figure 5.5: Renovation of green houses at Muguga

7.7 Workplace Environment

In compliance with requirement of Occupational Health and Safety Act (OSHA), KEFRI conducted environmental audit for all its work place in each eco-region countrywide and got certificates for safe and clean environment.

8.0 Implementation of ISO Quality Management System (QMS) and Environmental Management System (EMS)

During the Fiscal Year 2017/2018, KEFRI implemented the following activities:

- KEFRI Executive Committee conducted the management review and recommended the support of the Systems and allocated resources
- Corporate Affairs and Quality Assurance contracted Bureau Veritas Consultant (BVQVI) that trained 55 ISO champions, KEFRI top management, external committee and Internal Auditors on monitoring implementation and maintenance of the Integrated Management Systems (IMS) ISO 9001:2015 and ISO 14001:2015 EMS.
- Development of procedures for IMS, risk and opportunities that affect institute's operational areas
- Development of a Register of interested parties in KEFRI service delivery outputs
- Carried out internal audit and surveillance audit by SGS and recommended for certification in 2015 ISO standards, awaiting certification.

Appendix 1: Publications Produced in the Fiscal Year 2017 - 2018

1. **Cheboiwo J.K., Mutta D., Kiprop J. and Gatama S., 2018.** Public Private Partnerships Opportunities for Forestry Sector Development in Kenya: Synthesis of Primary and Secondary Production Actors, and Trade. *Journal of Environment and Earth Science* 8(1):47 - 69. ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online).
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Appendix 2: Financial Statement**Statement of Financial Performance for the Year Ended 30th June, 2018**

	Note	2017-2018	2016-2017
		Kshs.	Kshs.
Revenue			
Revenue from non-exchange transactions:			
Government Grants	3	1,536,359,277	1,487,423,344
External Grant for Research	4	206,315,381	242,468,332
Deferred Income from Donors	5(b)	30,279,269	34,536,462
Revenue from exchange transactions:			
Interest on TB, FDR and Savings A/c	6		854,760
Other Income	7	121,827,564	116,557,389
Total Revenue		1,894,781,491	1,881,840,287
Expenses			
Employee Costs	8	(1,180,879,465)	(1,166,840,038)
Operating Expenses	9	(585,566,977)	(499,983,886)
Board of Directors Expenses	10	(23,378,488)	(19,574,337)
Establishment Cost (Sinking Fund)	11(a)	(5,000,000)	(6,000,000)
Depreciation	5(a)	(88,610,913)	(90,262,597)
Amortization on Intangible Asset	12	(4,144,506)	(4,826,191)
TOTAL EXPENSES		(1,887,580,348)	(1,787,487,048)
OTHER GAINS/(LOSSES)			
Gain on Sale of Fixed Assets	13	1,060,747	
Exchange Gain/(Loss)	13(b)	(2,731,729)	3,215,264
		(1,670,982)	3,215,264
Surplus/(Deficit) for the Year		5,530,161	97,568,503

Statement of Financial Performance for the Year Ended 30th June, 2018

		2017-2018	2016-2017
		Kshs.	Kshs.
ASSETS	Notes		
CURRENT ASSETS			
Cash and cash equivalents	14(a)	298,878,846	296,988,922
Receivables from exchange transactions	15(a)	15,209,566	7,410,472
Receivables from non- exchange transactions	15(b)	1,283,774	2,060,451
Inventories	16	<u>64,410,175</u>	<u>88,554,825</u>
		<u>379,782,361</u>	<u>395,014,670</u>
NON-CURRENT ASSETS			
Property, Plant & Equipment	5(a)	5,796,221,100	5,783,614,743
Intangible Assets	12	<u>16,578,022</u>	<u>19,304,763</u>
		<u>5,812,799,122</u>	<u>5,802,919,506</u>
TOTAL ASSETS LIABILITIES		<u>6,192,581,483</u>	<u>6,197,934,176</u>
CURRENT LIABILITIES			
Payables from exchange transactions	17	12,458,567	11,231,236
Auditor General- accrued audit fee	17(c)	1,980,000	1,320,000
Payables from non-exchange transactions	17(d)	8,124,400	-
Unexpended External Donor Grants	4	192,174,312	273,715,134
Medical Scheme Funds	18	<u>742,883</u>	<u>742,883</u>
		<u>215,480,162</u>	<u>287,009,253</u>
NET ASSETS			
Government Grants for capital assets	19(a)	990,880,904	888,244,669
Deferred Income on Donated Assets	6(b)	586,799,202	617,078,471
Sinking Fund	11(b)	5,498,436	17,209,165
Revaluation Reserves	19(b)	4,467,199,488	4,467,199,488
Revenue Reserves	19(e)	<u>(73,276,709)</u>	<u>(78,806,870)</u>
		<u>5,977,101,322</u>	<u>5,910,924,924</u>
TOTAL NET ASSETS & LIABILITIES		<u>6,192,581,483</u>	<u>6,197,934,176</u>

Statement of Changes in Net Assets for the Year Ended 30th June 2018

	Deferred Income on Government Grants for Capital Assets (Kshs)	Deferred Income on Donated Assets (Kshs)	Revenue Reserves (Kshs)	Revaluation Reserves (Kshs)	Sinking Fund (Kshs)	Total (Kshs)
Balance as at 1st July 2016	843,287,021	651,614,932	(176,375,372)	4,467,199,488	11,953,651	5,797,681,720
As restated	843,287,021	651,614,932	(176,375,372)	4,467,199,488	11,953,651	5,797,681,720
Surplus/(Deficit) for the year			97,568,503			97,568,503
Sinking Fund expenses					(818,814)	(818,814)
Additions during the year	76,500,000				6,074,329	82,574,329
To Income & Expenditure	(31,542,352)					(31,542,352)
Deferred Income for the year		(34,536,462)				(34,536,462)
Balance as at 30th June 2017	888,244,669	617,078,471	(78,806,870)	4,467,199,488	17,209,165	5,910,926,924
Balance as at 1st July 2017	888,244,669	617,078,471	(78,806,870)	4,467,199,488	17,209,165	5,910,926,924
As restated	888,244,669	617,078,471	(78,806,870)	4,467,199,488	17,209,165	5,910,926,924
Surplus/(Deficit) for the year			5,530,161			5,530,161
Revaluation gain						
Transfers	8,251,817					8,251,817
Sinking Fund expenses					(17,636,979)	(17,636,979)
Additions during the year	143,231,199				5,926,250	149,157,449
To Income & Expenditure	(48,846,781)					(48,846,781)
Deferred Income for the year		(30,279,269)				(30,279,269)
Balance as at 30th June 2017	990,880,904	586,799,202	(73,276,709)	4,467,199,488	5,498,436	5,977,101,322

Statement Of Cash Flows For The Year Ended 30th June 2018

	Notes	2017-2018 Kshs.	2016-2017 Kshs.
Cash Flows from Operating Activities			
Surplus(Deficit) for the Year		5,530,161	97,568,503
Adjustment for:			
Depreciation	5(a)	88,610,913	90,262,597
Amortization for Intangible Asset	12	4,144,506	4,826,191
Deferred Income	5(b)	(30,279,269)	(34,536,462)
KEFRI Surcharge		(204,738)	(251,044)
Commission Income		(220,144)	(220,823)
Adjusted Surplus		67,581,428	157,648,961
Working Capital Changes:			
Decrease (Increase) in Debtors	15	(7,022,417)	(3,476,074)
Decrease (Increase) in Stock	16	24,144,650	(5,384,372)
Increase (Decrease) in Creditors	17	(71,529,091)	6,656,979
Net Cash from operating activities		(54,406,858)	(2,203,467)
Cash Flows from Investing Activities:			
Purchase of Assets	5(a)	(101,254,523)	(100,066,129)
Purchase of Intangible	12	(1,417,765)	(5,499,304)
Establishment Cost(Sinking Fund)	11(a)	(5,000,000)	(6,000,000)
Proceeds from sale of assets		1,098,000	
Net Cash from Investing activities		(106,574,288)	(111,565,432)
Cash Flows from Financing Activities:			
Development capital grants	3	94,384,418	44,957,648
Research Grants Received	4	130,783,168	270,296,075
Transfers/Adjustments		76,305,908	(16,100,363)
Research Grants Paid	4	(206,315,381)	(242,468,332)
Net Cash from Financing activities		95,158,113	56,685,028
Net Increase (Decrease) in Cash & Cash Equivalent		1,758,396	100,565,090
Opening Cash & Cash Equivalent		296,988,922	196,423,833
Closing Cash & Cash Equivalent		298,747,318	296,988,922
Cash & Cash Equivalent			
Bank balance	14(a)	298,878,846	296,988,922
Receivables from non- exchange transactions(staff debtors)	15(b)		
Travelling Imprest			972,280
Station/Special Imprest		1,219,950	633,890
Salary in Advance		11,045	
Salary Advance		52,779	454,281
Closing Cash & Cash Equivalent		300,162,620	299,049,373

Statement of Cash Flows for the Year Ended 30th June 2018

	Notes	2017-2018 Kshs.	2016-2017 Kshs.
Cash Flows from Operating Activities			
Surplus(Deficit) for the Year			
Adjustment for:		5,530,161	97,568,503
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