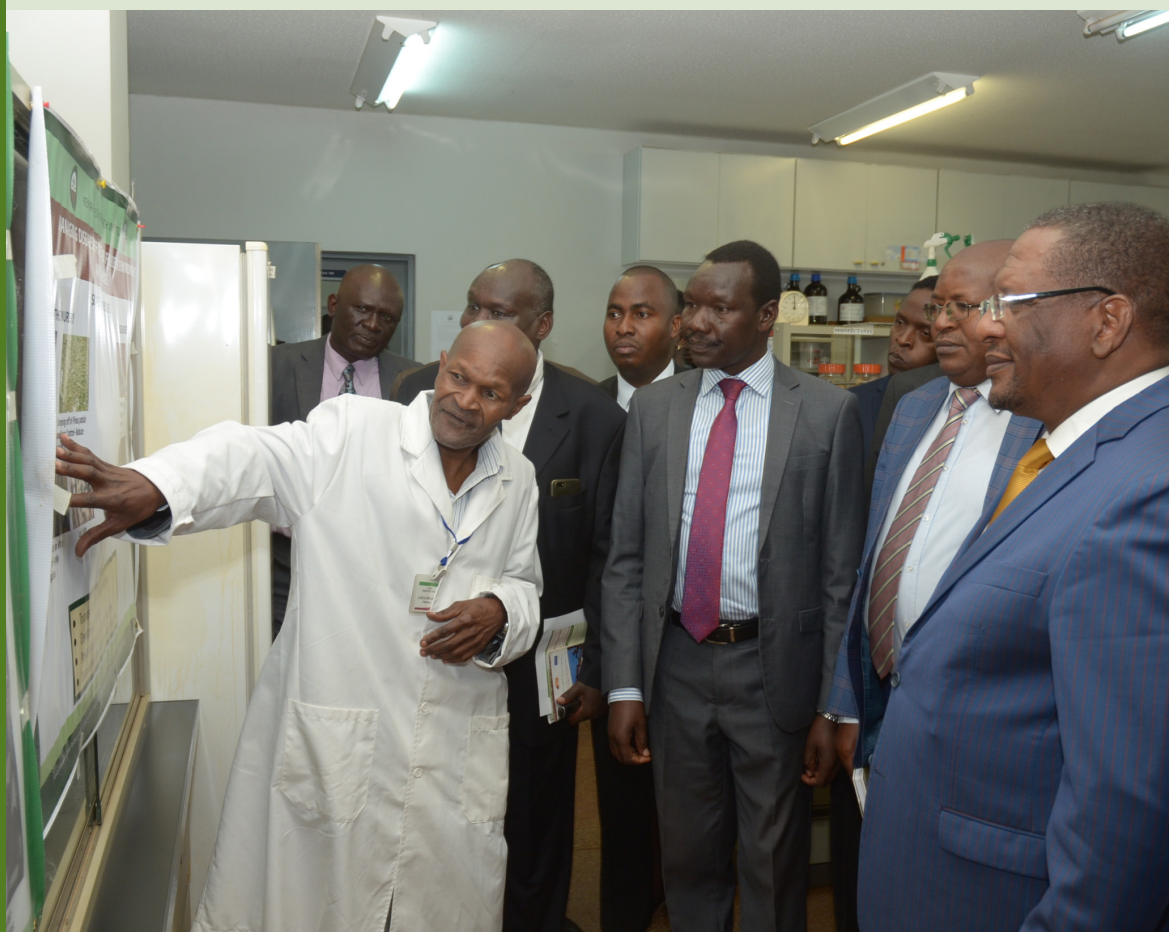




KENYA FORESTRY RESEARCH INSTITUTE



Annual Report and Record of Research 2019 - 2020

KEFRI is ISO 14001:2015 and 9001:2015 IMS Certified



KENYA FORESTRY RESEARCH INSTITUTE

Annual Report

and

Record of Research

2019 - 2020

KEFRI is ISO 14001:2015 and 9001:2015 IMS Certified

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ACRONYMS

ASALs	Arid and Semi-arid Lands
ASR	After Storage Ripening
CBO	Community Based Organization
CCF	Chief Conservator of Forests
CERP	Coast Eco-region Research Programme
CHERP	Central Highlands Eco-region Research Programme
CITES	Convention on International Trade in Endangered Species
DERP	Drylands Eco-region Research Programme
DG	Director General
BIDCO	Business and Industry Development Corporation
BGC	Bluegum Chalcid
EMS	Environmental Management System
IUFRO	International Union of Forest Research Organizations
IMS	Integrated Management System
FY	Fiscal Year
GDP	Gross Domestic Production
Ha	Hectare
HIV	Human Immunodeficiency Virus
HR	Human Resources
IG	Inspector General
IMS	Integrated Management System
IPM	Intergrated Pest Management
ISO	International Standard Organization
ISTA	International Seed Testing Association
JICA	Japan International Cooperation Agency
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
KFSC	Kenya Forest Seed Centre
Kg	Kilogram
Kshs	Kenya shilling
KTDA	Kenya Tea Development Authority
LVBERP	Lake Victoria Basin Eco-region Research Programme
MDAs	Ministry Departments and Agencies
MoAs	Memorandum of Agreements
MoEnv& F	Ministry of Environment and Forestry
MoUs	Memorandum of Understanding
NGO	Non-Governmental Organization
NWFP	None Wood Forest Products
OSHA	Occupational Safety Health Act
PC	Performance Contract
PH	Potential of Hydrogen
PhD	Doctorate of Philosophy
QMS	Quality Management System
RVERP	Rift Valley Eco-region Research Programme
SFTC	Social Forestry Training Centre
STI	Science, Technology and Innovation
UNIDO	United Nations Industrial Development Organisation

SERVICE DELIVERY CHARTER

No	Services/Goods	Requirements to obtain Services/ Goods	Cost	Timeline
1	Develop forest technologies	Research based on stakeholder needs	Depends on the technology	1-5 years depending on technology
2	Disseminate forest technologies	Formal Request	Free	Within 60 days
3	Production of quality tree seed	Demand for priority tree species	Depends on the tree species	Within 90 days
4	Production of high quality tree seedlings	Demand for priority tree species	Depends on the tree species	Within 90 days
5	Sale of high quality tree seed and seedlings	- Formal request - Filled seed order form	As per tree seed catalogue	Within 2 hours
6	Training on forest technologies	Formal request	Depends on the type of training	Within 90 days
7	Wood, plant and soil analysis	Formal request	As per analytical price catalogue	Within 10 working days
8	Advisory services	Formal request	Free	Within 5 working days
9	Contribute to policy formulation in the environment and forestry development	Formal request	Depending on the nature of the policy	1-5 years depending on the policy
10	Attachment of students	Acceptance letter from HR	Free	90 days
11	Consultancy in forestry and allied natural resources	Formal request	Free	1 week to 5 years
12	Establish linkages and partnerships	Formal request	Free	Within 90 days
13	Handling of customer complaints and compliments	Complaint / Compliment form	Free	Within 2 weeks after receiving the complaint

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

The Director Kenya Forestry Research Institute P.O. Box: 20412-00200, Nairobi Tel: +254 722 157 414, 724 259 781/2 Email: director@kefri.org contact@kefri.org Website: www.kefri.org	The Commission Secretary/Chief Executive Officer Commission on Administrative Justice P.O. Box 20414-00200, Nairobi Tel: +254 20 2270000/2303000/2603765/2409574/0777125818 Email: info@ombudsman.go.ke/complain@ombudsman.go.ke
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HUDUMA BORA NI HAKI YAKO

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Chairman, Board of Directors Statement



In the Fiscal Year 2019 /2020, KEFRI Board of Directors continued to provide leadership in designing and control of credible strategic intentions and implementation of obligatory global and national development agenda for research and development in forestry and allied natural resources in our country.

The 10th Board, inaugurated in July 2019, continued to oversee implementation of KEFRI's 6th Strategic Plan (2018-2022) which was developed in alignment to; The Constitution of Kenya 2010, Kenya's Vision 2030, and the Government Big Four Agenda.

As the Institute continued with implementation of key activities including development of technologies, dissemination of information, and implementation of policies for provision of efficient and effective services delivery, the Board of Directors continued to review and analyze progress made in key strategic activities consequently steering the Institute to realize various milestones:

During the fiscal year 2019/20, the Institute increased tree seed collection targets from mapped quality trees by double from 20 up to 40 tonnes, and intensified distribution of seeds to tree growers. These are part of efforts towards compliance to the Presidential directive of achieving at least 10% tree cover by 2022. Furthermore, KEFRI together with relevant bodies drafted the National Bamboo Policy 2019, Commercialization of Forestry Policy, reviewed the National Forest Policy 2016, and Forest Conservation and Management Act 2016, Other key achievements include:- Launch of Taita Taveta Sub-region Centre to bolster research activities under the Coast Eco-Region Research Programme; piloting of aerial seeding at Maasai Mau Forest to gauge its potential as a more efficient technology in rehabilitation of degraded forestlands and landscapes; development of GreenApp a software for provision of information on tree species - site matching to (potential) tree growers; and enhancement of staff medical cover by 95 percent, enabling staff to access to a wider range of medical facilities.

In compliance with Mwongozo Code of Governance for State Corporations, the Board ensured leadership and good governance, financial stewardship and discipline through prudent use of allocated GoK funds as well as externally mobilized resources from Development Partners to accomplish the set performance targets. Implementation of some activities were adversely affected by measures to contain the global pandemic COVID-19, however, the Board through its constituted committees examined any deviation from the targets and suggested corrective measures to mitigate the challenges encountered.

I take this opportunity, on behalf of the Board of Directors and myself, to most sincerely thank the Cabinet Secretary for Environment & Forestry - Mr. Keriako Tobiko for inaugurating and re-appointing Board of Directors from previous alliances to provide institutional memory and continuity. In the course of the fiscal year however, there were changes in the composition of the Board emanating from expiry of terms of service. Dr. Roy Mugiira replaced Ms. Margaret Maimba representing the Director-General of the National Commission for Science Technology & Innovation; Dr. Lucy Ng'ang'a replaced Mr. Henry Obino representing the Permanent Secretary in the Ministry of Environment and Forestry; and Mr. Elly Ongei replaced Mr. Felix Ateng representing the Cabinet Secretary in the National Treasury.

Special thanks to the National Government through the Ministry of Environment and Forestry, other ministries departments and agencies (MDAs), County Governments, Development Partners, my colleagues in the Board, entire KEFRI staff and all stakeholders for the immense support which enabled successful achievement of the targets set for the fiscal year 2019/2020.



Dr. Sammy Letema

Chairman - KEFRI Board of Directors

Foreword by the Director



During the Fiscal Year 2019-2020, KEFRI continued with implementation of the performance contract targets derived from its 6th Strategic Plan 2018-2022. These targets, were carried out within thematic areas namely: Forest Productivity and Improvement; Forest Biodiversity and Environment Management; Forest Products Development; Forest Socio-economics, Policy and Governance; Forest Research Support Services; Corporate Affairs and Quality Assurance; and Corporate Services.

In the period under review, the Institute accomplished several outstanding projects. KEFRI achieved: collection and distribution of over 38 tonnes of tree seed from 114 different species, a significant increase compared to 16 tonnes from 103 species collected in the previous fiscal year; establishment of 45.5 ha of tree seed sources; and raising tree planting materials across the eco-region research programmes. These activities made a major contribution towards implementation of Presidential directives to increase tree cover to a minimum of 10% by 2022. The Institute continued development of diverse forestry technologies for: enhancing tree productivity; efficient use of forestry resources and sustainability of forests for national development; food security, health, and creation of green jobs; and intensified use of ICT in dissemination and sharing of information in forestry and allied natural resources.

The management oversaw engagement with stakeholders and the public through various fora including presentation of research findings in: the 2019 IUFRO World Scientific Congress held in Brazil; other forums for promoting forestry based climate change adaptation and mitigation initiatives; and avenues for adoption and upscaling forestry technologies for environmental conservation and livelihood improvement. Further, to overcome challenges presented by the COVID-19 pandemic, the Institute Management resorted to innovative measures such as use of virtual means to achieve specific priorities of KEFRI.

During the year under review, the Institute, continued to devolve services in eco-regions and counties by improving seed processing facilities countrywide as well as infrastructure in Taita Taveta, Migori, Lamu, Laikipia, Narok to support research and development. Mobilization of funds for research and development activities were extended to the two levels of government, and development partners. KEFRI Management gave priority to implementation of integrated ISO standards (both Environmental and Quality) as well as staff capacity development to enhance skills for efficient and effective service delivery.

On behalf of KEFRI management and myself, I thank the Board of Directors for steadfast support and leadership, national as well as the county governments, Ministry of Environment and Forestry, development partners and all other stakeholders for their cooperation and support during the financial year 2019-2020.

A handwritten signature in blue ink, which appears to read 'Joshua K. Cheboiwo'.

Joshua K. Cheboiwo (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 replaced by the Science, Technology and Innovation Act No. 28 of 2013 to undertake research in forestry and allied natural resources, generate, promote and improve technologies for sustainable developed.

Vision

A world class Centre of excellence in forestry and allied natural resources research for sustainable 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 to stakeholders
- Building capacity of stakeholders and
- Establish partnerships and cooperate with other research organization and institutions of higher learning in joint research and training

Core Values

- Teamwork
- Healthy environment
- Professionalism
- Partnership
- Innovation
- Creativity
- Customer focus

1.0 TREE SEED DEVELOPMENT AND PRODUCTION

Forests and trees provide important ecosystem services that include; habitat to many organisms, conservation of water catchment areas, soil protection and carbon sequestration. In Kenya, it is estimated that 90% of the rural and peri-urban use fuelwood energy, and the formal forest sector employs about 50,000 people directly and about 600,000 indirectly - contributing about 3% of the GDP and 10% of the non-monetary economy.

The Kenya government forest policy - draft Sessional paper No.9 of 2005, aims to increase national forest cover to 10% to conform to acceptable minimum by international standards. To achieve this, the government set an annual planting target of 360 million seedlings but was revised to 500 million seedlings annually in order to achieve the target by 2022. The bulk of this production is for planting outside forest reserves, and the balance will be for reforestation and afforestation purpose.

Forestry research and development would play a major role in provision of high quality germplasm to meet the demand for forest products and services. In the year under review KEFRI continued with development, production and conservation of tree germplasm which involves: establishment of seed stands and seed orchards of highly demanded tree species; and seed production. The activities aims to facilitate the attainment of at least 10% tree and forest cover as well as fulfilling the requirements of numerous tree planting programmes within and outside the country.

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 (seed orchards and seed stands).

1.1.1 Establishment of seed orchards

During the fiscal year 2019 - 20, KEFRI established seven (7) seed orchards comprising different tree species including; *Cupressus lusitanica*, *Eucalyptus grandis*, *Gmelina arborea*, *Grevillea robusta*, *Moringa stenopetala* and *Pinus patula* in the various eco-regions as shown in Table 1.1.

Table 1.1: Seed orchards established in different Centres/sites in 2019 - 2020

Species		Centre / Location	Hectares (ha)
<i>Cupressus lusitanica</i>	CHERP	Muguga tree bank / seed orchard	2
<i>Pinus patula</i>	RVERP	Ongoing activity	3
<i>Cupressus lusitanica</i>		Makutano forest Compartment Lalakwen 1A	4
<i>Eucalyptus grandis</i>		Makutano – Londiani	2
<i>Moringa stenopetala</i>		Parmolok Island – Lake Baringo	2
<i>Gmelina arborea</i>	LVERP	Migori - Lichota	4ha
TOTAL			17ha

1.1.2 Establishment of seed stands

The Institute also established seed stands of various species including; *Eucalyptus camaldulensis*, *Eucalyptus urophylla*, *Gmelina arborea*, *Grevillea robusta*, *Melia volkensii*, *Milicia excelsa* and *Osyris lanceolata*

Table 1.2: Tree seed stands established in 2019 - 2020

Species	Centre	Location	Hectares (ha)
<i>Milicia excelsa</i>		Gede	2
<i>Gmelina arborea</i>		Gede	2
<i>Melia volkensii</i>		Gede	1
<i>Milicia excelsa</i>		Gede	2
<i>Eucalyptus urophylla</i>	CHERP		
<i>Osyris lanceolata</i>			
<i>Gmelina arborea</i>	DERP	Kitondo, Kisau & Mba Pimary Schools in Makueni, and Kitui GoK Prisons	3
<i>Gmelina arborea</i>		Muthwani Secondary School, Makueni Igumuro Secondary Embu County	1.5 Beating up undertaken
	RVERP		
	LVERP	Nyagera Primary School	2
		Mago School in Yimbo, Bondo County	2
Total			18.5

1.2 Seed collection, processing and distribution

Production of high quality tree seed involves: identification of seed sources; seed survey to determine timing of collection in a particular seed source; actual seed collection; seed processing i.e. seed extraction, drying and cleaning; and quality testing before storage and distribution to the consumers.

1.2.1 Seed collection

In year 2019 - 20, Kenya Forestry Seed Centre collected **38,394 kg** of seed up from **16,961.50 kg** in the year 2018 - 2019 (Table 1.3). The seed were collected from a range of 114 different species (Table 1.4), a wider range compared to 103 species collected in the previous year.

The tree seed are normally collected from selected and established seed sources and seed orchards located in five KEFRI Eco regional research programmes and sub-centres, covering all the ecological regions of Kenya. The Central Highlands Eco-Region Research Programme (CHERP) has two seed collection stations of Muguga and Nyeri, Drylands Eco-region Research Programme (DERP) has three stations of Kitui, Kibwezi and Garissa, Coast Eco-region Research Programme (CERP) has three stations of Gede, Lamu and Taita Taveta, Rift Valleys Eco-Region Research Programme (RVERP) has two stations of Londiani and Turbo, and Lake Victoria Eco-Region Research Programme with three stations of Maseno, Kakamega and Migori.

All the seed (both fresh and in storage for more than 6 months) was subjected to quality tests as per International Seed Testing Association (ISTA) rules before storage or distribution to clients. The seed testing involves determination of various qualities including; moisture content, purity, germination and seed weight (number of seed per kg). The seed were supplied to stakeholders including; individual farmers, private and public institutions both nationally and within the region.

Table 1.3: Summary of tree seed production and distribution in Fiscal year 2019-2020

Seed Collection Centre	Amount collected (kgs)
Enterprise	395.5
Londiani	4801.76
Nyeri	7806.53
Taita Taveta	1706.32
Kibwezi	2161.55
Kakamega	8186.59
Turbo	3626.54
Muguga	3099.12
Garissa	1192.85
Gede	1600.78
Kitui	2,224.4
Maseno	443.9
Migori	354.25
Lamu	794.2
Total	38,394.29

Table 1.4: Tree species from which seed was collected

SPECIES		
<i>Acacia elatior</i>	<i>Cupressus lusitanica</i>	<i>Senna spectabilis</i>
<i>Acacia gerrardii</i>	<i>Dalbergia melanoxylon</i>	<i>Sesbania sesban</i>
<i>Acacia kirkii</i>	<i>Delonix elata</i>	<i>Spathodea campanulata</i>
<i>Acacia lahai</i>	<i>Eucalyptus camaldulensis</i>	<i>Sterculia appendiculata</i>
<i>Acacia mearnsii</i>	<i>Eucalyptus globulus</i>	<i>Syzygium cumini</i>
<i>Acacia melanoxylon</i>	<i>Eucalyptus grandis</i>	<i>Syzygium guineense</i>
<i>Acacia mellifera</i>	<i>Eucalyptus maculata</i>	<i>Tamarindus indica</i>
<i>Acacia nilotica</i>	<i>Eucalyptus saligna</i>	<i>Tectona grandis</i>
<i>Acacia nubica</i>	<i>Flacourtia indica</i>	<i>Terminalia brownii</i>
<i>Acacia polyacantha</i>	<i>Gmelina arborea</i>	<i>Terminalia cattapa</i>
<i>Acacia robusta</i>	<i>Grevillea robusta</i>	<i>Terminalia ivorensis</i>
<i>Acacia Senegal</i>	<i>Hakea saligna</i>	<i>Terminalia mentalis</i>
<i>Acacia seyal</i>	<i>Jacaranda mimosifolia</i>	<i>Terminalia prunoides</i>
<i>Acacia sieberiana</i>	<i>Juniperus procera</i>	<i>Terminalia spinosa</i>
<i>Acacia tortilis</i>	<i>Kigelia africana</i>	<i>Thevetia peruviana</i>
<i>Acacia xanthophloea</i>	<i>Leucaena diversifolia</i>	<i>Tipuana tipu</i>
<i>Acrocarpus fraxinifolius</i>	<i>Leucaena leucocephala</i>	<i>Trichilia emetic</i>
<i>Adansonia digitata</i>	<i>Maesopsis eminii</i>	<i>Vangueria madagascarensis</i>
<i>Adenanthera pavonina</i>	<i>Markhamia lutea</i>	<i>Vangueria infausta</i>
<i>Afzelia quanzensis</i>	<i>Melia azedarach</i>	<i>Vitex doniana</i>
<i>Albizia adianthifolia</i>	<i>Melia volkensii (seed)</i>	<i>Vitex keniensis</i>
<i>Albizia coriaria</i>	<i>Melia volkensii (nuts)</i>	<i>Vitex payos</i>
<i>Albizia gummifera</i>	<i>Milicia excelsa</i>	<i>Warburgia ugandensis</i>
<i>Albizia lebbeck</i>	<i>Mimuscops fruticosa</i>	<i>Zanthoxylum gillettii</i>
<i>Araucaria cunninghamii</i>	<i>Moringa oleifera</i>	<i>Ziziphus mucronata</i>
<i>Azadirachta indica</i>	<i>Moringa stenopetala</i>	
<i>Balanites aegyptiaca</i>	<i>Newtonia hildebrandtii</i>	
<i>Berchemia discolor</i>	<i>Ocotea cymosa</i>	
<i>Brachychiton acerifolius</i>	<i>Olea africana</i>	
<i>Brachystegia speciformis</i>	<i>Olea capense</i>	
<i>Caesalpinia sp</i>	<i>Paramacrolobium coeruleum</i>	
<i>Callistemon citrinus</i>	<i>Parkinsonia aculaeta</i>	
<i>Callitris robusta</i>	<i>Phoenix reclinata</i>	
<i>Calodendrum capense</i>	<i>Pinus patula</i>	
<i>Carissa edulis</i>	<i>Podocarpus falcatus</i>	
<i>Casuarina equisetifolia</i>	<i>Podocarpus latifolia</i>	
<i>Casuarina jughuniana</i>	<i>Polyalthia longifolia</i>	
<i>Combretum africana</i>	<i>Polyscias kikuyensis</i>	
<i>Combretum schumanii</i>	<i>Prunus africana</i>	
<i>Cordia africana</i>	<i>Pyracantha angustifolia</i>	
<i>Croton macrostachyus</i>	<i>Sclerocarya birrea</i>	
<i>Croton megalocarpus</i>	<i>Senna siamea</i>	

1.2.2 Improvement of Seed Production Facilities and Activities

During the year under review, seed production, seed processing and storage facilities within various eco-region centres were improved as follows:

- An in-house refresher course for KFSC laboratory staff
- Upgrading Migori to a seed collection centre and a forester was posted there
- Modification of the annual tree seed targets for 2019/2020 circulated to the concerned seed collection staff members.
- Nyeri, Kakamega, Migori and Gede were each provided with new vehicles to facilitate in seed collection.

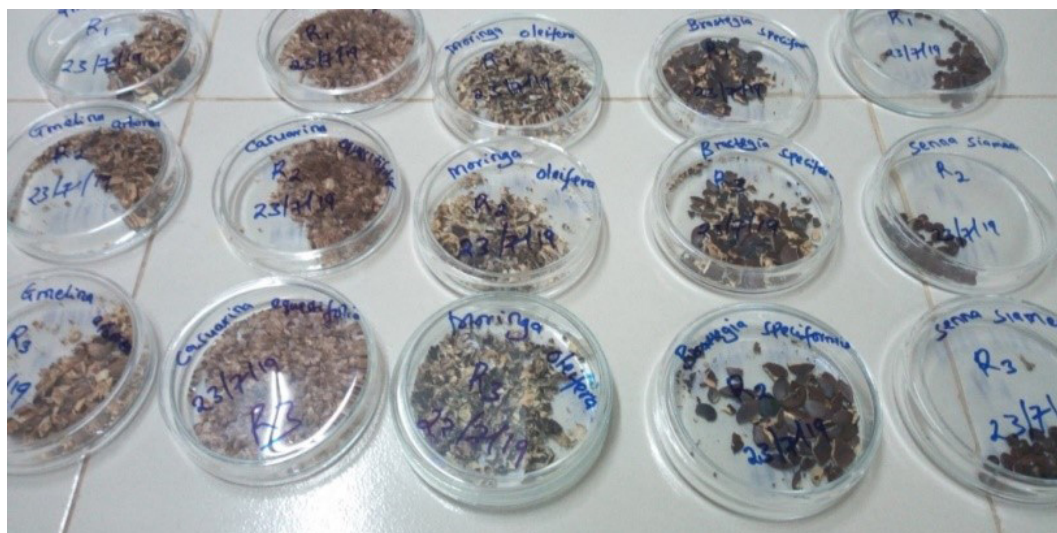


Figure 1: Tree seed samples ready for moisture content test at KEFRI laboratory in Gede

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 2019 - 2020, the Institute continued to raise seedlings for: species that are difficult to propagate (Table 2.1); superior genetic quality some of which KEFRI uses in raising high quality seed sources (Table 2.2); and assorted tree species to meet demand from various stakeholders or programmes (Table 2.3).

Table 2.1: Seedlings raised in 2019 - 2020 for species that are difficult to propagate

Species	Site	Number of seedlings produced
<i>Dendrocalamus giganteus</i>	CHERP Muguga	1238
<i>Dendrocalamus asper</i>		1560
<i>Bambusa blumeana</i>		2001
<i>Bambusa vulgaris</i>		2029
Sub-total (various bamboo species)		6828
Osyris seedlings		2731
<i>Melia volkensii</i>	DERP	78,992 (last year 44,921)
<i>Bamboo spp.</i>		10,100 (7412 last year) (target 6000)
<i>Osyris lanceolata</i>		5173 (last year 6188) (target 5000)
<i>Ximenia americana</i>		1200 (target 500)
Bamboo seedlings (<i>B. vulgaris</i> , Giant bamboo & <i>Oxtenanthera abyssinica</i>)	DERP (Kitui & Kibwezi)	10,100 (surpassed target of 6000)
<i>Vitex payos</i>		700
<i>Terminalia brownii</i>		5080
<i>Dalbergia melanoxylon</i>		1200
<i>Dendrocalamus giganteus</i>	CHERP Muguga	1238
<i>Dendrocalamus asper</i>		1560
<i>Bambusa blumeana</i>		2001
<i>Bambusa vulgaris</i>		2029
Sub-total (various bamboo species)		6828
Osyris seedlings		2731
<i>Cupressus lusitanica</i> of improved grafts	RVERP	1100
Total		2092

Table 2.2: Planting material raised in year 2019-2020 for superior genetic quality

Species	Site	Number
<i>Cupressus lusitanica</i>	CHERP	1100 grafted seedlings
Grafted Grevillea		1000
<i>P. patula</i> propagules	RVERP (Turbo & Londiani)	1000
<i>Gmelina arborea</i> grafts	CERP	Not provided
Improved Melia grafts	DERP	1800

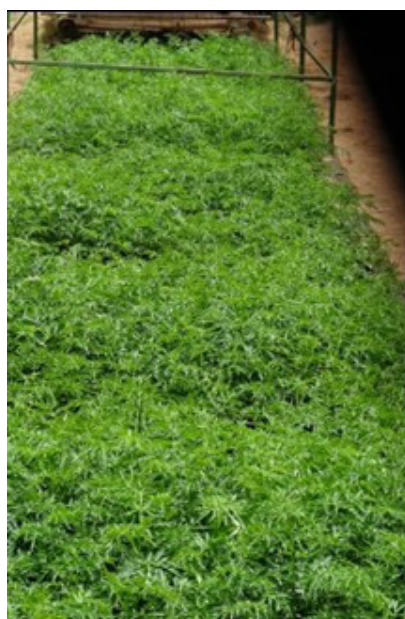
In addition, KEFRI raised more seedlings of various species in its nurseries across its centres. These seedlings were planned for establishment of plantation within the Institute, sales and free issues to the public and institutions. Seedlings of species raised in the nurseries for the high rainfall areas during the year included:

Callistemon lanceolatus, *Callindra calothyrsus*, *Cupressus lusitanica*, *Dombeya torrida*, *Erthyrina abyssinica*, *Eucalyptus ficifolia*, *Eucalyptus grandis*, *Grevillea robusta*, *Hagenia abyssinica*, *Hakea saligna*, *Juniperus procera*, *Olea africana*, *Olea capensis*, *Pinus patula*, *Podocarpus falcatus*, *Prunus africana*, *Syzygium guneensis*, *Markhamia lutea*, *Vitex kienensis*.

Seedlings of drylands tree species raised within the period included: *Acacia elata*, *Acacia gerrardii*, *Acacia mellifera*, *Acacia tortilis*, *Acacia xanthophloea*, *Adansonia digitate*, *Aloe vera var chinensis*, *Annona cherimoya*, *Ashok*, *Azadirachta indica*, *Balanites aegyptica*, *Bambusa vulgaris*, *Caesalpinia velutina*, *Carica papaya*, *Citrus lemon*, *Croton megalocarpus*, *Dalbergia melanoxylon*, *Eucalyptus camaldulensis*, *Ficus thoningii*, *Flowers (assorted spp)*, *Gmelina arborea*, *Grevillea robusta*, *Jacaranda mimosifolia*, *Loncocarpus eriocalyx*, *Mangifera indica*, *Melia volkensii*, *Moringa oleifera*, *Moringa stenopetala*, *Osyris lanceolata*, *Parkinsonia aculeate*, *Psidium guajava*, *Sclerocarya birrea*, *Senna siamea*, *Senna spectabilis*, *Syzygium cumminii*, *Tamarindus indica*, *Terminalia brownii*, *Terminalia cattapa*, *Terminalia mentalis*, *Thevetia peruviana*, *Vitex payos*, *White sapota* and *Zyzyphus mauritania*.

Table 2.3: Production of seedlings in the Eco-regions FY 2019 -2020

Eco-region	Stations	No. of seedlings raised for 2019 - 20
CERP	Production for region which included; Gede, Lamu and Taita Taveta	219,416 (Gede – 101,900) (Lamu - 52,926) (Taita-taveta- 80881)
DERP	Production for region which included: Kitui, Kibwezi, Garissa and Hola One of the key species in the dry lands raised in Kibwezi, Tiva and Kitui Centre Tree nurseries was Melia seedlings.	230,640 (Kitui – 112,561) (Kibwezi – 83,176) (Garissa – 28,603) (Hola – 6,300)
CHERP	Production for region which included Muguga (Nderi, Sumitomo, Forest estate) and Nyeri Bamboo is also majorly produced in Muguga nurseries	383,095 (Muguga- 335,897) (Nyeri – 47,198)
RVERP	Production for region which included Londiani, Marigat, Turkana and Turbo	319,283 (Londiani– 155,289) (Marigat – 51,195) (Turkana – 14,130) (Turbo – 98,669)
LVERP	Total production for region which included Maseno, Kakamega, Ramogi, Kuja River and Migori	181,089 (Maseno -74,850) (Migori – 69,239) (Kuja – 23,750) (Ramogi – 13,250)

**Figure 2: Raising of improved *Melia volkensii* seedlings at KEFRI Kitui and Kibwezi tree nurseries**

3.0 DEVELOPMENT OF FORESTRY TECHNOLOGIES

KEFRI plays an instrumental role in generation of technologies for forestry development to; improve forest productivity, increase forest and tree cover, promote rehabilitation of degraded forests and woodlands, supply wood for domestic and industrial use, and develop forest products for improved livelihoods. During the FY 2019 - 2020, KEFRI developed technologies for: propagation of difficult to propagate tree species; breeding tree species for improved yields; and silvicultural management of tree species. Research in socio-economics, policy and governance were conducted on cross-cutting issues that influence management of forests and the environment in Kenya. The research focused on society interests in forests and the environment; forest resource management; and markets and trade in forest products.

3.1 Propagation of Difficult to Propagate Tree Species

3.1.1 Propagation of Bamboo

Demand in Bamboo is on the increase for use in rehabilitation and protection of water catchments and degraded river banks and other riparian sites. The species is also used as timber substitute in construction, fencing and basketry works. During the year under review, KEFRI propagated Bamboo species namely; *Bambusa vulgaris*, Giant bamboo and *Oxytenanthera abyssinica* (solid bamboo).



Figure 3: Giant bamboo cuttings under propagation, Giant bamboo clump, *Bambusa vulgaris* stand

Propagation of the species involves: collection of healthy bamboo culms, nursery preparation by making trenches, preparation of bamboo stem cuttings, application of pesticide/fungicide to prevent termites/fungus attack, sowing the cuttings while covering with sand, splitting of bamboo sprouts, and potting of sprouts.

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

Over exploitation of *Osyris lanceolata* (East African Sandalwood) to extract essential oils threatens survival of the species in the wild. The mode of harvesting aggravates this threat as it involves uprooting the tree. Domestication of *O. lanceolata* offers great potential for conservation of the remaining natural populations and ensuring availability of its products on sustainable basis. However, propagation of *O. lanceolata* is constrained due to inadequate availability of seedlings which is caused by erratic and unreliable availability of seed. Further, difficulties are experienced at nursery during the early stages of seedling growth since *O. lanceolata* is a hemi-parasite and must attach to roots of an appropriate host plants from which they absorb nutrients.

In the FY 2019-2020, KEFRI identified seed sources, and developed a seed collection, handling and germination protocols. A method of producing seedlings through use of marcots has also been developed as an alternative to seed. As KEFRI continued testing different species to host *Osyris*, *Acacia polyacantha*, *Desmodium spp.*, and *Sedum reflexum* were introduced within the year under review.



Figure 4: *Osyris lanceolata* seedlings hosted with *Sedum reflexun*

3.1.3 Propagation of *Vitex payos*

Vitex payos commonly known as black plum is one of the common trees in drylands with fruits rich in vitamin B and high levels of phytonutrients. The fruit is consumed both at domestic levels and income generation in form of edible fruits, jam and juice. KEFRI has embarked on propagation of *V. payos* to promote its domestication. The species has difficulties in germination a factor attributed to its hard seed coat that does not allow water to penetrate. Currently, pre-treatment of the species involves soaking the seeds in cold water for 7 days before sowing. Sown seeds have indicated germination after 21 days.



Figure 5: *Vitex payos* fruits (Exotic fruits of Africa), and Right: Pricked out *Vitex payos* seedlings

3.1.4 Propagation of *Terminalia brownii*

Terminalia brownii is a useful indigenous tree species which grow widely in the arid and semi-arid lands of East Africa. The species is found in the grassland, bush-land with scattered trees and wooded savannas. The tree has multiple benefits as it produces good timber, fuelwood and is useful in ecosystem services.

Terminalia seeds are covered by a thick wing-like seed coat that hinders water penetration into the seeds thus making seed germination difficult. To overcome the seed dormancy manual pre-treatment can be applied by removal of seed coat resulting to a germination percentage of about 72.6%.



Terminalia brownii fruits extraction process



Terminalia brownii seeds germinated in glasshouse



Pricked out *T. brownii* seedlings in the nursery

Figure 6:
Process of raising *Terminalia brownii* seedlings

3.2 Technologies for Breeding Tree Species for Improved Yields

3.2.1 Grafting of *Melia volkensii*

Melia volkensii is a highly preferred tree in the drylands due to its high value timber. The wood is durable and termite resistant and is therefore highly desired in construction and furniture making. *Melia* is also a fast growing tree that takes 10-15 years to reach maturity.

KEFRI has carried out *Melia* improvement through a breeding strategy for the species that involved initial selection of Candidate Plus Trees (CPTs) found in both remnant natural stands and on-farm populations. Scions from these trees were collected and used for establishment of clonal seed orchards in Tiva and Kibwezi. The improved *Melia volkensii* was used as a source of scions in order to produce *Melia* grafts. Grafting of *Melia* involved selection of second generation trees from existing progeny tests, scion collection, and consequently grafting.

The procedure of obtaining the scions involved collection of 6-7 inch scions from each selected trees, pre-treatment and labelling. Grafting of *Melia* involved treatment of scions with fungicide, top grafting, wrapping of the new graft with clear polythene tube and placement in the glasshouse for management. Weekly monitoring of the grafts was done.

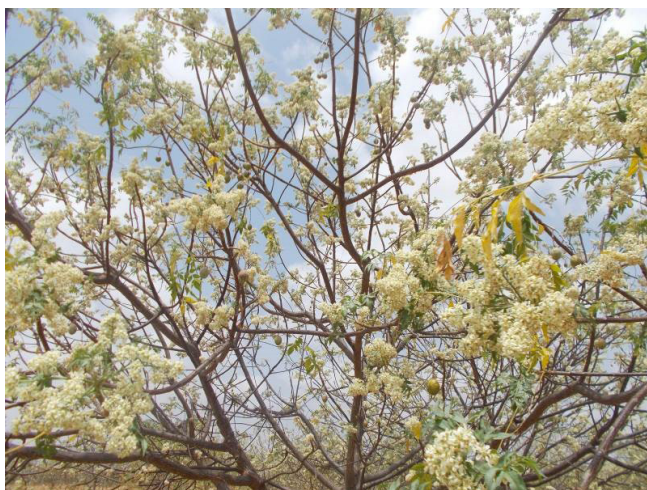


Figure 7: A 3-year old *Melia volkensii* tree flowering and fruiting in Kibwezi seed orchard flowering

3.2.2 Establishment of *Eucalyptus grandis* Progeny Trial from selected Candidate Plus Trees (CPTs)

Eucalypts are among the most widely cultivated forest trees in the world. Their adaptability, relatively fast growth rate, coppicing ability, diverse utility value and broad climatic range have endeared them to tree growers. Most plantings of eucalypts had been established to supply fibre to pulpwood markets, however interest is increasing in other products including; solid wood, veneer, charcoal and biomass. The primary markets of *Eucalyptus grandis* are sawn timber and transmission poles. *Eucalyptus grandis* is also used as a main hybrid partner parent. In Kenya the objective of breeding *E. grandis* aims to improve the species productivity, which include; fast growth, lower wood splitting, improved tree health and improved tree form.

At the beginning of the year under review, 111 *Eucalyptus* families of provenances were imported from Australia and established as new infusions to broaden the genetic base. In addition, selections were also made from Ex Zimbabwe and Ex South Africa seed stands, plantations and trees grown in tea estates where a total of 58 plus trees were selected. Seeds were collected from 52 families that were seeding. The seeds were used in the establishment of the F1 progeny trials in Nyeri, Londiani and Kieni.

Over 100 seeds from each of the 52 families were sown in the glass house in separate containers that were clearly labeled with the family codes (selection codes). Land preparation that included bush clearing and removal of any other trees and shrubs within the experimental site was done prior to planting of the seedling. Trees were planted at a spacing of 3m x 3m. General seedlings of *E. grandis* were used to plant the guard rows.



Figure 8: Raising of F1 seedlings of *E. grandis* in the glasshouse

3.3 Management Technologies for Selected Tree Species

3.3.1 Mangroves Rehabilitation: Achieving successful mangrove restoration

To achieve successful restoration and reforestation of mangrove areas, it is important that: potential rehabilitation sites be identified; the main agent of degradation determined; severity of the damage assessed; and processes to address the damage selected.

If site conditions that have been drastically changed, restoration may be initiated with *Avicennia marina*, due to its high level of tolerance to harsh conditions. For successful planting, collected propagules should be sorted based on; maturity, health, free from disease and pest attack, and physical injury and freshness. e.g. for *Avicennia*, seedling is not viable if it has lasted more than 3 days on the ground after falling.

Seeds and fruits of some mangrove species such as *Sonneratia*, *Avicennia* and *Heritiera* should be soaked in water for pre-germination. After, identifying the appropriate mangrove species, planting can be done either by; direct planting of propagules, use of wildings (seedlings that have germinated naturally in the forest) or planting nursery raised stock. Direct planting of propagules is done for mangroves belonging to *Rhizophoraceae* family (*Rhizophora*, *Ceriops* and *Bruguiera* species). These species produce large and pointed propagules that could be planted directly into the mud.



Degraded Mangrove ecosystem



Mature *Rhizophora mucronata* propagules



Mangrove seedlings in a nursery



Restored mangrove site through planting

Figure 9: Process of raising mangrove and restoration

3.3.2 Management of Major Insect Pests and Diseases of Eucalyptus in Kenya

Pests and pathogens pose one of the most serious threats to commercial farming of Eucalyptus. In Kenya, some of the most recent Eucalyptus pests include: Blue Gum Chalcid (BGC) (= Eucalypt gall wasp), *Leptocybe invasa*, and the winter bronze bug, *Thaumastocoris peregrinus* (Table 3.1).

The genus *Eucalyptus* is also affected by many diseases that affect seeds, seedlings and mature trees. Some of the major diseases reported on this genus include: damping off by *Calonectria pauciramosum*, Botryosphaeria stem cankers and leaf disease, Chrysosporthe cankers, Eucalyptus root rot caused by Armillaria and *Phytophthora spp*; wilts caused by species of Ceratocystis and Teratosphaeria – Mycosphaerella leaf disease complexes (Table 3.2).

Table 3.1: Major insect pests of Eucalyptus in Kenya

Insect pests	Host damage symptoms	Damage on trees	Management options
<i>Thaumastocoris peregrinus</i> – Winter Bronze Bug 	Leaf discoloration (bronzing, reddening, yellowing), early leaf fall and stunted growth. Heavy infestations can lead to severe defoliation, branch dieback, and eventually tree death		Biological control: A biological control agent, <i>Cleruchoides noackae</i> is available, though not yet released in Kenya
<i>Leptocybe invasa</i> (Blue gum chalcid (BGC, or Eucalyptus gall wasp) 	Trees have bump-shaped galls on leaf midribs, petioles, young twigs and the leaves appear twisted	 Coalesced galls	Chemical control for high value crop such as nursery seedlings and seed stands Biological control: <i>Seletrichoides neseri</i> (Wasp) has been identified
<i>Gonipterus scutellatus</i> Eucalyptus Snout Beetle 	Leaf damage and shoot die-back	Shoot die back 	Biological control: Use of parasitoid <i>Anaphes nitens</i>
<i>Odontotermes</i> sp. Termites	Ring barking especially of sapling, root and heartwood damage	Root collar damage 	Chemical control: Application of termiticides such as Premis, Termidor Conifidor in the soil
<i>Ctenarytaina eucalypti</i> (Blue gum psyllid)  Blue gum psyllid nymphs	Discoloration, and rolling of leaves, twig distortion, twig die-back results		Cultural control: Application of water beneath the outer canopy

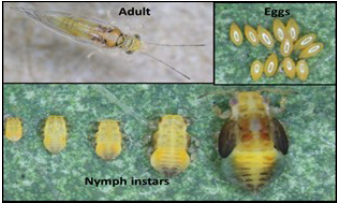
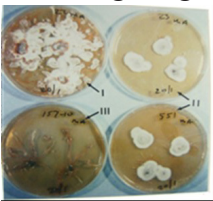
<i>Glycaspis brimblecombei</i> - Red gum lerp psyllid 	Leaves are covered with white waxy secretions, honey-dew and sooty mould Leaf discoloration and in heavy infestations, severe leaf drop and twig dieback	 Infested plantation yellowish foliage canopy, conical lerps on leaves surface, and heavy infestation with sooty mould	A biological control has been identified <i>Psyllaephagus bliteus</i> Yet to be released in Kenya
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Table 3.2. Major diseases of Eucalyptus in Kenya

Disease	Host damage symptoms	Photo of damaged trees	Management options
Root rots Pre- and post-emergent damping off mainly caused by fungi including species of <i>Fusarium</i> , <i>Verticillium</i> , <i>Pythium</i> , <i>Phytophthora</i> and <i>Rhizoctonia</i>	Root and stem collar rots Seedling death		Ensure nursery hygiene Avoid over-watering, high humidity, high seedling density. Appropriate, fungicides may be applied
Powdery mildews	Presence of white mycelia on host leaf surface Powdery appearance on the upper side of leaves	 Powdery mildews on seedlings	Prompt removal of infected plants Regular spraying with fungicides such as Ridomil, chlorothalonil, Milraz, Kocide
Canker disease of Eucalyptus e.g. Eucalyptus stem canker caused by <i>Botryosphaeria</i>	Formation of stem cankers, production of gum, stunted growth and dieback	 Canker on stem	Attacked trees should be removed to avoid the spread of the disease Ensure species site matching
<i>Mycosphaerella</i> leaf disease	Localized necrotic spots, early defoliation in juvenile plants, early death of branches, shoot die-back and stem cankers	 Diseased leaves	Use fungicides such as benomyl and chlorothalonil. Breeding for resistance disease
Armillaria root rot (<i>Armillaria mellea</i>) or Shoestring fungus 	Dying of whole trees White coating between the bark and the wood.		Removal of dead trees including roots excavation. Burn the diseased material

3.3.3 Species-Site Matching: Check List and Database of Valuable Species for Rift Valley

Trees grow best when planted on sites that are similar to the sites where their parent trees originated from. The site type is determined by; altitude, longitude, aspect, rainfall and soil.

Offsite planting manifests in less desirable features of tree form, great variation in form, losses through drought or frost, disease or pest attack, wind damage, timber defects, and low levels of seed production. Due to lack of information on site requirements of tree species, tree growers who choose to invest on tree planting and management continue to incur losses. To address these challenges, KEFRI has initiated development of an easy-to-use tree growing species-site matching database that can be queried for highly valued trees in the Rift Valley region. The trees considered are both indigenous and exotic, valuable tree species within the Rift Valley.

KEFRI undertook a study to;

1. Obtain a checklist of all tree species both indigenous and exotic currently growing on farms, in plantations and in natural forests in the Rift Valley.
2. Identify high value (tree) species of notable ecological and socio-economic importance
3. Determine ecological distribution and document bio-physical characteristics of high value (tree) species provenances

Existing knowledge on priority species was documented and a knowledge table for priority 50 species in the Rift Valley developed. Information in the table included; family, species, agro-ecological zone, rainfall (mm), r/E0 (%), altitude (m), soil depth, soil texture, temperature (deg.), propagation method and uses.

Classification of conditions for suitability mapping per species was completed for 25 species. This classification included: species, exotic/indigenous, class/conditions, rainfall, elevation, temperature, soil-pH, texture, drainage and depth.

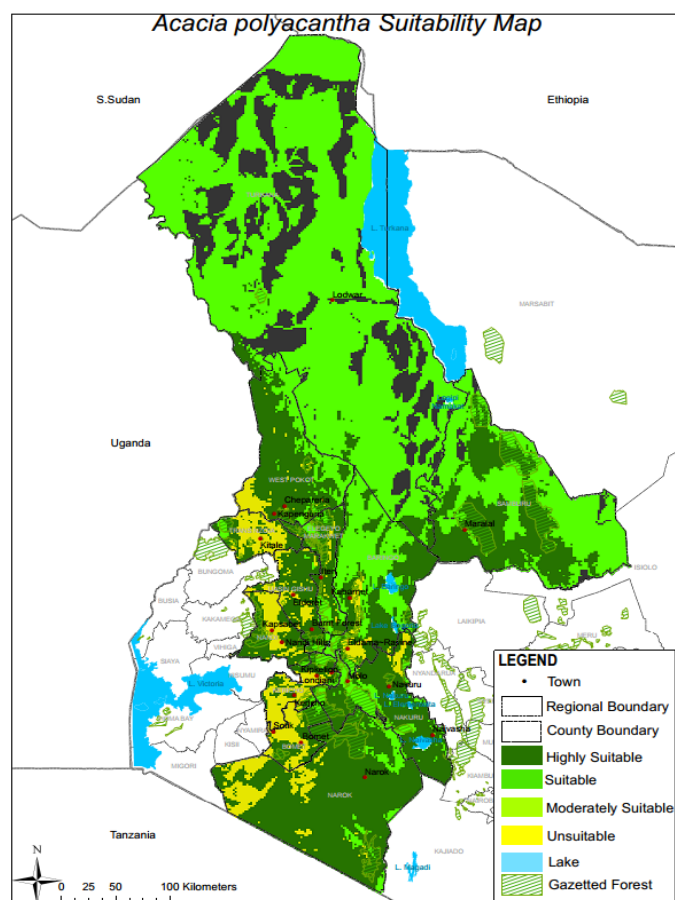


Figure 10: Suitability map for *A.polyacantha* species distribution

3.4 Indigenous Knowledge-Based Practices for Mangrove Utilization and Management in Lamu County

In Kenya, mangrove forests cover about 61,271 ha, representing approximately 3.0% of the natural forest cover. About 59% of these mangrove forests occur in Lamu County. There are nine mangrove species in Kenya, with *Rhizophora mucronata* and *Ceriops tagal* being the most dominant. Mangrove ecosystems offer a range of benefits and opportunities for local and national economic development hence the need to protect and conserve the species. The mangrove ecosystems however face serious threats associated with deforestation and degradation. The main root causes of mangrove loss and degradation include; increased population, weak governance, inadequate awareness of the true value of mangrove ecosystems, high levels of poverty, lack of alternative livelihoods, and inadequate management prescriptions. Mangrove losses in turn have negative impacts on fisheries, shoreline stability, and resource sustainability. In Lamu County, over-reliance of local communities on mangrove resources for their livelihoods presents a unique challenge to conservation of mangroves. In the past communities in Lamu used indigenous knowledge to sustainably manage the resource. A study to document indigenous knowledge-based practices associated with mangrove utilization and management was undertaken in Lamu County.

Summary of key findings

- Mangrove harvesting was the main source of livelihood as it was major source of household income, building and construction materials.
- The most preferred/utilized mangrove species was *Rhizophora mucronata* because it was abundant, has many uses, and has good form/straight boles. The least utilized/preferred species was *Avecenia marina* as it has limited uses and poor timber formation.
- Traditional knowledge and associated practices were widely applied in mangrove utilization, conservation and management. The practices included: selective harvesting guided by the intended use of the timber or poles. Harvesting was mainly done through hand tools such as hand saw and axe which are not destructive. With the use of these tools, mother trees which are big are spared. Selective harvesting opens up areas for young mangroves to grow. Mentorship or transfer of knowledge from the elderly to young mangrove cutters was practiced.
- Harvesting was guided by the seasons. During the rainy season boats cannot sail to far areas due to insufficient wind for navigation, therefore harvesting is restricted to areas close to settlements. During the dry season, winds are strong, which allows the big boats to access mangroves in far areas. This system allows for controlled harvesting, allowing for growth and recovery of already harvested areas.
- Conventional mangrove harvesting strategies currently being applied entail use of government agencies to enforce laws and regulations pertaining to mangrove utilization, conservation and management. There are increasing efforts to have joint conservation and management activities amongst various stakeholders including local communities, NGOs, CBOs and government agencies which have resulted in more community awareness on the importance of mangrove conservation.

3.5 Monitoring Tree Products Markets and Price Trends for Key Tradable Forest Products in Kenya

The Forest industry plays an important role in the socio-economic development of Kenya. The industry is one of the key sectors identified by the Vision 2030 as critical to sustainable development in the country. According to KNBS Economic Survey 2019, forestry and logging contributes 1.3% to the GDP a value which excludes provision of environmental services and contribution to other sectors of the economy.

Over the past few decades, the forestry industry has been faced with numerous challenges. Imposition of a moratorium on logging in public forests has further affected the industry leading to increase in prices of timber over the past two years which has directly affected many players in the sector. The key primary and secondary

forestry processing actors in the country include; saw millers, reconstituted wood manufacturers, utility pole manufacturers, charcoal producers, wood carvers, paper and paper product manufacturers, biomass energy producers, and non-timber producers. The major wood products traded are sawn wood, transmission poles, construction poles, charcoal and industrial firewood. In 2019/2020 KEFRI conducted a study to record price change updates and identify opportunities and constraints in trade in forestry products in Kenya. The study was conducted in Western, Rift Valley, Central Kenya and Coastal regions, and focused on the key forest products, industries and players that included; timber traders, sawmills, treatment plants, charcoal dealers, fencing and construction poles/posts dealers.

3.6 Prices of Wood Products

3.6.1 Sawn wood prices

Prices of sawn wood varied with regions. Cypress sawn wood was the most scarce and expensive in all the major markets visited countrywide. The scarcity can be attributed to the moratorium on logging which was imposed in public plantations in February 2018. The prices of cypress sawn wood ranged from KES 62 per board foot in the Rift Valley region to a high of KES 110 per board foot at the coast. Eucalyptus and Grevillea sawn wood were available which was attributed to supply from farmlands. The prices of Eucalyptus and Grevillea sawn wood ranged from a low of KES 32 per board foot in the Rift Valley and parts of central Kenya to KES 117 at the coastal region. Traders were finding it difficult to sell cypress and pine timber owing to their high prices as consumers preferred cheaper Eucalyptus and Grevillea timber.



Figure 11: Eucalyptus logs (Left) and timber in Machakos County

3.6.2 Prices of construction poles

Construction poles found in most urban areas were mostly harvested from Eucalyptus and *Casuarina equisetifolia*. Demand for poles has been on the rise over the years due to vibrant construction activities taking place in various towns in the country as a result of devolution. Pole prices varied depending on the species type, diameter and height. Eucalyptus was the most dominant and preferred species for construction poles in all the markets surveyed and prices varied in different towns. For small, medium and large poles prices were KES. 100 to 250, 110 to 400 and 200 to 500 respectively as shown in Table 3.3

Table 3.3: Retail prices for untreated construction eucalyptus poles (15-18 ft long) in selected towns

Town	Prices (KES) of construction poles in 2020		
	Small (3")	Medium (4")	Large (5")
Nairobi	150	200	300
Mombasa	225	310	325
Kisumu	150	180	300
Nakuru	120	150	250
Eldoret	100	110	200
Embu	120	150	200
Nyeri	180	215	325
Kitui	180	250	350
Malindi	250	400	500
Machakos	145	175	215
Kitale	120	200	300
Kericho	120	180	250
Kisii	150	250	350
Embu	130	180	250

3.6.3 Transmission poles prices

Imposition of the ban on harvesting in public forests temporarily affected operations of treatment plants in 2018, after which operations resumed. The industry has been affected mainly by production of concrete poles which are used by Kenya Power and Lighting Company. Majority of the plants have diversified production to two lines; one for treated poles and the other for concrete poles. The transmission pole industry has also shifted from poles for electricity to making reconstituted timber products such as Medium Density Fibreboard. This shift was mainly attributed to imposition of the moratorium on logging in public forests and emergence of new technologies for timber processing in the market. Prices of poles at farm gate have remained relatively stable with a 10-meter-long pole with 5"-7" inch top diameter retailing at between KES 2,500 to 3,500 in most markets in the Rift Valley and Western Kenya. The prices of treated poles ranged from KES 330 for short length poles used in fencing to KES 11,170 for poles used for transmission poles.

3.6.4 Charcoal prices

Imposition of the forest moratorium also affected the charcoal industry. Most of the charcoal being consumed in major urban towns of Nairobi, Mombasa, Kisumu and Nakuru are imported from Uganda and South Sudan. Import data from Busia and Malaba border points indicated increased imports of charcoal over the past two years mainly from Uganda and South Sudan. The landing cost of charcoal at the border point ranged from KES 700-1,600 depending on the quality, and sold at an average of KES 2,500 in Nairobi and other major urban centres in the Country.



Figure 12: Charcoal assembling at Busia Border

3.6.5 Industrial firewood prices

The ban on logging affected major consumers of firewood i.e. KTDA affiliated tea processing factories, BIDCO and industries dealing in textile and food processing within Nairobi, central highlands and Rift Valley. Prices of industrial firewood ranged from KES 2,000 to 2,500 per m³.

Challenges facing the forest products markets industry include;

- Scarcity of cypress timber mainly attributed to the moratorium on logging in public forests imposed in 2018.
- Prices offered to farmers by middlemen on-farm are exploitative for instance the traders offer farmers prices based on tonnage measured by truck capacity e.g. a 3.6 tonne lorry would fetch a farmer KES 50,000 as opposed to individual valuation of trees. Others offer prices of between KES 800 to 7,000 per tree depending on tree size which is generally low
- Most of the timber sourced from the farms was of small size as the trees are harvested before reaching their maturity period
- Most of the forest products businesses had scaled down operations mainly attributed to the moratorium on logging in public forests

4.0 DEVELOPMENT, REFINEMENT, PROTOCOL DEVELOPMENT AND LINKING TREE PRODUCTS TO MARKETS

Through development and promotion of wood and non-wood forest products (NWFPs) as alternative sources of income, KEFRI contributes to improved livelihoods of Kenyan communities. The communities are in turn motivated to conserve 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 2019-2020 KEFRI developed and refined new products, developed processing protocols, and linked various technologies to markets.

4.1 Development of New Tree Products

4.1.1 Developing jam from Guava fruits

Guava, (*Psidium guajava*) is a small evergreen fast-growing tree reaching to a height of 3-10 m. The species has its origin from Southern America. Guava is also cultivated in Africa, mainly grown for its edible fruits that are eaten raw or made into pulp, jam, jelly, paste, juice, syrup and chutney. In Kenya, Guavas are mainly consumed at household level, but there is need to promote commercialization through development of diverse products.

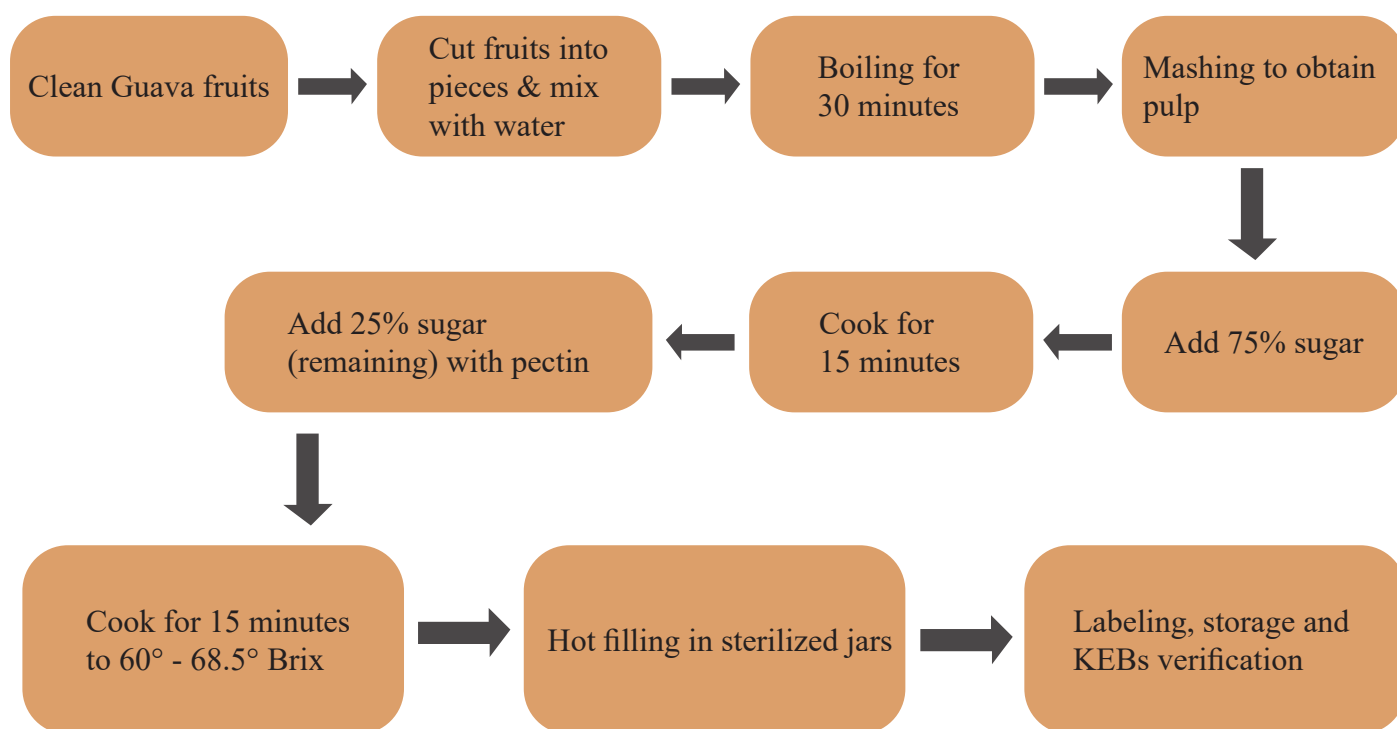


Figure 13: Flow chart showing processing of Guava jam

The taste, colour, aroma and texture/spreadability of the jam produced was good. The jam consistency compared well with commercial products. The jam passed Kenya Bureau of Standards (KEBS) verification test, however there is need to undertake further test on its shelf life.



Figure 14: Indicating processing of Guava Jam from ripe fruits to packaging

4.1.2 Development of Soap from Mangrove Leaves and Bark

Mangroves are evergreen salt-tolerant trees and shrubs growing in sheltered tidal waters between low and extreme high-water spring tides on tropical shores. The most common species along the Kenyan coast are *Rhizophora mucronata*, *Ceriops tagal* and *Avicellllia marina*. The coastal communities have been using Mangroves as sources of medicine among other uses such as timber, fuelwood and fish traps. The bark of *Rhizophora*, *Bruguiera* and *Ceriops* was once used for tannin production, has insect and worm repellent, and is used to preserve fishing nets, ropes and sails from destruction from water and organisms.

Mangrove plants are potential sources of biologically active chemicals that have high application in ethno-pharmaceutical and are largely used for medicinal purpose.



Bruguiera gymnorhiza



Mangrove soap

Figure 15: Preperation of medicinal soap from Mangrove

In the year 2019/2020 KEFRI developed an antibacterial soap from the leaves and bark of mangroves. Formulation of the anti-microbial soap from the bark of mangroove also incorporated other ingredients i.e. coconut oil, glycerine, water, caustic soda, sodium silicate, aloe sap and preservative.

Qualitative and quantitative screening and mineral analysis of the selected 5 mangrove plants revealed that the major classes of phyto-compounds and elements were present which can be used to develop new pool of natural products.

4.2 Refinement of New Tree Products

4.2.1 Refining Development of Detergent from *Sesbania sesban*

Sesbania sesban grows widely in arid and semi-arid areas. The tree contains saponins which have detergent properties and give stable foams in water with ability to lather. Saponins extracted from *Sesbania sesban* have potential for beneficial pharmacological effect which can be used to develop surfactant-based products, such as detergent and toothpaste. During the year under review, KEFRI developed soap and laundry detergent with natural anti-fungal and antimicrobial properties. Liquid detergent and solid soap were successfully developed from *Sesbania sesban* leaf extract. The detergent is multipurpose and can be used in a wide array of cleaning activities.

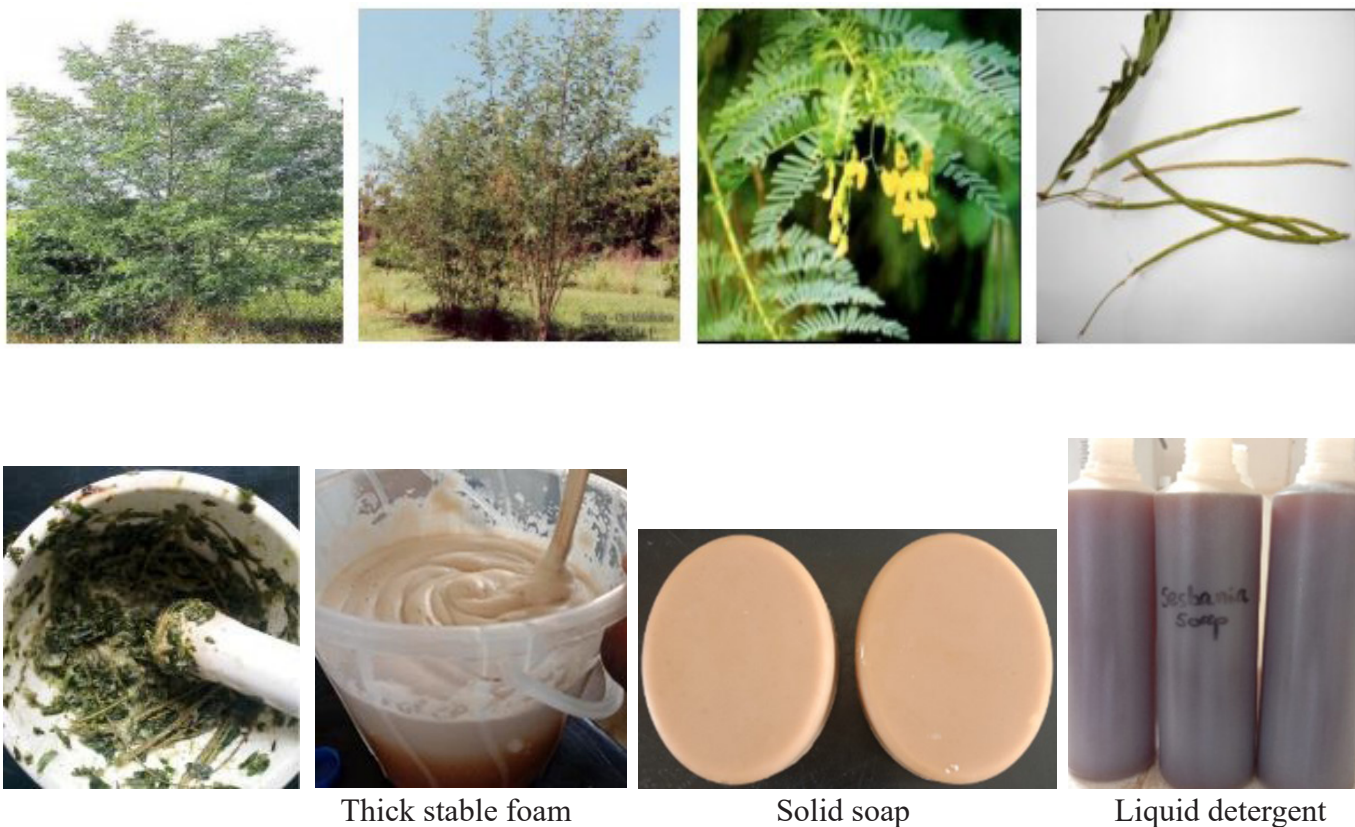


Figure 16: *Sesbania sesban* tree features (above) and process of preparing soap and detergent

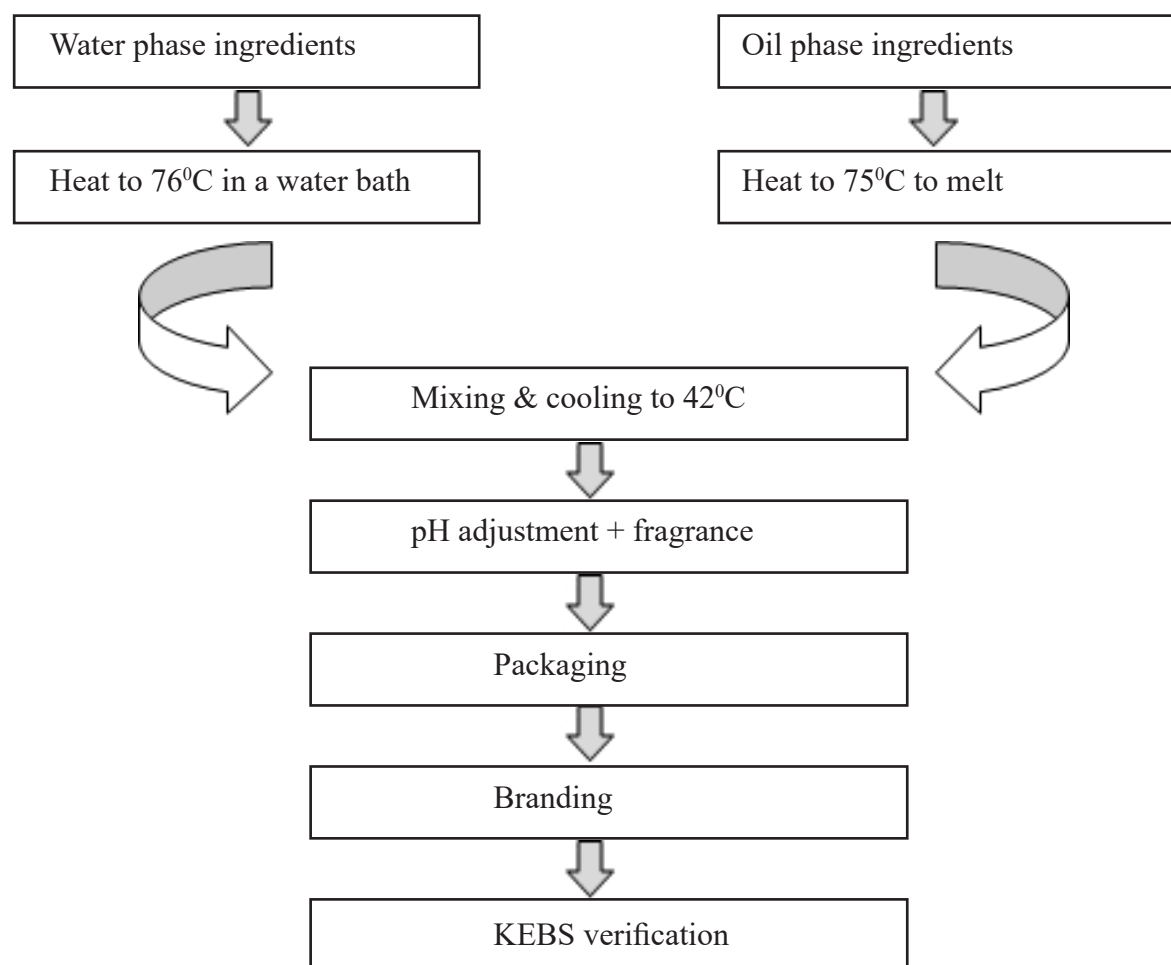
4.2.2 Refining Lotion from *Ximenia americana* Seed Oil

Ximenia americana commonly known as wild olive or sour plum is a semi-deciduous shrub that usually grows up to 6 m tall. The species is a drought resistant widely distributed in hot and low-altitude regions between 900-2000 metres above the sea level and mean rainfall of 300-1250 mm.

The species has great potential of producing *Ximenia* oil valuable due to presence of fatty acids that make it stable to oxidation. The oil is used to develop cosmetic products such as lotion, antiseptic soap and facial cream. KEFRI refined hand and body lotion from *X. americana* for uptake by SMEs

Other components used in preparation of the lotion were; distilled water, Glycomonostearate(GMS), Lanolin, Propylparaben, Methylparaben, Cetyl sterolalcohol (CSA), Glycerin, Triethanolamide (TEA) and Tea tree oil (Fragrance).

The pH was monitored before it was dispensed into cream containers and labelled. The lotion developed was verified for suitability as skin care in accordance with KEBs standard (KS 580:2006)



Ximenia oil



Ximenia lotion

Figure 17: Flow chart showing process of refining *Ximenia* oil and lotion

4.2.3 Refining of Bathing Soap from *Osyris lanceolata* Extract (Sandalwood oil)

Traditionally, *Osyris lanceolata* (sandalwood) oil has been used as an astringent and antiseptic for management of headache, stomach-ache and bacterial infections. In some African communities, the paste or the essential oil of sandalwood has been used in treatment of skin conditions and inflammatory diseases. Sandalwood wood and roots produce essential oil that is used for processing of various luxurious cosmetics, perfumes and fragrances.

KEFRI in 2019/2020 refined the earlier developed bath soap from *Osyris lanceolata* extracts and ascertain its compliance with the required standard (i.e. KS580:2006). Ingredients used for making the soap are; Sandalwood hydrosol/distillate, sandalwood essential oil, coconut oil, caustic soda and glycerine.

Refined process of soap making from Sandal wood

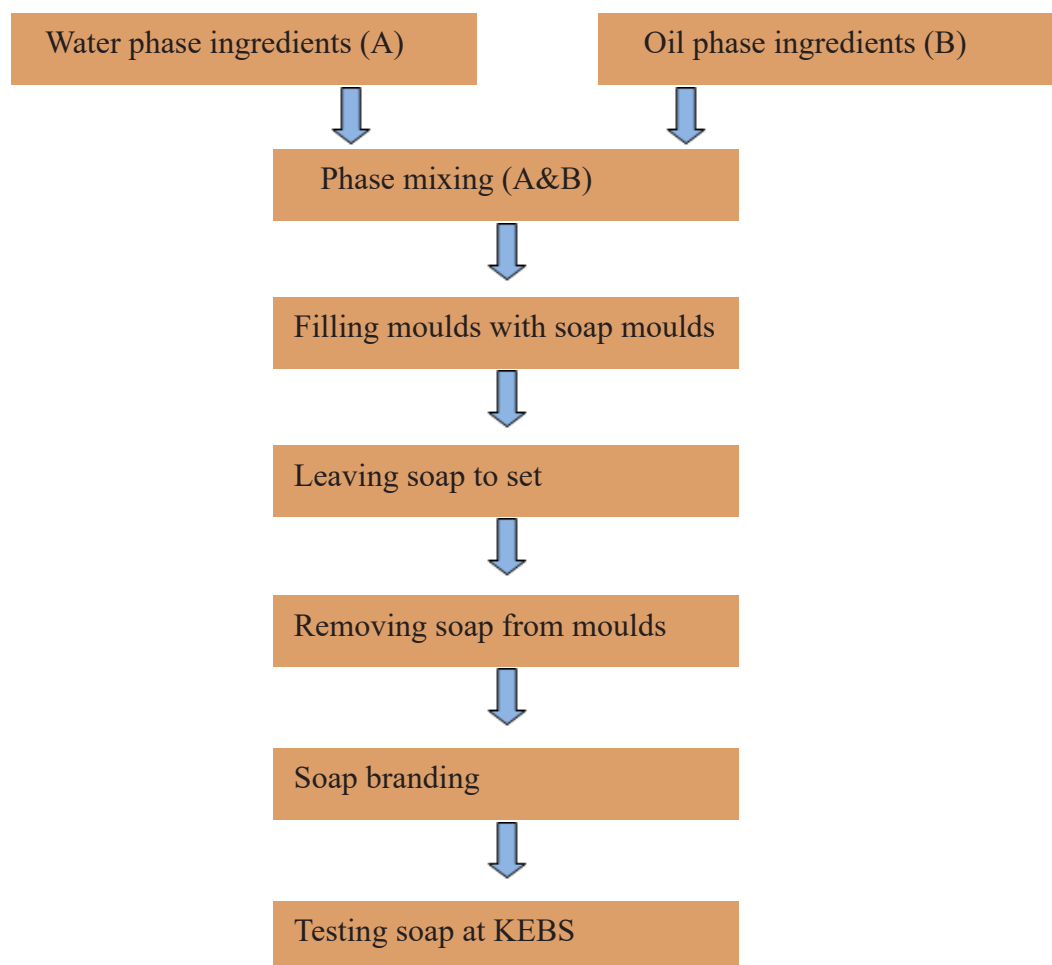


Figure 18: Process of refining soap from sandalwood

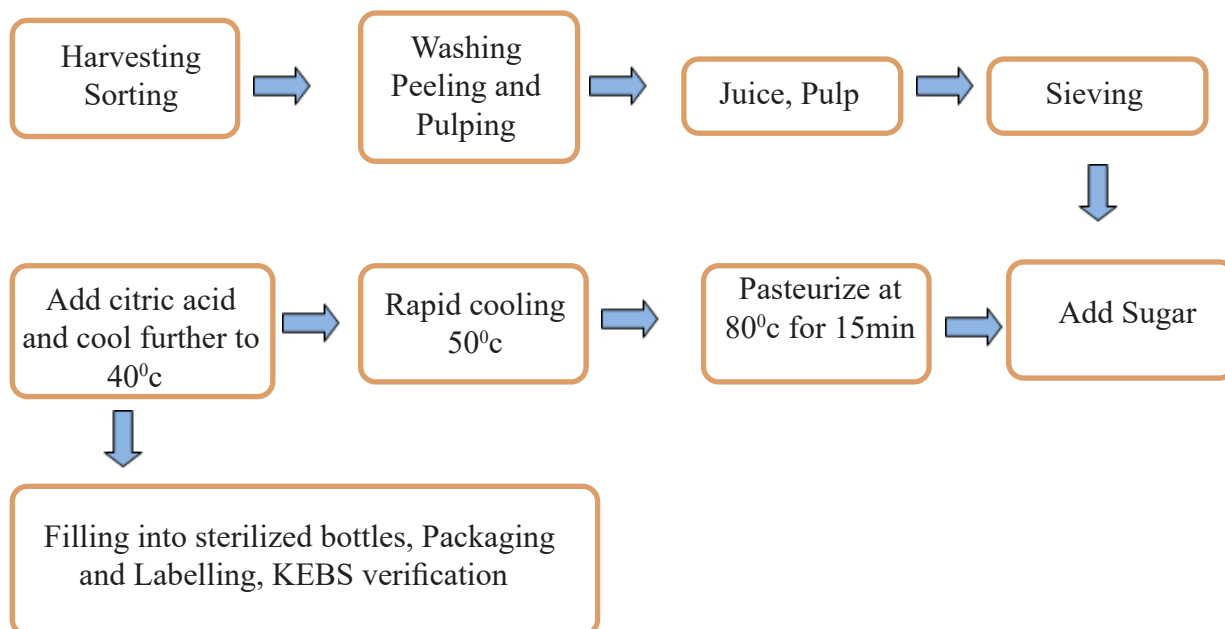
Results from KEBS indicated that sandalwood soap conformed to the following parameters; Free caustic, Freedom from grittiness, Mush and Total fatty matter. Results for lather were slightly lower (190 ml) than the minimum requirement of 200 ml while that of total alkalinity was above the required maximum levels of 1.0%. Although the sandalwood soap developed can effectively serve as cleaning agent for removal of dirt and microorganisms from skin, it needs to be refined further to meet the consumer expectations and to conform with the KEBS standards.

4.4 Linking New Products to Markets

KEFRI linked refined products to Small and Medium Enterprises (SMEs) by training communities in Meru County on Amarula (*Sclerocarya birrea*) juice processing, and Tharaka Nithi County through Tharaka Green Gold Capacity Enhancement Network on soap making.

4.4.1 Linking Amarula Juice Production

Ingredients used in production of Amarula juice include; Amarula fruit pulp water, sugar and -citric acid preservative.



Process of Marula juice



Pasteurizing juice



Rapid cooling



Filling of juice into sterilized bottles

Figure 19: Flow Chart and plates indicating process of preparing Marula juice

4.4.2 Linking Soap Production from Neem and Tamarindus

Making of tamarindus bathing soap and neem bathing soap were carried out as per the Kenya standard for cosmetic creams specification (KS 580; 2006)

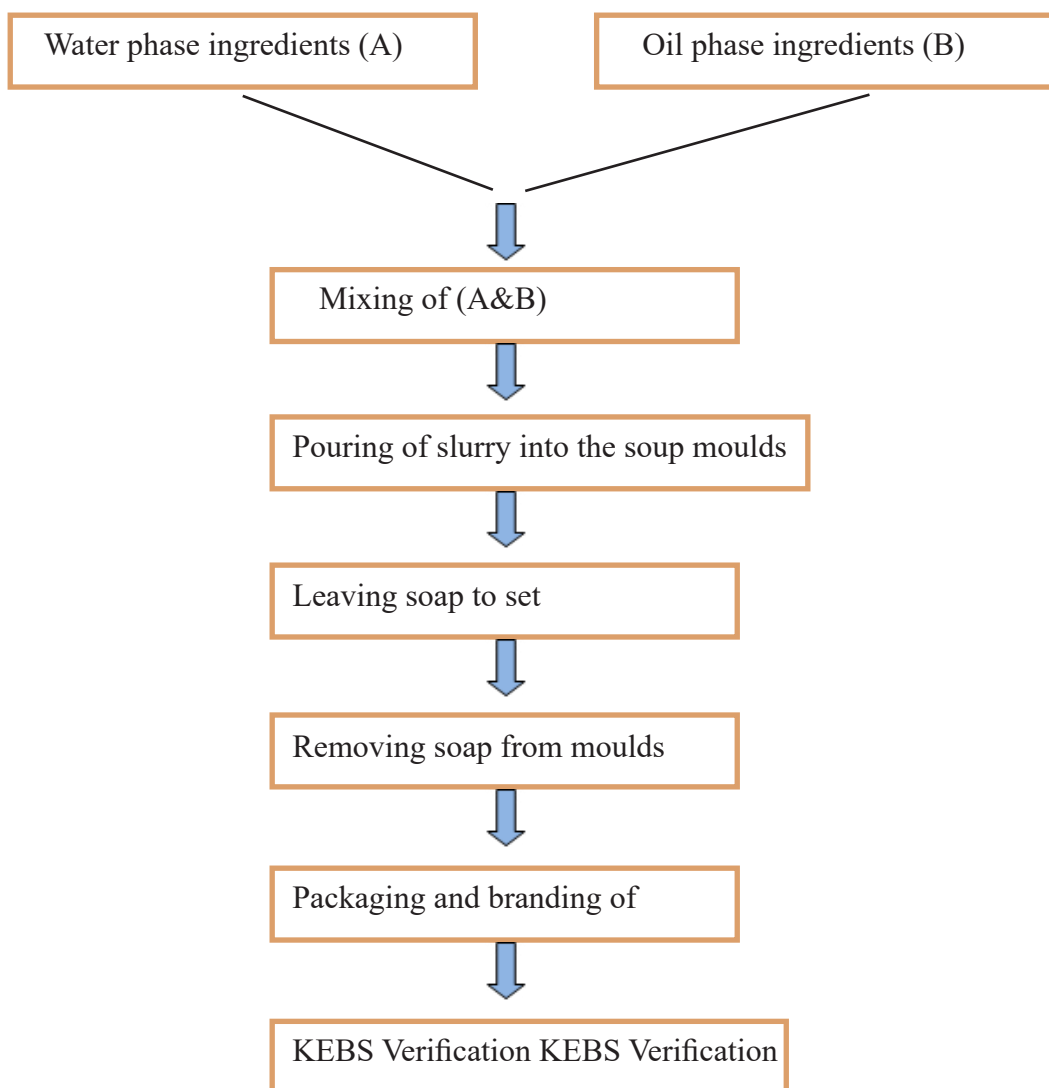


Figure 20: Flow Chart Showing process of preparing Tamarindus bathing soap

Soap making process flow chart



Filling in the mixture into soap moulds



The dark coloured soap is from Tamarindus pulp while the cream coloured soap is from Neem oil

Figure 21: Soap making process and hardening

5.0 DISSEMINATION AND PUBLICITY ACTIVITIES

During the Financial Year 2019/2020, KEFRI continued to entrench corporate communication to disseminate research findings for adoption and up scaling forestry technologies to stakeholders and strategically profile the organization at national and international level.

These functions were accomplished through various publicity events branding of products, corporate social responsibility, and seeking feedback from stakeholders.

5.1 Dissemination of forestry technologies through exhibitions, and mass media

KEFRI exhibited several technologies in 11 Agricultural Society of Kenya (ASK) shows across the regions under the theme “Promoting Innovation and Technology in Agriculture and Trade”. The show offered KEFRI opportunities to display and demonstrate technologies on tree seeds production and marketing, tree improvement and IPM, conservation and rehabilitation of ecosystems, value addition to wood and non-wood forest products, and to seek collaboration with exhibitors/partners at regional, continental and global. KEFRI emerged winner under the Seed Production and Marketing category at the Nairobi International Trade Fair and Central region ASK show – Kabiruni Nyeri County. KEFRI stands in other regions were rated and awarded trophies and certificates for the performance in various categories as indicated in (Table 5.1):



Figure 22: CS Environment and Forestry Keriako visiting KEFRI stand

Table 5.1: ASK performance in various categories

Name	Theme Int’p	Res & Dev	Seed P&M	Non-Agri. Based SB	Ap. EQS	Inov & Inv	Energy Conser	Youth A, E& C B	Gvt Min Stand
Nakuru 3 rd - 7 th July 2019	3 rd	3 rd	3 rd		3 rd		3 rd		
Kisumu 24 th - 28 th July 2019	3 rd	3 rd		3 rd	3 rd				
Mombasa 4 th - 8 th Sep 2019									
Nyeri 11 th - 14 th Sep 2019	2 nd	2 nd	1 st		1 st				
Nairobi ITF 29 th Sep - 6 th Oct 2019	1 st	1 st	1 st						
Kabarnet 12 th - 14 th Sep 2019	2 nd	1 st			1 st		1 st		
Kitale 18 th - 21 th Sep 2019	2 nd				1 st				
Migori 10 th -12 th Oct 2019	1 st	1 st		1 st				2 nd	3 rd
Eldoret 4 th -7 th Mar 2020	3 rd	3 rd	1 st						
Kakamega 29 th May to 1 st June 2020	Undone due to Lockdown as the country managed COVID 19 pandemic								

Key

Theme Interpretation (TI), Research & Development (Res&D), Seed Production &Marketing (Seed P&M), Non-Agricultural Based Statutory Board, Youth Affairs, Empowerment and Capacity Building, Innovation and Invention, Energy Conservation, Government Ministries Stand

5.2 Field / Open Days

The Institute organized 40 field days and 6 open days countrywide to demonstrate forestry technologies and disseminate information. Themes for these events are summarized as follows:

- Conservation and rehabilitation of degraded hilltop forests, wetlands, riverine and water catchment areas using bamboo and indigenous tree species.
- Propagation, management and utilization of bamboo, East African sandalwood
- Propagation, management and utilization of *Osyris lanceolata*
- Management of commercial tree woodlots of - *Eucalyptus*, *Gmelina arborea*, *Casuarina equisetifolia*, *Grevillea robusta*, *Melia volkensii*, *Milicia excelsia*, *Tectona grandis*, *Vitex keniensis*.
- Conservation of *Acacia tortilis* in *Prosopis* invaded areas.
- Integrating agroforestry technologies – for fodder crop, soil fertility improvement and water retention in fragile ecosystems.
- Management of invasive species such as Dodder and *Prosopis juliflora* (Mathenge)
- Value addition to wood and non-wood forest products eg: *Aloe turkanensis* and *Mondia whytei*,
- Charcoal production and briquettes making techniques using *prosopis* and bamboo.
- Value addition to gums and resins,
- Indigenous fruits - *Tamarindus indica*, *Vitex payos*, wild *Guava*.

5.3 Mass and Social Media Publicity

a. Print media

KEFRI featured various articles in newspapers and magazines, Annual reports, leaflet, flyers, newsletters, scholarly journal and posters. The articles featured technical articles in simplified language understandable to the general public

b. Radio Talks and TV show

The Institute used mainstream media both national and the county FM radio station, television, as well as social media to create awareness of various forestry issues as well as mobilize the public to various institutional events. Six radio talks and 8 Television appearances were accomplished during this financial year featuring topical issues on: the essence of growing more trees to achieve the 10% tree cover; adoption of Mukau (*Melia volkensii*) for conservation of environment and livelihood improvement in the dry lands; research and development agenda for drylands and Lake Victoria Basin; rehabilitation of degraded hilltop forest and riparian areas; growing bamboo for environmental protection and livelihood improvement.

5.4 Partaking in other stakeholder's dissemination activities

The institute participated and exhibited technologies in other national, regional and international environmental and forest forums. During the implementation of the National Tree Planting Programme that aligns to Presidential order of planting 1.8 billion trees to increase the forest cover to 10% by 2022, for the very first time in Kenya, KEFRI through the Ministry of Environment and Forestry used aerial seeding technique to disperse 1.9 tonnes of tree seeds of 13 species to restore the 22,000 hectares of the Maasai Mau forest/water towers. It also supported in planting over 81,342 tree seedlings in counties of eastern and coast regions during the short rains season October to December 2019.



Figure 23: KEFRI display in Mugumu Tanzania

The institute was represented in the World Environment Day (WED), International Day of Forests (IDF), World Drought and Desertification Day (WDD), 8th Mara Day Celebrations held in Mugumu, Tanzania and County devolution conference in Kirinyaga County, and the International Union of Forest Organizations (IUFRO) Congress, held at Curitiba, Brazil 29th September – 5th October 2019.

5.5 Corporate Social Responsibility

KEFRI donated tree seeds, seedlings, trophies, beehives, water tanks and foodstuff to support needy communities.

The Choir participated at internal and national events to raise KEFRI profile and peddle national cohesion whereas staff also participation in environmental awareness campaigns, clean up exercises and philanthropic fund-raising events.

5.6 Publications

In the year 2019/2020 the institute produced various information products as indicated in Table 5.2

Table 5.2: Types of publications produced in 2019-20

Type of Publication	Number
Peer reviewed journal papers	18
Technical Notes/Research notes	2
Guidelines/extension materials	10
Policy briefs	1
Book (consisting 8 Technical /Research Notes)	1
Total	32

Over 6, 720 publications were distributed to stakeholders through regional programmes and other dissemination avenues. Additionally, 756 publications categorized in 5 communities which include: KEFRI Publications; Books and Book Chapters; Policy Documents; Theses; and Sleek Programme on Climate Change were reserved in an online central institutional repository.

5.7 Building Capacity of KEFRI Partners

KEFRI conducted capacity building for partners and communities to adopt and upscale forestry technologies for environmental conservation and livelihood improvement. Participants were drawn from national and county governments as well as international level institutions. The contemporary trainings were implemented using different approaches including presentations, interactive discussions, demonstrations, case studies, and excursions to selected field sites.



Figure 24: Staff participating at Standard Chartered Nairobi marathon 2019



Figure 25: Demonstration propagation of Sakura tree (*Prunus puddum*), a deciduous cherry tree found in Asia, to pupil of Nairobi Japanese School

Table 5.3: Capacity building for KEFRI partners and Communities

Course	Objective	Target group	Duration	Remarks
Technical Study Tour on Peri-urban Farming to Build Resilience to Climate Change	To strengthen the capacity of Project Implementation Unit (PIU) members to implement integrated farming system and restore deteriorated soil fertility	10 PIU from South Sudan and 2 JICA officers at South Sudan office	24 th to 28 th February 2020	
Capacity Development Project for Sustainable Forest Management in the Republic of Kenya (CADEP-SFM) Component 5	Expose participating farmers to good practices in natural resource management, as well as motivate them to adopt the good practices observed in the field	18 participating farmers selected from various regions and counties	8 th to 13 th March 2020	Due to COVID-19 pandemic the activity was deferred
Regional training course on Forest Genetic Resources (FGR) by the UK Centre for Ecology and Hydrology, University of Oxford	Induction to the principles of genetic conservation of tree species	Research institutions and universities in Kenya	3 days from 10 th to 12 th December, 2019	

The Institute also trained local community groups on: propagation, management and utilization of bamboo and East African Sandalwood (*Osyris lanceolata*) in Siaya, Kericho and Kiambu County; non-timber forest products in Samburu, Isiolo and Laikipia counties; farmer's exchange visit-in Embu and Taita Taveta counties; management of *Prosopis* in Shompole, Kajiado County; youth and women groups in tree nurseries establishment and management in Transmara, Narok County; and establishing and managing botanical garden by Njuri Ncheke council of elders in Meru County. KEFRI interactive database on forest health (insects, pests and diseases) was also updated.

6.0 KEFRI PARTNERSHIP AND RESOURCE MOBILIZATION

During the Financial Year 2019/2020, KEFRI undertook various activities outlined in the KEFRI Guidelines and Resource Mobilization Strategy 2018-2022 to enhance networks and linkages with partners and stakeholders at national and regional level, willing to compliment research and development initiatives.

6.1 Enhanced linkages and partnership

The Institute continued with identification of funding gaps, avenues to increase revenue, and improve resource mobilization for research and development, assessment of exclusive research concepts, proposal and letters of interest requiring donor financial support. Bids were submitted for consultancy in several areas of natural resource management. Additionally, there were smooth interaction with 26 strategic development partners from public sector, private sector, universities, development partners, academia, media, NGOs, and CBO with mutual interest in specific area of cooperation.

6.2 Increase partnership for joint research and resource mobilization

KEFRI refined proposals developed with Global Climate Fund (GLF) in 2017, JICA Priority research areas and 15 proposals were submitted to the Ministry of Environment and Forestry to assist in fund raising. There was advanced interactions with partners namely; Ministry of Education, UNDP, Kenya Water Towers Agency, NEMA/Treasury, Hydroquip Limited, Net fund on collaborations and proposal writing process.

6.3 Strengthening uptake of forest technologies through Public Private Partnerships

The institute signed Memorandum of Understanding (MoUs) with partners namely; World Vision Kenya, Nyeri, Kitui, Meru and Turkana counties, Kipsinende technical Training Institute, Komaza, Mianzi Designs, Garissa University, NAGAAD Limited and Tsavo Heritage Foundation. Other MoUs were shared with Savannah, Garissa University, Hydroquip Limited on production of liquid fertilizer potential from invasive species, hyacinth and other waste matter.

KEFRI and KFS agreed on research and management liaison activities, identified membership of Technical Liaison Committee (TLC) from the collaborating institutions, and the launch of the workforce.

6.4 Resource mobilization strategy

In the reporting year, KEFRI faced challenges of dwindling GoK and shifting donor funds amid desert locust invasion and COVID 19 pandemic. In retrospective, the Institute heightened domestic resource mobilization efforts through: pursuing increased GoK programs; identification and development of 21 project proposal and 15 concepts; consultancy bids in forestry research development and natural resource management for consideration for the national and international competitive grants.

The following proposals were developed and submitted to leverage collaborative partnership in the journey towards sustainable financing in forestry research and development.

- Discussions over funding on Four (4) proposals are ongoing with UNDP, GoK, Africa Development Bank and UNIDO.
- Fifteen concept notes under Kenya climate smart agriculture to World Bank for consideration
- Six KCSAP full proposals developed and funded
- Developed 3 proposals to respond to call by National Research Fund
- Developed 2 proposals in response to call by inclusive conservation initiative with 2 partners.
- GCF proposal under IUCN (2016/2018) TWENDE: Toward ending droughts emergencies, ecosystem-based adaptation in Kenya's arid and semi-arid rangelands. Through conservation international KEFRI is to participate under activities on gums and resin
- Developed proposals on KCSAP, GEF 6 first funding, and Foundation Franklinia on conservation of endangered tree species in the eastern Arc mountains forests of Taita hills, Kenya.



Figure 25: KEFRI Director and Kipsinende TTC officials exchanging a memorandum of understanding at KEFRI headquarters



Figure 26: KEFRI Director meeting with delegates from the University of Eldoret seeking to strengthen partnership in forestry research and capacity building

7.0 HUMAN RESOURCE MANAGEMENT, ADMINISTRATION AND IMPROVEMENT OF WORKPLACE ENVIRONMENT

During the year 2019/2020, KEFRI undertook human resource management, and infrastructural development.

7.1 Staff Establishment

The Institute as at 30th June 2020 had 857 employees out of which 748 are on permanent and pensionable terms of service whereas 106 are on contract terms.

Table 6.1: Staff strength in the FY 2019-2020

	Cadre	Number of staff
1	Research scientist	99
2	Technologist	42
3	Technician	46
4	Forester	21
5	Finance	40
6	Audit	7
7	Human resource	5
8	Administration	16
9	Supply chain management	32
10	Other professional support	75
11	Other support	474
	Total	857

7.2 Recruitments and selection

To address identified skill gaps in various research and development themes, KEFRI recruited twenty six (26) staff with nine (9) being on permanent and pensionable terms of service and seventeen (17) being on contract. All positions were competitively recruited internally and externally and in consideration of gender parity.

7.3 Training and Development

To improve output of the staff, KEFRI continued building capacity of staff through assorted trainings. The Institute supported; 3 on-going Doctoral studies, 4 on-going MSc and 141 staff at Kenya School of Government (KSG) and various in-house trainings.

Staff were also trained on: skills for developing award winning proposals; carrying out research and analysis towards result oriented targets; and matters of national development process including policy formulation and budgeting.

7.4 Internship

To comply with the Government directives to transfer knowledge by offering youth internships and industrial attachments, the Institute engaged a total of twenty-six (26) interns for the year 2019 who were posted to various Centers and Sub-Centers.

7.5 Infrastructure Development

During the FY 2019/2020, KEFRI continued to expand; infrastructures, maintenance and repair of buildings, installation of generators and water pumps, as well as ground maintenance. The activities were carried out at the headquarters and in the eco-regions and sub-centres to devolve services as well as research implementation activities and dissemination of technologies. Some of the highlights include: initial establishment of facilities Rumuruti Sub-centre in Laikipia County, which started within the year under review; restoration of Lodwar Sub-centre for re-occupation after destruction by floods, and construction of Bamboo processing plant at Migori Sub-centre.



Figure 27: Fenced 6 of the 24 acres and nursery house at KEFRI Rumuruti sub region



Figure 28: Bamboo Processing Plant at KEFRI Migori sub-centre

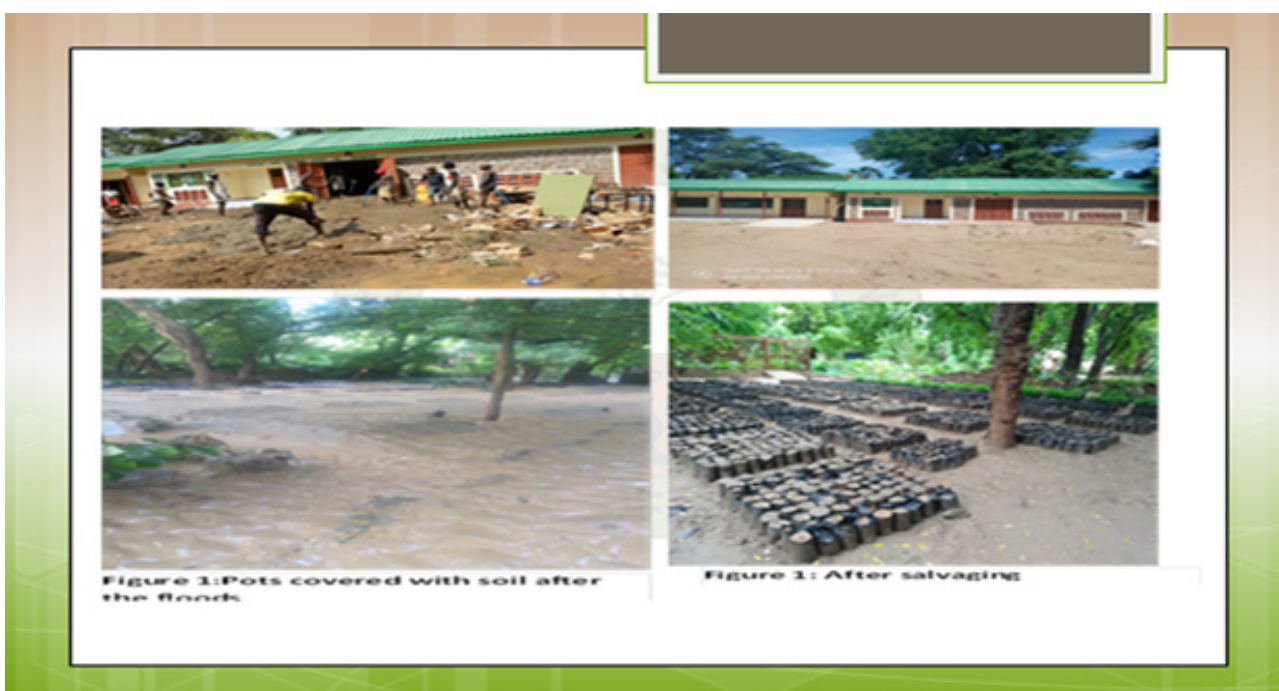


Figure 29: Restoration of KEFRI Lodwar sub-centre

8.0 WORK ENVIRONMENT AND OSHAS

In consideration that workplace environment can lead to increased productivity, improved morale, fostered growth and collaboration, KEFRI implemented several safety and security measures to achieve a positive working environment embracing employee safety, growth and goal attainment.



Figure 30: A display of Occupational Health and Safety Act, 2007, and tools for environmental safety and health

During the Fiscal Year 2019 -2020, the Institute renewed its work place permit from Directorate of Occupational Safety and Health Services (DOSHS) and renewed certification to the Integrated Management System ISO 9001:2015 and ISO 14001:2015 standards. Additionally, the Institute undertook IMS internal audits and management review, developed and maintained all the required documentations with conformity to Integrated ISO standards, Occupational Health and Safety Act, 2007 Employment Act, 2007, work injury benefits Act, 2007, and other legal requirements on work place safety.

The Management also conducted audit survey in Kitui, Londiani regional centres and Turbo Kibwezi, Taita Taveta and Garissa sub-regional centres to assess compliance to applicable statutory and regulatory requirements as well as compliance to the requirements of the performance contract. The audit assessed the adequacy of integrated management System objectives, control of documents and record, awareness of the policy, compliance to applicable legal and statutory requirements. Largely, it was observed that the sub-centres have put in place measures required to eliminate risks and hazards to employees' health and safety and have complied with the requirements of the Occupational Safety and Health Act of 2007. The work environments were conducive to a successful workforce, and related matters such as adherence to the Ministry of Health measures towards COVID -19 pandemic.

Other than Compliance to IMS, the Institution also undertook; development and submission of Disability mainstreaming policy and the annual work plan; Waste management mechanism to reduce environmental impacts; Safety and health; Awareness trainings and prevention of HIV infections; Safety promotions and campaigns such as attainment of Universal Health Care at the workplace; Business continuity and disaster preparedness planning; Emergency preparedness and response.

Appendix 1:

KEFRI Publications Produced in FY 2019 - 2020

Journal papers

1. Kitheka E., Kimiti J., Oduor N., Mutinda J.W., Ingutia C. and Githiomi J. Factors Influencing Adoption of Biomass Energy Conservation Technologies in Selected Areas of Kitui County, Kenya. *Journal of Environmental Science and Engineering A* 8 (2019) 70-81. doi:10.17265/2162-5298/2019.02.003
2. Luvanda A.M., Kamau C.N., Uchi S.M., Bala P., and Okeyo M.M. 2019. Domestication of *Terminalia brownii* Among Smallholder Farmers in Eastern Kenya: A Double Hurdle Approach. *Journal of Economics and Sustainable Development*. 10(16): 61 – 69. www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) DOI: 10.7176/JESD
3. Maua J. O., Tsingalia H. Mugatsia and Cheboiwo J. (2019). Economic value of non-timber forest products utilized by the households adjacent to the South Nandi forest reserve in Kenya. *East African Agricultural and Forestry Journal*, 83 (4): 368-391. <https://doi.org/10.1080/00128325.2019.1660037>
4. Maua J. O., Tsingalia H. Mugatsia, Cheboiwo J. and Odee D. (2019). Population structure and regeneration status of woody species in a remnant tropical forest: A case study of South Nandi forest, Kenya. *Global Ecology and Conservation*. (2019). doi: <https://doi.org/10.1016/j.gecco.2019.e00820>. © 2019 Published by Elsevier B.V.. Received Date: 3 June 2019 Revised Date: 15 October 2019 Accepted Date: 16 October 2019
5. Musingo Tito E. Mbuvi, Kungu J.B., Gachathi F.N., Wekesa C. Nereoh Leley and Muthini J.M. 2019. Annotated checklist of plant species of Loita Forest (Entim e Naimina Enkiyio Forest or the forest of the lost child), Narok County, Kenya. Research Article. *International Journal of Advanced Research in Biological Sciences* (2019). 6(3): 54-110. ISSN: 2348-8069 www.ijarbs.com DOI: 10.22192/ijarbs Coden: IJARQG(USA). DOI: <http://dx.doi.org/10.22192/ijarbs.2019.06.03.006>
6. Oduor N., Kitheka E., Ingutia C., Nyamai N., Kimwemwe J. and Juma Kevin. 2019. Quality and Emission Analysis of Charcoal from Various Species of Wood Using Improved Carbonization Technologies in Kenya. *Journal of Environmental Science and Engineering A* 8 (2019) 16-25 doi:10.17265/2162- 5298/2019.01.002
7. Okeyo M.M., Obwoyere G.O., Makanji D.L., Njuguna J.W., Omondi Jackline A. 2019. Fungal Diseases Attacking Floral Phenology of *Terminalia brownii* in Drylands, Kenya. 2019. *Poplar* 203: 5-11. www.ilfe.org. UDC: 582.776.7:632.4(676.2)
8. Wekesa L., Mwalewa S., Muema K., Muthini J., Riziki P., Mukirae P. and Menya C. 2019. An Economic Assessment of Woodlots for Smallholder Farms in the Coast Region of Kenya, *East African Agricultural and Forestry Journal*. 83 (1): 1-12. <https://doi.org/10.1080/00128325.2018.1532694>. Published online: 02 Jul 2019.

9. Jaoko V., Clauvis Nji Tizi Taning, Backx S., Mulatya J., Van den Abeele J., Magomere T., Olubayo F., Sven Mangelinckx, Werbrouck S.P.O. and Smagghe G. 2020. The Phytochemical Composition of *Melia volkensii* and Its Potential for Insect Pest Management. Review. Plants 2020. 9: 143 – 155. doi:10.3390/plants9020143 www.mdpi.com/journal/plants Received: 31 December 2019; Accepted: 20 January 2020; Published: 22 January 2020
10. Mbuvi, M.T.E., Musyoki, J.K., and Ndalilo, L.A. (2020). Forest Management Teams, a Citizenship Paradigm Analysis through Influence and Importance Factors; Experience from Arabuko Sokoke Forest, Kenya. Open Journal of Forestry 10: 81-109. <https://doi.org/10.4236/ojf.2020.101007>
11. Mutitu E.K., Hoareau T.B., Hurley B.P., Garnas J.R., Wingfield M.J. and Slippers B. 2020. Reconstructing early routes of invasion of the bronze bug *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae): cities as bridgeheads for global pest invasions.
12. Owino J.O, Kemboi J.J, Mwenje P, Ibuya KC, Enyang G.A., Emanikor F.E., Wachira J.M., Kibor F.J., Looyan B.E., Eremon M.E., Lomor R.L., Long’or M.E., Ejore E.I., Ateyo S.N., Ekiru W.E., Ekal F., Long’ura M.E., Lokato F.E., Lodung’ C.E., Ngare M.I., Lomulen Z.E. and Muturi G. (2020). Ecological assessment of performance of tree species used in rehabilitating degraded areas of Turkana County, Kenya. Academia Journal Environmental Science 8(4): 064-070, April 2020. DOI: 10.15413/ajes.2020.0104 ISSN: 2315-778X Accepted 14th February 2020. Published April, 2020.
13. Jaoko V., Clauvis Nji Tizi Taning, Backx S., Mulatya J., Van den Abeele J., Magomere T., Olubayo F., Sven Mangelinckx, Werbrouck S.P.O. and Smagghe G. 2020. The Phytochemical Composition of *Melia volkensii* and Its Potential for Insect Pest Management. Review. Plants 2020. 9: 143 – 155. doi:10.3390/plants9020143 www.mdpi.com/journal/plants Received: 31 December 2019; Accepted: 20 January 2020; Published: 22 January 2020
14. Wondafrash M., Slippers B., Nambazimana A., Kayumba I., Nibouche S., van der Lingen S., Asfaw B.A., Jenya H., Mutitu E.K., Makowe I.A., Chungu D., Kiwuso P., Kulimushi E., Razafindrakotomamonjy A., Bosu P.P., Sookar P. and Hurley B.P. 2020. Distribution and genetic diversity of five invasive pests of Eucalyptus in sub-Saharan Africa. Biological Invasions. <https://doi.org/10.1007/s10530-020-02250-4>. 17 pages. Received: 12 April 2019 / Accepted: 21 March 2020
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16. Onyango, A.A., Angaine, P.M., Inoti, S.K., and Owino, J.O. (2020). Patula pine (*Pinus patula*) cones opening under different treatments for rapid seed extraction in Londiani, Kenya. Journal of Horticulture and Forestry, 12(2), 63-69. Received: 28 April 2020. Accepted: 26 May 2020. Published: 30 June 2020. <https://doi.org/70-83> <https://academicjournals.org/journal/JHF/article-abstract/01539FC64055>

17. Owino J.O., Angaine P.M., Onyango A.A., Ojunga S.O. and Otuoma J. (2020). Evaluating Variation in Seed Quality Attributes in *Pinus Patula* Clonal Orchards using Cone Cluster Analysis. Journal of Forests Volume 7, 1, pp 1-8. Received: 16 March, 2020. Revised: 20 April, 2020. Accepted: 22 May, 2020. Published: 12 June, 2020. DOI: 10.18488/journal.101.2020.71.1.8
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Technical Notes/Research notes

19. AI-CD / KEFRI. 2019. Guideline on Effective Measures for Combating Desertification for Achieving Sustainable Development in the Horn of Africa.
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Book (consisting 8 Technical /Research Notes)

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Appendix II**FINANCIAL STATEMENT:****Statement of financial performance for the year ended 30th June 2020**

	Note	2019-2020 Kshs.	2018-2019 Kshs.
REVENUE			
Revenue from non-exchange transactions:			
Government Grants	3	1,642,248,013	1,480,753,334
External Grant for Research	4	89,662,908	145,338,285
Deferred Income from Donors	5(b)	24,014,149	26,831,046
Revenue from exchange transactions:			
Other Income	6	140,314,648	126,177,683
TOTAL REVENUE		1,896,239,718	1,779,100,348
EXPENSES			
Employee Costs	7	(1,170,506,714)	(1,178,546,081)
Operating Expenses	8	(613,024,565)	(521,214,660)
Board of Directors Expenses	9	(17,218,626)	(11,426,979)
Establishment Cost(Sinking Fund)	10(a)	(4,000,000)	(15,000,000)
Depreciation	5(a)	(84,397,518)	(81,574,755)
Amortization on Intangible Asset	11	(3,109,734)	(3,488,958)
TOTAL EXPENSES		(1,892,257,157)	(1,811,251,434)
OTHER GAINS/(LOSSES)			
Gain on Sale of Fixed Assets	12	-	491,351
Exchange Gain/(Loss)	12(b)	(650,779)	(1,094,717)
		(650,779)	(603,366)
Surplus/(Deficit) for the Year		3,331,782	(32,754,452)

Appendix III

Statement of Financial Position as at 30th June 2020

		2019-2020	2018-2019
		Kshs.	Kshs.
ASSETS	Notes		
CURRENT ASSETS			
Cash and cash equivalents	13	316,838,433	381,133,474
Receivables from exchange transactions	14(a)	23,003,847	18,268,486
Receivables from non- exchange transactions	14(b)	3,178,600	56,139
Inventories	15	35,194,364	58,466,839
		378,215,244	457,924,938
NON-CURRENT ASSETS			
Property, Plant & Equipment	5(a)	5,750,406,850	5,752,762,412
Intangible Assets	11	12,438,938	13,955,832
		5,762,845,788	5,766,718,244
TOTAL ASSETS		6,141,061,032	6,224,643,182
LIABILITIES			
CURRENT LIABILITIES			
Payables from exchange transactions	16	6,293,886	2,477,771
Auditor General- accrued audit fee	16(c)	513,969	1,320,000
Payables from non-exchange transactions	16(d)	8,124,400	8,124,400
Unxpended External Donor Grants	4	157,302,625	139,998,262
Medical Scheme Funds	17	742,883	742,883
		172,977,763	152,663,317
NET ASSETS			
Government Grants for capital assets	18(a)	1,043,537,781	1,130,750,947
Deferred Income on Donated Assets	5(b)	535,954,008	559,968,157
Sinking Fund	10(b)	24,495,256	20,496,321
Revaluation Reserves	18(b)	4,467,199,488	4,467,199,488
Revenue Reserves	18(e)	(103,103,264)	(106,435,046)
		5,968,083,269	6,071,979,866
TOTAL NET ASSETS & LIABILITIES		6,141,061,032	6,224,643,182

Appendix IV

Statement of Changes in Net Assets for FY ended 30th June, 2020

	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 1 st July 2018	990,880,904	586,799,202	(73,418,709)	4,467,199,488	5,498,436	5,976,959,322
Prior period adjustment			(261,885)			(261,885)
As restated	990,880,904	586,799,202	(73,680,594)	4,467,199,488	5,498,436	5,976,697,436
Surplus/(Deficit) for the year	-		(32,754,452)			(32,754,452)
Adjustments	-					-
Transfers from Sinking fund						-
Sinking Fund expenses					(2,115)	(2,115)
Additions during the year	187,000,000				15,000,000	202,000,000
To Income & Expenditure	(47,129,957)					(47,129,957)
Deferred Income for the year		(26,831,046)				(26,831,046)
Balance as at 30 th June 2019	1,130,750,947	559,968,157	(106,435,046)	4,467,199,488	20,496,321	6,071,979,866
Balance as at 1 st July 2019	1,130,750,947	559,968,157	(106,435,046)	4,467,199,488	20,496,321	6,071,979,866
Prior period adjustment						
As restated	1,130,750,947	559,968,157	(106,435,046)	4,467,199,488	20,496,321	6,071,979,866
Surplus/(Deficit) for the year	-		3,331,782			3,331,782
Adjustments	-					-
Transfers from Sinking fund						-
Sinking Fund expenses					(1,065)	(1,065)
Additions during the year	92,053,850				4,000,000	96,053,850
To Income & Expenditure	(179,267,016)					(179,267,016)
Deferred Income for the year	-	(24,014,149)	-	-	-	(24,014,149)
Balance as at 30 th June 2020	1,043,537,781	535,954,008	(103,103,264)	4,467,199,488	24,495,256	5,968,083,269

Appendix V

Statement of Cash Flows for the Fiscal Year ended 30th June, 2020

		2019-2020	2018-2019
	NOTES	Kshs.	Kshs.
Cash Flows from Operating Activities			
Surplus(Deficit) for the Year		3,331,782	(32,754,452)
Adjustment for:			
Depreciation	5(a)	84,397,518	81,574,755
Amortization for Intangible Asset	11	3,109,734	3,488,958
Deferred Income	5(b)	(24,014,149)	(26,831,046)
KEFRI Surcharge		(310,669)	(244,611)
Commission Income		(217,092)	(217,827)
Adjusted Surplus		66,297,125	25,015,777
Working Capital Changes:			
Decrease (Increase) in Debtors	14	(7,857,822)	(1,973,285)
Decrease (Increase) in Stock	15	23,272,475	5,943,336
Increase (Decrease) in Creditors	16	20,314,447	(62,816,845)
Net Cash from operating activities		35,729,100	(58,846,794)
Cash Flows from Investing Activities:			
Purchase of Assets	5(a)	(82,041,956)	(38,134,966)
Purchase of Intangible	11	(1,592,840)	(866,768)
Establishment Cost(Sinking Fund)	10(a)	(4,000,000)	(15,000,000)
Proceeds from sale of assets	12	-	510,250
Net Cash from Investing activities		(87,634,796)	(53,491,484)
Cash Flows from Financing Activities:			
Development capital grants	3	(87,213,166)	139,870,043
Research Grants Received	4	106,851,398	94,916,928
Transfers/Adjustments		(9,016,884)	80,128,444
Research Grants Paid	4	(89,662,908)	(145,338,285)
Net Cash from Financing activities		(79,041,560)	169,577,129
Net Increase (Decrease) in Cash & Cash Equivalent		(64,650,132)	82,254,629
Opening Cash & Cash Equivalent		381,488,565	299,233,937
Closing Cash & Cash Equivalent		316,838,433	381,488,565
		(0)	
Cash & Cash Equivalent			
Bank balance	13(a)	316,838,433	381,133,474
Receivables from non-exchange transactions (staff debtors)	14(b)		
Travelling Imprest		41,100	-
Station/Special Imprest		3,131,500	30,000
Salary Advance		6,000	26,139
Closing Cash & Cash Equivalent		320,017,033	381,189,613

Appendix VI: Statement of Comparison of Budget and Actual Amounts for the FY ended 30th June, 2020

	Notes	Original budget	Adjustments/Supplementary	Full budget	Actual on Comparable	Performance difference	Budget Vs Actual
		2019-2020	2019-2020	2019-2020	2019-2020	2019-2020	%
Revenue		Kshs	Kshs	Kshs	Kshs	Kshs	
Recurrent Grants	3	1,462,980,997	-	1,462,980,997	1,462,980,997	-	-
Development Grants	3	213,600,000	-	213,600,000	92,053,850	121,546,150	57
Research Grants	4	91,000,000	-	91,000,000	89,629,308	1,370,692	2
Deferred Income from donors	5b	24,100,000	-	24,100,000	24,014,149	85,851	0
Other Income	6	100,000,000	39,000,000	139,000,000	140,314,648	(1,314,648)	(1)
Total Income		1,891,680,997	39,000,000	1,930,680,997	1,808,992,953	121,688,044	6
Development Grants: Income Recognised		85,000,000	-	85,000,000	84,809,579	190,421	0
NET TOTAL INCOME		1,976,680,997	39,000,000	2,015,680,997	1,893,802,531	121,878,466	
Expenses		Kshs	Kshs	Kshs	Kshs	Kshs	
Employees Costs	7	1,247,510,000	(20,000,000)	1,227,510,000	1,170,506,714	57,003,287	5
Operation Expenses	8	610,150,000	-	610,150,000	613,024,565	(2,874,565)	(0)
Board Expenses	9	16,500,000	1,000,000	17,500,000	17,218,626	281,374	2
Establishment Cost (Sinking Fund)	10	14,000,000	(10,000,000)	4,000,000	4,000,000	-	-
Depreciation	5a	84,400,000	-	84,400,000	84,397,518	2,482	0
Amortization Expenses	11	3,110,200	-	3,110,200	3,109,734	466	0
Total Expenditure		1,975,670,200	(29,000,000)	1,946,670,200	1,892,257,157	54,413,043	
Other Gains/(Losses)							
Exchange Gain/(Loss)	12b	(650,000)	-	(650,000)	(650,779)	-	
Sub-Total		(650,000)	-	(650,000)	(650,779)	-	
Suplus /(Deficit) for the period without capital assets		360,797	68,000,000	68,360,797	894,595	67,465,422	
Capital Expenditure		40,150,000	-	40,150,000	38,134,966	2,015,034	5
	Notes	Original budget	Adjustments/Supplementary	Full budget	Actual on Comparable	Performance difference	Budget Vs Actual
		2019-2020	2019-2020	2019-2020	2019-2020	2019-2020	%
Notes							
1. GoK : Development Grant						Kshs	
Budget Estimates						213,600,000	
Less: Received from Exchequer						(92,053,850)	
Not Received from Exchequer						121,546,150	
2. Budget adjustment was done during internal reallocation of funds							
3. Capital Expenditure comprises of funds from opening balance and other development partners funded projects							

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