KENYA FORESTRY RESEARCH INSTITUTE

Annual Report and Record of Research

2020 - 2021

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

KENYA FORESTRY RESEARCH INSTITUTE

Annual Report

and

Record of Research

2020 - 2021

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

BOARD OF DIRECTORS

Dr. Sammy Letema
Board Chairman

Dr. Joshua Cheboiwo
CEO & Board Secretary

Ms. Maureen Mwangovya
Board Member

Dr. Ali M. Mohamed
Board Member

Dr. Naomi Apali
Board Member

Dr. Antony Njagi Getambu
Board Member

Prof. A. O. Ayawa
Board Member

Mr. Chrislogus Makokha
Board Member

Dr. Lucy Nganga
Board Member

Mr. Elly Ongei
Board Member

Mr. Julius Kamau
CCF, Board Member

TABLE OF CONTENTS

ACRONYMS

ASALs	Arid and Semi-arid Lands
CBO	Community Based Organization
CCF	Chief Conservator of Forests
CERP	Coast Eco-region Research Programme
CHERP	Central Highlands Eco-region Research Programme
CIRAD	French Agricultural Research Centre for International Development
CITES	Convention on International Trade in Endangered Species
COVID - 19	Coronavirus disease
CPTs	Candidate Plus Trees
CRAC	Centre Research Advisory Committte
CVE	Counter-violent extremism
DERP	Drylands Eco-region Research Programme
DG	Director General
EMS	Environmental Management System
FY	Fiscal Year
GDP	Gross Domestic Production
Ha	Hectare
HIV	Human Immunodeficiency Virus
HR	Human Resources
IG	Inspector General
IMS	Integrated Management Systems
IPM	Intergrated Pest Management
ISO	International Standard Organization
ISTA	International Seed Testing Association
IUFRO	International Union of Forest Research Organizations
JICA	Japan International Cooperation Agency
KFS	Kenya Forest Service
KFSC	Kenya Forest Seed Centre
KNBS	Kenya National Bureau of Statistics
Kshs	Kenya shillings
LVBERP	Lake Victoria Basin Eco-region Research Programme
MDAs	Ministry Departments and Agencies
MoUs	Memorandum of Understanding
NGO	Non-Governmental Organization
NDICCC	National Development Implementation and Communication Cabinet Committee
NWFPs	None Wood Forest Products
OSHA	Occupational Safety Health Act
PC	Performance Contract
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
UV	Utra Violet

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@ombusman.go.ke/complain@ombudsman.go.ke

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

HUDUMA BORA NI HAKI YAKO

Chairman, Board of Directors Statement

KEFRI plays a significant role of developing research technologies, as well as sharing information for sustainable forestry management that contributes national and international agendas.

In the Fiscal Year [FY: 2020-2021], KEFRI Board of Directors continued to provide leadership in designing suitable strategies and supporting national and international policies through approval of perquisite budgets as well as foreseeing achievement of agreed performance target. The Institute continued to implement its annual research activities guided by its 6th Strategic Plan, and in line with the government's performance contracting policy taking cognizance of Visions 2030 and the Big Four Agenda. This ensured the Citizens' service delivery charter for customer care and hospitality; corporate social responsibility, and public complaints and feedback were implemented in compliance to national statutory obligations and legal requirements.

Prudent use of resources and rescheduling of activities enabled the institute enhance its strategic approach to mitigate low donor response, competition for donor funding due to COVID - 19 pandemic and perceived low value of forestry, development of high impact proposals through in-house capacity building and formation of strategic alliances when seeking donor funding.

The Institute has continued to pioneer world class research and during the year under review, piloting of aerial seeding to rehabilitate degraded Maasai Mau forest was undertaken. This noble approach has led to more partners seeking collaboration in forestry rehabilitation in the country, and strategies to acquire drones for use in research and development are at an advanced stage. Notably, the development of KEFRIApp to guide farmers and other stakeholders undertake species site matching for enhancing tree survival and growth is a definite indicator of the Institute pivotal roles to ensure the country attains 10% tree cover.

On behalf of the Board of Directors and myself, I pledge for continued support to KEFRI development agenda in human capacity improvement, facilities and implementation of research projects. Special thanks to the Government of Kenya, development partners, entire KEFRI staff and many more stakeholders for the support which enabled successful achievement of the research and development agenda in the Fiscal Year 2020-2021.

Dr. Sammy Letema
Chairman - KEFRI Board of Directors

Foreword by the Director

KEFRI implemented research and development activities scheduled for Fiscal Year [July 2020 - June 2021] in line with its 6th Strategic Plan [2018 - 2022] and other national programmes geared towards realization of Vision 2030 and the Big 4 agenda. Some of key focus of forestry research within the fiscal year was to enhance tree productivity, efficient use of forestry resources, supporting forestry based climate acions adaptation and mitigation initiatives through partnerships.

Notable activities undertaken include: tree improvement and provision of high quality germplasm, development and validation of propagation protocol for Sandalwood, *Melia volkensii*, *Acacia tortilis*, and indigenous bamboo; development of tree products, screening of commercial plantation for seed and germplasm production; evaluation of tree species for preferred end products; and building capacity for stakeholders. Additionally, sharing of research technologies in silvicultural -management for both exotic and indigenous species such as Pines, Eucalypts, *Melia volkensii*, *Gmelina arborea, Terminalia brownii,* Acacia spp among others and assessment of the performance of natural forest rehabilitation technologies were disseminated to various stakeholders.

During the year under review, the Institute intensified its visibility through strategic profiling of its image at national and international levels. The Institutes CV and that of all scientists are available on KEFRI Website. The institute has continued to enhance the quality of research output at a global level through linkages with global networks. This has enhanced its strategic partnerships with research institutes, both local and international universities and more strategically the private sector for research and development activities. As the national research institute in forestry KEFRI has continued to provide research support to all the county governments. These initiatives have enabled the Institute to be a leader in forestry research in the Eastern Africa Region and has continued to provide expertise and capacity building in the region. For instance, the JICA supported African Initiative for Combating Desertification to Strengthen Resilience to Climate Change in the Sahel and Horn of Africa (AI-CD) has enabled the Institute provide skills for combating desertification in the region.

The Institute during the year under review exhibited technologies and innovation with socio-economic impact through international meetings and national events including field days, open days and interactive sessions held in demonstration plots located countrywide. Though the COVID-19 pandemic significantly interrupted the activities, innovative approaches were used to mitigate the challenge in line with Ministry of Health guidelines. Through the efforts of staff under the guidance of the Board of Management, the institute was rated 'Very Good' with a score of 3.4 at the end of the Performance evaluation. This made the institute the leading parastatal at the Ministry of Environment and Forestry.

On behalf of the entire KEFRI staff and myself, I thank the Board of Directors for guiding and providing enabling environment for the institute to implement its research agenda that has made significant impact to forest sector development and improved livelihood of our citizens.

Joshua K. Cheboiwo (PhD)
Director, /CEO-KEFRI

SENIOR MANAGEMENT

Dr. Joshua K. Cheboiwo
CEO and Board Secretary

Dr. Jane Njuguna
SDD, Res & Devpt

CPA George Otieno
SDD, Corporate Services

Dr. Jackson Mulatya
DD, CA&Q A

Dr. James Kimondo
DD, FPI

Dr. Joram Kagombe
DD, SPG

Dr. M. T. E. Mbuvi
DD, FRSS

Dr. James K. Ndufa
A.g. DD, FBEM

Dr. George M. Muthike
DD, FPD

CHRP (K). Evelyn Oroni
DD, Human Resource

FCPA Rose Osoro
DD, Finance

Tingos Kiprotich
Supply Chain Manager

CPA Karen Muka
Internal Audit

Mr. Phillip Kichana
Corporation Secretary &
Manager Legal Services

Ms. Betty Prissy Njoki
Partnership and
Res. Mobilization

Ms. Mary Miingi
GM, Enterprises

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 GERMPLASM DEVELOPMENT AND SEED PRODUCTION

KEFRI through its Forest Productivity Improvement Programme improves the quality of tree germplasm (planting materials) to advance forestry sector development in Kenya. Tree germplasm development therefore is supported by establishment of seed sources and seed production. This is in line with the National Forest Programme (2016 - 2030), Kenya's Constitution 2010 and Vision 2030 blue prints which aim to achieve a minimum target of 10% tree cover by 2030. This target was reviewed by Presidential directive (2018) to be realized by 2022.

1.1 Establishment of tree seed sources

Seeds of good genetic quality is a key input in forestry development. KEFRI therefore implements and maintains a programme that establish and manages seed sources with the view of yielding high quality seed. The Institute realizes establishment of seed sources is an important step in ensuring that tree growing programmes access the improved germplasm. KEFRI therefore collects seed from superior performing trees and establish seed stands that also provide commercial tree growers with seed that confer similar qualities in yield as seed from orchards.

In the Financial Year (FY) 2020 - 2021, the Institute established seed orchards and stands covering 18 ha of different tree species in the Eco-region indicated in Table 1.

Table 1: Tree seed stands established in different Eco-region in 2020 - 2021

Species	CERP		CHERP		DERP		Total area/ (ha)
	Seed stand	Seed orchard	Seed orchard	Seed stand	Seed orchard	Seed stand	
Acacia gerrardii						1.1	1.1
Acacia polyacantha						1	1
Azadirachta indica						1.2	1.2
Dalbergia melanoxylon						1.4	1.4
Eucalyptus camaldulensis						1.6	1.6
Eucalyptus urophylla				2			2
Gmelina arborea						3.1	3.1
Grevillea robusta			2				2
Melia volkensii	2						2
Osyris lanceolata						0.5	0.5
Tamarindus indica						1.1	1.1
Terminalia brownii						1	1
Total area/ category	**2**		**2**	**2**		**12**	**18**


Fig.1: *Gmelina arborea* seed stand at God Jope in Migori and a *Eucalyptus grandis* seed stand in Kaimosi,Vihiga County

1.2 Tree seed collection, processing and distribution

Tree seed production involves: identification of seed sources; seed survey to determine the timing of collection; actual seed collection; seed processing (i.e. seed extraction, drying and cleaning); and quality testing before seed is distributed to tree growers. Seed production in KEFRI is under respective Eco-regional Research Programmes. The collected seed is then forwarded to Kenya Forestry Seed Centre at KEFRI headquarters for further processing, quality testing, storage, marketing and distribution. In the year under review, the Institute collected **45,476** kilograms of tree seed as indicated in Table 2.

Table 2: Total seeds (kg) collected by respective seed collection centres

	Seed collection centre	Seed weight (kg) collected
1	Baringo	856
2	Garissa	1,113
3	Gede	2,571
4	Kakamega	6,783
5	Kibwezi	6,917
6	Kitui	4,709
7	Lamu	2,359
8	Londiani	3,333
9	Maseno	1,989
10	Migori	4,458
11	Muguga	2,061
12	Nyeri	4,444
13	Taita taveta	1,159
14	Turbo	2,727
	Total	**45,476**

All seed collected by KEFRI is subjected to quality testing as per internal procedures guided by International Seed Testing Association (ISTA), and best practice of seeds genebanks. Tree seed testing is done to determine the standards of a seed lot mainly in terms of physical purity, moisture, and viability thereby enabling the tree growers to get quality seeds.

In the year under review, a special seed testing exercise was also undertaken to assess viability of seed lots collected and stored in previous years. About 800 seed lots were subjected to rapid viability tetrazolium test.

Fig.2: Extraction of *Pinus patula* seed through sun drying of cones in a seedbed

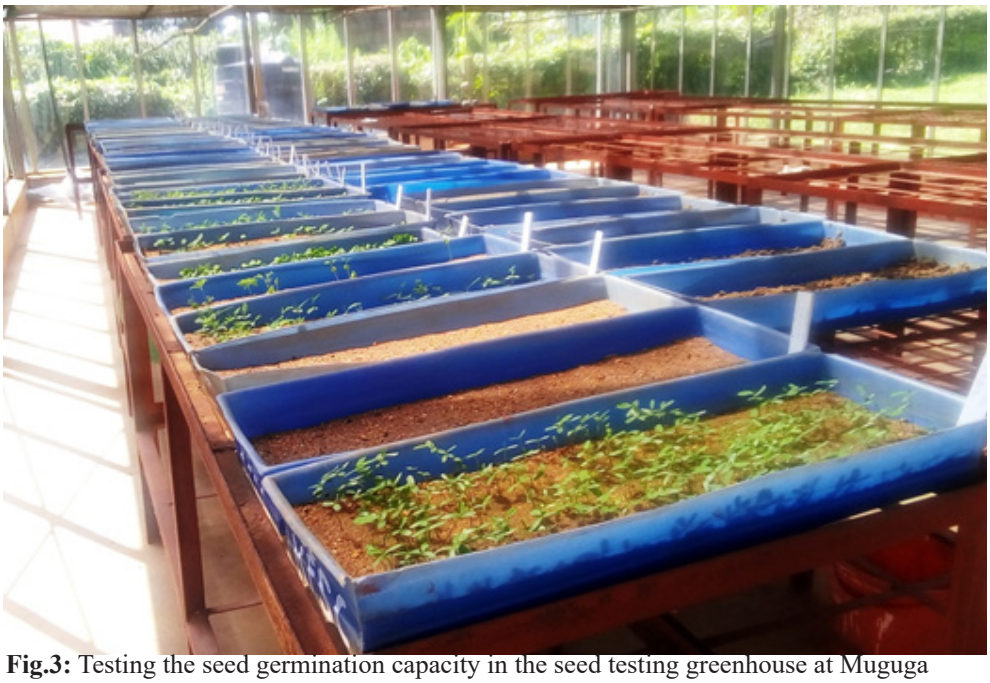

Fig.3: Testing the seed germination capacity in the seed testing greenhouse at Muguga

Fig.4: Gatsby Africa representative donating modern seed cleaning equipment to KEFRI

2.0 PRODUCTION OF PLANTING MATERIALS

KEFRI has established tree nurseries in all its eco-regional programmes that cuts across the country. These nurseries provide high quality seedlings for on-farm tree planting, afforestation, aesthetics and rehabilitation of degraded forests and other landscapes.

Some of the seedlings raised are for internal use in; research purposes, establishment of seed production units (orchards and seed stands); establishment of plantations within the KEFRI estates in various eco-region programmes, and beating up of established plantations. However majority of the seedlings are sold to both public and private institutions as well as other tree growers.

During the FY 2020-2021, the Institute raised about 1.5 million planting materials of different categories which included; superior genetic material and species that are difficult to propagate (Table 3). Among the difficulty to propagate species is *Osyris lanceolata, Vitex payos* and Bamboo, which is planted mainly for soil stabilization and its utility in value added products. To diversify species for riparian and soil conservation, KEFRI embarked on raising Vetiver grass *(Chrysopogon zizanioides)* through vegetative propagation in its nurseries at Muguga. The grass has ability to controls soil erosion, spreads storm water and recycles soil nutrients. The grass is deep rooted and create a perfect barrier that filters out sediments, and may tolerate extreme climatic conditions including prolonged drought, floods, fires and frost. Some materials were planted along Nairobi Riverine at the rehabilitated John Michuki Memorial Park.

Fig.5: Vegetative propagation of Vetiver grass

Table 3: Tree seedlings raised in FY 2020 - 2021

Number of seedlings in respective categories				
Eco-region	**Popular species**	**Difficult to propagate**	**Superior genetic quality**	**Grand Total**
CERP	188,085	13,200	-	201,285
CHERP	264,209	2,642	1,000	267,851
DERP	317,083	29,809		346,892
LVBRRP	229,065	12,250		241,315
RVERRP	447,607	12,393		460,000
Grand Total	**1,446,049**	**70,294**	**1,000**	**1,517,343**

Fig.6: *Osyris lanceolata* and *Vitex payos* seedlings in Kitui nursery

3.0 DEVELOPMENT OF FOREST TECHNOLOGIES

3.1 Establishment of *Cupressus lusitanica* progeny trial from selected candidate plus trees

Cupressus lusitanica (Mexican cypress) is native to Mexico. The species was introduced in Kenya in 1905 mainly from South Africa and France and has since become an important industrial plantation crop in high elevation areas between 1500 to 3000 m above sea level. Intensive breeding of *C. lusitanica* in Kenya began in 1950 with 74 families selected to establish progeny trials. New infusions were brought in 1965 from Newzealand, Costa Rica, Mexico and Australia. In addition, 102 new selections from the East Africa land races were used for further improvement of the species. The tree improvement efforts in the 1960s resulted in the establishment of two clonal seed orchards, in Muguga in 1967 and 1968. Overtime, further new infusions have been introduced to the breeding program and more recently through further selections of 390 families from KFS plantations in Rift valley between 2004 and 2019. These selections were used to establish three progeny trials in Kamara in 2006, 2008, 2013, and 10 clonal seed orchards. The clonal seed orchards avail improved seeds to the stakeholders.

A key practice in tree breeding is systematic improvement through recurrent selection of superior germplam (Candidate Plus Trees-CPTs) that are genetically superior. KEFRI currently has first generation (F1) improved germplasm that needs to be advanced to F2 (second generation germplasm). The F2 progeny trial *C. lusitanica* is important as it is part of the progression of breeding program of this species, and will avail even higher quality planting materials. In FY 2020-2021, selection of CPTs was done in Londiani, Muguga, Nyeri and Meru (Table. 4) and seed from the CPTs collected.

Table 4: *Cupressus lusitanica* CPTs selected for establishment of second generation progeny trials

Site of selection	Number of CPTs
Londiani	50
Muguga	38
Nyeri and Meru	35
Total	**123**

The collected seeds were processed for each CPT, labelled and then stored separately. The seeds will then be raised as individual progenies for establishment of progeny trials in different sites of the country.

Fig.7: Seed processing from the selected CPTs at Muguga

3.2 Develop hybrids of *Eucalyptus urophylla* and *Eucalyptus camaldulensis* for fast growth and drought tolerance

Eucalyptus species were first introduced in Kenya in 1902, mainly for the supply of fuelwood. Eucalypts are grown widely in most ecological zones in Kenya, but the rates of growth depend on the species and environmental conditions. Three eucalyptus namely; *E. grandis, E. saligna* and *E. camaldulensis* are dominant species in the Kenyan landscape.

Planting of clonal Eucalyptus species hybrids was started in Kenya in 1997. Most of the clones performed impressively compared to local races in some sites and a significant amount of site/clone interactions was evident, for example clone GC 14 performed well in Embu but poorly in Hombe.

The principal reasons for producing hybrids are: to combine complementary traits of two parents; to exploit hybrid vigour (heterosis); and to increase adaptability for afforestation in marginal areas. Furthermore, hybridization gives the opportunity to combine characteristics which cannot easily be obtained in pure species. Examples of successful hybrids are the *E. grandis* x *E. Urophylla* cross produced at Aracruz in Brazil that showed greater coppicing ability and resistance to Diaporthe stem canker than would be obtained by selection of *E. grandis* alone.

KEFRI under the Camcore partnership is to produce crosses of *E. camadulensis* and *E. urophylla* to avail hybrid seed for use by other Camcore member countries. The two species have characteristics (Table 5) which could be combined in the first generation (F1) families.

Table 5: Characteristics of *E. camaldulensis* and *E. urophylla*

Species	Growth vigor	Drought tolerance	Resistance to diseases	Rooting ability	Termite resistance	Beetle resistance
E. camaldulensis	Low	High	Moderate	High	Low	Moderate
E. urophylla	Moderate	Moderate	High	Moderate	Moderate	Moderate

In FY 2020-2021, trees were selected from Ramogi, Ndori, Sidindi and Nyadiwa in Siaya County. Pollen collected from the selected trees was processed in the microbiology lab and subjected to viability tests. The viability of the pollen varied with the most viable pollen having 85% and the least 10%.

The *E. urophylla* mother trees were selected in a seed stand at Muguga. Twenty one (21) trees were selected on the basis of being in flower and free from disease. The target female flowers at the right stage of development were emasculated and bagged and artificial pollination with desired crosses undertaken. The female flowers were emasculated and bagged to avoid self and cross pollination. The capsules will be monitored and the seeds from the successful crosses will be collected upon maturity for conducting progeny trials.

Fig.8: Emasculation, artificial pollination and bagging

3.3 Effects of Dismegistus sanguineus insect on *Osyris lanceolata* seed quality

Domestication of *Osyris lanceolata* has faced challenges of seed viability that constraints seedling production. Seed viability cut tests show many empty seeds that cannot germinate due to several factors including diseases and damage by insect. *Dismegistus sanguineus,* is an insect belonging to the super family Hemiptera, whose members are suspected to transmit plant pathogens in *Osyris lanceolata*. The insect is associated with Osyris in the field and has been observed probing the fruit.

Fig. 9: *Dismegistus sanguineus* adult bugs

A study was undertaken to ascertain the relationship between the insect and Osyris seed viability. Samples of twigs, seeds and the *Dismegistus sanguineus* bug were collected from Kitui, Muguga and Kijabe in Kiambu and at the lab, separated into colour groups as either green mature, green immature, yellow or red. The seeds were then observed under a microscope for probe status, probe intensity, viability status, presence of other larvae and fungal staining. The seeds were subjected to surface sterilization by using hydrogen peroxide to rid them of contaminants while maintaining their initial identity. The surface sterilized seeds were rinsed, dried and plated on 2% Malt Extract Agar and incubated at 22^{o} C and observed for mycelial growth after 3-4 days. The mycelial growths were sub-cultured for identification as illustrated in Fig. 10 A-D.

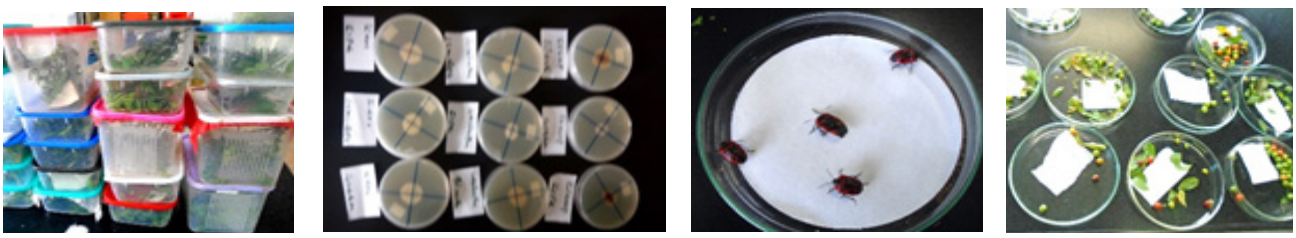

Fig.10: Illustration of; A) Twigs infected by bugs, (B) Fungal isolation, (C) *D. sanguineus bug,* (D) *Osyris lanceolata* seeds

Negative correlations were observed between the number of probe marks and the proportion of viable seeds. Similarly, a negative correlation was obtained between seed viability and fungal growth. However, there was a positive correlation between number of probe marks on the seeds and fungal growth (Fig. 11).

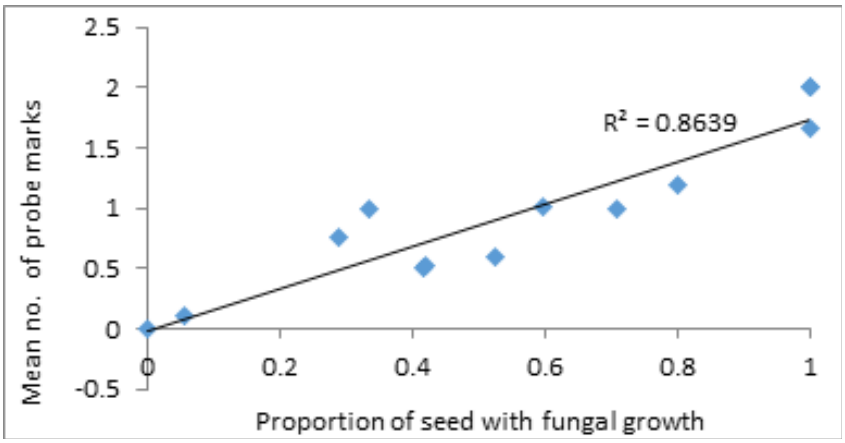

Fig.11: Correlation between number of probe marks on the seeds and growth of fungi

Preliminary results indicates that the probing of the insect is responsible for fungal attack of the seed. Further studies are planned to determine whether the insect transmits the fungal pathogen that lead to loss of seed viability.

3.4 Development of restoration technologies for Lake Kenyatta Ecosystem to improve water quantity and quality

Lake Kenyatta (Mukunganya) in Mpeketoni, Lamu County is facing numerous challenges which are threatening its existence including: population increase due to urbanization; increased land use activities like paddy rice farming; livestock watering; and over-fishing. These land use activities have led to the deterioration of water quality in the lake hence reducing its ecological function. Degradation of the lake is attributed largely to climatic weather conditions, siltation, extended use water by pastoralist and farming communities, interference with feeder streams, encroachment on the riparian area by rapidly growing population

Fig.12: Lake Kenyatta, in Lamu county (Source: Standard Daily)

In the year under review, KEFRI mapped and assessed the water quality, quantity and pollution to obtain the baseline data on the degradation status of the lake. The remote analysis and geospatial mapping of water extent and key quality parameters have been carried out using the Australian Water Detection from Space (WOFS) satellite imagery algorithms measuring and analysing parameters like chlorophyll matter, suspended solids and depth.

Time series analysis of water extent (observed areas) in terms of lake area between 2013 and 2020 showed that in 2014 and 2018 the lake nearly dried up. In April 2014 and 2018, the water body area became reduced to 0.10 km2 from 1.5 km^2 in 2013 due to prolonged droughts.

KEFRI is contributing towards the enhancement of forest cover through restoration - planting of suitable trees and bamboo species in riparian land alongside the Lake inoder to control soil erosion and improve water quality.

3.5 Development of Efficient Briquette Cook stove

In Kenya, biomass energy which include carbonized charcoal briquettes from agricultural wastes like, sugarcane bagasse, coffee or rice husks provides 68% of the national energy requirements and it is expected to remain the main source of energy in future. In the recent years, sale of charcoal is highly regulated and in some parts of the country banned to curb deforestation and landscape degradation.

Fig.13: Improved jikos for use in domestic cores and restaurant

In this context, KEFRI in the year under review, conducted research to address challenges on cooking stoves, such as high ash content that blocks airflow thus reducing burning rate of the fuel. KEFRI worked with partners to test efficiency of two prototype stoves whose design allows moderation of size to suit the needs of the consumer, mainly the household and minor restaurants. The design improved on existing stoves by increasing the grate size to allow the ash to fall freely by gravity and incorporating throttling feature just beneath the combustion chamber to create air turbulence and improve heat production. Briquettes from carbonized sugarcane bagasse were used to evaluate fuel consumption and heating efficiency based on time required to bring water to boil. Three other existing stoves were evaluated alongside the improved designs. The jikos were also distributed to households and restaurants for validation and improvement based on feedback from users. The research has led to development of cookstoves with ease removal of ash, better performance in fuel consumption, thermal efficiency and energy. The improved Jiko channels a large percentage of the heat energy to the bottom of cooking pot hence reducing the heat loss by radiation to the environment. These factors and use of briquettes forms a strong basis for acceptance by small restaurants and households.

3.6 Potential role of forestry interventions in landslide prone areas of Cherangany Escarpment

Landslides pose a threat to livelihood and cause social, economic and environmental damage. Indirect damage of landslides include long-term economic development, disruption and population displacement. anthropogenic activities such as logging, burning, and development exacerbated by growing population are the main causes of landslides. Landslides are triggered by natural events such as heavy rainfall, floods, earthquakes or volcanic eruptions. The landslides prone areas in Kenya are: Mt. Elgon, Nandi Escarpment, Gucha, Kericho, Rift Valley Escarpment, Cherangany Hills, Tugen Hills, Nyambene Hills, Muranga, Taita Hills and Nakuru Town.

In the FY2020-202,1 KEFRI undertook a study to determine the role of forestry in halting landslides and its contribution to degradation neutrality in landslides prone areas of Cherangany Hills ecosystem, in Elgeiyo-Marakwet County. The study employed exploratory survey design (grounded theory approach) and mixed method approach in data collection. The data included historical reconstruction of landslides occurrences, perceptions on landslide occurrences, land use and land use change, effects of landslides (socio-economic and environmental) and the existing and potential landslides remediation measures/policies. Bio-physical characteristics as predisposing attributes were assessed

Fig.14: Typical terrain in Elgeyo Marakwet Cherangany and Kerio Valley escarpments

The study established that most of the landslides observed in the escarpment were a combination of displaced mudslides, rock falls, topples and spreads. The apparent driver of the landslides in the escarpment could be attributed to unsustainable anthropogenic activities. These include encroachment of forested upslope areas, deforestation and unsuitable farming practices (intensive and continuous cultivation). Other factors observed to exacerbate landslides were slope topographic features such as steep slope, fragile geology (weak soil and rock structure) and apparently the force of gravity.

The survey found that land use practices have evolved in the escarpment over the years from an undisturbed forest to shift cultivation of orphaned and indigenous crops (cultivated land was left fallow for about three years) to intensive and continuous farming of improved crop varieties coupled with use of agro-chemicals and irrigation. These activities weaken and destabilise the soils/colluvium and the geology by exposing soils to erosion and the rocks to rapid weathering.

Fig.15: Indication of mud flow (movement of soil and rock under the influence of gravity)

The rapid vegetation assessment on the landslides affected areas showed that sites are characterized by low vegetation cover as exhibited by scattered relic trees and very low tree density and species richness. The remnant trees are characterized by big diameters but negligible regeneration and succession an indication of disturbance through continuous deforestation . The tree canopy cover was observed to be <5% which reduces the potential of the tree crowns to intercept rainfall hence pre-dispose these fragile sites to landslides. Nonetheless, some of the affected areas are showing secondary succession as indicated by colonization of early successional species such as *Pteris aquilina, Rhus natalensis, Rhus vulgaris* and *Olinia rochetania* among others. The recovery of these sites could therefore be hastened through reforestation.

Fig.16: Remnant trees drying up and heavy regeneration of *Senna siamea* on a landslides affected areas in Kaben

3.7 Potential of trees in phytoremediation and rehabilitation of polluted ecosystems in Kenya

Mining is a key economic activity in Kenya, contributing 1% of the country's GDP and 2% of export earnings. It is, however, a major source of environmental pollution with heavy metals, such as Lead (*Pb*), Cadmium (*Cd*), Copper (*Cu*), Mercury (*Hg*) and Arsenic (*As*) used in processing of minerals ending up contaminating the top soil, surface water resources and the atmosphere.

In the Financial Year 2020-21 KEFRI undertook a study to investigate the application of trees in the phytoremediation of heavy metal polluted sites in Macalder in Migori County, Rostaman in Kakamega County, Ondiri Swamp in Kiambu County and Njiru River in Nairobi County. Phytoremediation approaches comprises mopping up of heavy metals contaminants from affected sites, and subsequent rehabilitation of such degraded landscapes and ecosystems using suitable plant species. The approach has been identified as one of the most viable and affordable technologies to address environmental problem and promote forestry-based livelihoods.

Fig.17: A core mining site where sediment and water samples were collected

Samples of the top soil, surface water and plant tissue from mining and effluent producing sites were collected and analyzed in the laboratory to determine the baseline concentration of different heavy metals. Different native and introduced tree species were planted in soils collected from the polluted sites which are being subjected to plant tissues analysis every six months to determine the concentration of heavy metals as an indication of the capacity of each woody species to carry out phytoremediation.

Preliminary results indicate that the polluted areas had concentration levels of Pb, Cd and Cu much higher than those permissible under World Health Organization (WHO) guidelines, with mining sites having significantly higher concentration of heavy metals than effluent polluted sites (Table 6).

Table 6: Concentration of heavy metals in soils in mining sites in Macalder, Rostaman, and riparian zones in Ondiri Swamp and Njiru River

		Concentration of heavy metals (ppm) (WHO maximum permissible level in unpolluted soil in bracket)		
Mining site	**Treatment**	**Pb ppm (85)**	**Cd ppm (0.8)**	**Cu ppm (36)**
Macalder	Contaminated	500.19	12.02	3309.31
	Intermediate	226.14	7.29	1154.41
	Control	66.93	3.30	150.11
Njiru	Contaminated	78.86	14.54	47.08
	Intermediate	60.87	10.75	17.49
	Control	51.10	6.98	14.279
Ondiri	Contaminated	85.94	4.79	26.519
	Intermediate	85.61	3.68	21.229
	Control	57.45	3.02	18.24
Rostaman	Contaminated	80.16	23.79	445.24
	Intermediate	31.13	20.83	70.65
		19.95	19.12	35.83

NB: All values are in parts per million (ppm)

Tree species with the highest phytoremediation capacity are expected to be used for both phytoremediation of heavy metal contaminants and physical restoration of the degraded mine lands.

Fig.18: Different trees grown on soil sample from the polluted sites to determine their phytoremediation capacity

3.7 Documentation of traditional knowledge associated with the use of non-wood forest products (NWFPs)

KEFRI undertook a study to document traditional knowledge, challenges and opportunities associated with the use of Non-Wood Forest Products (NWFPs) in Taita Taveta and Kwale Counties. The ultimate goal was to ensure that the locals apply the knowledge to diversify and improve their livelihoods through sustainable commercialization of various nature-based enterprises.

a) Traditional knowledge associated with honey

The study found honey was the most utilized natural products by the NWFPs enterprises interviewed. There are a number of traditional practices and cultural values associated with the use of honey such as; making of traditional brews, treatment of various ailments, dowry payments and intercessions during rain making ceremonies.

However, communities experience various challenges which can be addressed through; support to construct apiaries and control of pest and disease attack, capacity building on bee keeping enterprises, promotion of fruit trees and other heavy pollen producing trees for pollination and support towards certification of their honey by KEBS. In addition, measures should be taken to make bee hives and harvesting kits more affordable to enable groups expand the bee keeping enterprises for enhanced profitability, conservation of trees and of crops.

b). Traditional knowledge associated with food from wild plants

Some nature based enterprise groups were involved in utilization of food from wild plants including trees. Utilization of these plants was informed by the fact that most of these plants have been abandoned or under-utilized yet their cultural and nutritional values are very significant. The community groups pass knowledge from one generation to the other through social events where they showcase and sell various traditional foodstuff.

Traditional wine made from a mixture of Marula fruits (see picture), sugarcane and honey is a common delicacy prepared by some groups while others have specialized in making nutritional supplements made from food crops and herbal plants to treat chronic diseases such as high blood pressure and malnutrition among children. Indigenous fruits such as guavas, passion fruits and gooseberry are also widely propagated for income generation. These fruits have high nutritional value and are particularly useful in supplementing local diets during periods of food scarcity.

The main challenges faced in utilization of food from wild plants is poor attitude by the youth towards these foods, inadequate market for their products resulting from low demand, inadequate capital to establish profitable ventures and inadequate support from key stakeholders including the county governments. The groups recommended support by County Government and other partners to develop their enterprises and provided with a wider platform for showcasing their traditional foods. In addition, local communities and especially the youth should be sensitized on the nutritional and health importance of the traditional foods.

3.8 Traditional knowledge associated with use of aloes

Aloes are widely grown in Taveta Sub-County and are thus utilized by a number of nature based enterprises. Aloes are mainly used for their medicinal and cosmetic values. Traditionally, communities use indigenous aloes to treat both human and livestock diseases. For instance, aloe has been used to treat stomach related ailments among human beings as well as coccidiosis in poultry. In the recent past, local communities in support of various development partners ventured into aloe growing with an aim of selling to cosmetic and pharmaceutical industries.

Unfortunately, a number of community groups engaged in aloe growing have been left stranded with no markets for their produce. The lack of equipment for processing aloes have further led to losses and disillusionment within the groups. There is need for capacity building of these groups to equip them with the necessary skills and equipment for processing of aloe products, as well as linking to competitive markets.

3.9 Development of KEFRI App

The Institute in collaboration with the Ministry of Environment and Forestry as wells other partners, developed and incubated a ***web-based*** mobile Application named KEFRI App, as one of the platforms to provide information on tree species site matching.

The App is globally available in the Google play store for stakeholders and public to utilize in sustainable tree growing activities. It has the capability to provide critical information to guide tree growers on the right species to grow (species - to - site matching) up to each administrative sub-location and summarizes the information in tabular form. It also links to *m-FORESTER* module to provide tree management guidelines for the desired products e.g. tree seedlings and locale of the nearest tree nursery.

The KEFRIApp is therefore a critical tool to support tracking progress towards achieving and maintaining 10% tree cover by 2022. The App will provide statistics on;

- Real time tally of all the trees planted in different ecological zones
- Surviving trees and effective percentage change in tree cover

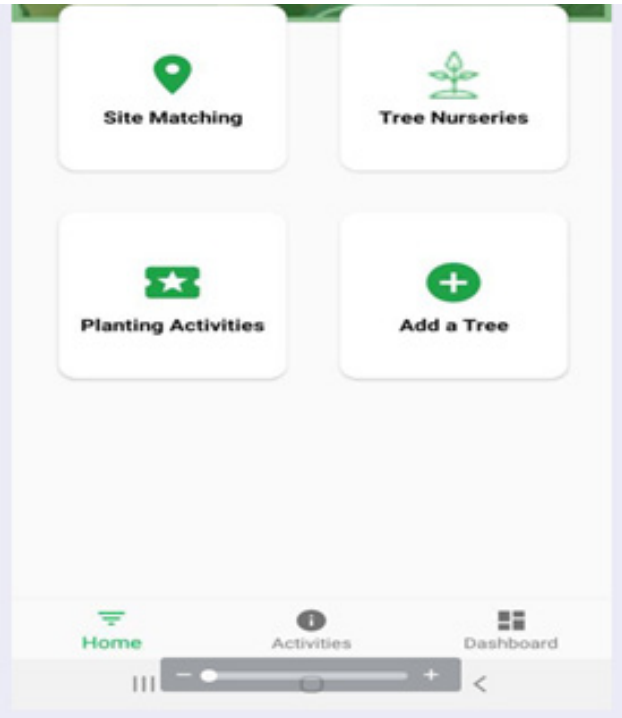

Fig.19: KEFRIApp typeface

In the fiscal year 2020-2021, based on 64 popular tree species (indigenous and exotic) were documented in different ecological zones, a total of 1,160 entries captured in the App for tree planting campaign activities since August 2019.

The App is user friendly, for registration by various categories of stakeholders; public, private and individuals involved in tree growing activities.

4.0 DEVELOPMENT, REFINEMENT, CAPACITY BUILDING AND LINKING OF TREE PRODUCTS TO MARKETS

KEFRI undertakes multi-disciplinary research, innovation and development initiatives in tree products leading to; development of bio-enterprises, creation of forest products-based wealth and linking of technologies to relevant consumers to improve the living standards of communities through provision of an alternative source of livelihood while contributing to sustainable development and environmental conservation. In addition to research, training and incubation for forest product development and processing is undertaken. This involves in-house training and on-site demand driven passive incubation, short term and long-term training and follow-up on forestry-based technologies for business. This is line with the KEFRI strategic plan 2018-22 and other National development goals including attainment of Vision 2030, the Big 4 agenda and increasing tree cover to 10%.

During the financial year 2020-2021, KEFRI developed and refined tree products, undertook capacity building and linked various technologies to markets.

4.1 Development of New Tree Products

4.1.1 Development of Lotion with Calodendrum capense (Cape Chestnut) oil

In the fiscal year 2020/2021, KEFRI developed lotion fortified with *Calodendrum capense* oil to determine its suitability as a skin care product. *Calodendrum capense* (Cape chestnut) is from the Rutacea family that is native to South Africa, Zimbabwe, Zambia, Kenya, Ethiopia and Uganda. In Kenya, the tree grows naturally and is found in abundance in the highlands of Nyeri County. The tree produces brown fruits which on maturing, rupture and release black non-edible nuts from which oil is obtained through cold press method. The oil is used in soap making and cosmetic industries due its sun screening properties.

Skin care products formulated from plant extracts such as seed oils are quite effective in enhancing the appearance of human skin. The products are developed for the purpose of moistening and nourishing the skin. Their demand is on rise due to low cost and significant effectiveness on the management of multiple skin conditions such as protection from the ultra violet (UV) radiation, management of dandruff, varicose, control of muscle spasms, healing of wounds, cracked skin and lesions among others.

Research shows that *Calodendrum capense* oil is used against sunburns and has essential elements (Zn, Mn, Fe) that have antioxidant properties for skin care. It is therefore necessary to develop cosmetic products from this resource to motivate local communities to conserve the tree and its environment.

Calodendrum capense seeds were harvested from Nyeri County. The seeds were dried and oil extracted by cold press method using a screw type machine. The oil was further and lotion produced in accordance to KEBs standard (KS 580:2006) for development, optimizing and verifying cosmetic creams, to determine its suitability as a skin care product.

The lotion was then subjected to microbiological tests that included; total viable count and gram negative pathogens such as *Salmonella typhi, Pseudomonas aeruginosa, Escherchia coli.*

Fig.20: *Calodendrum capense* dry seeds ready for oil press and production of lotion

KEBs verification results demonstrate that the refined *Calodendrum capense* lotion is recommended for topical application and is suitable for use as a skin care product. It is therefore necessary to upscale the processing of the product in preparation of commercialization of the product. Samples from the first batch should be tested for effectiveness and subjected to customer satisfaction surveys for continual improvement of the product.

Efficacy tests are recommended to establish its effectiveness on different skin conditions and organoleptic tests should be undertaken to further refine the lotion to fine tune it for commercialization. A protocol for processing lotion also needs to be developed. The product should be linked to the market through empowering communities where the resources are and training groups to initiate cottage industries. In addition, population assessment of *Calodendrum capense* is recommended to determine its current resource status for sustainable utilization.

4.1.2 Phytochemical investigation of the genus Zanthoxylum for antimicrobial and anticancer principles

There has been a global development of conventional medication to manage diseases such as cancer and microbial infections. Nevertheless, treating cancer in Kenya ranges from Ksh 6,000 (US$ 60) to Ksh 600,000 (US$600) per treatment course, making it a financial drain for most households. In addition the chemotherapy drugs are rendered ineffective by the tendency of cancer - inducing microbials as well as resistance developed by the cancerous cells, which is causing a major challenge. Natural products have thus been suggested as leads to overcome multidrug resistance (MDR) in cancer cells and microbial infections.

Zanthoxylum species are extensively used in traditional medicine to manage ailments ranging from bacterial, viral and fungal diseases to curing conditions such as cancer and malaria. Communities living in the coastal areas of Kenya use stem and root extracts of *Zanthoxylum paracanthum* in the management of tumors and other related diseases.

In the FY 2020-2921, KEFRI undertook a phytochemical isolation studies that evaluated antimicrobial and antiproliferative potencies of the root bark of *Z. paracanthum* collected from Mrima Hills in Kwale County.

The isolated compounds and extract were tested for antimicrobial (against four microbes, *Escherichia coli, Staphylococcus aureus, Candida albicans* and MRSA) and anticancer (human breast and prostate cancer cell lines) activities using broth dilution and MTT assay - reduction of a yellow tetrazolium salt (3-(4,5-*dimethylthiazol*-2-yl)-2,5-*diphenyltetrazolium bromide*) respectively.

Results from this study provide scientific evidence for the popularity of root extracts of *Z. paracanthum* as a traditional plant medicine, which is used for microbial infections and/or cancer-related ailments in locations where the plant is found. Other studies of the chemistries and bioactivities of the leaf extracts of this species should be carried out, as leaves are a more renewable source of material for pharmaceutical application, compared to both stems and roots.

4.2 Refining promising tree products

4.2.1 Refining Ximenia Facial Cream

In the fiscal year 2020/2021, KEFRI refined product facial cream, a promising healthcare products fortified with *Ximenia americana* essential oil. *Ximenia Americana*, also called wild plum, is a shrub that belongs to the family of Olocaceae. It is an evergreen and a drought resistant species that grows up to 4 metres tall and native from tropical Africa. In Kenya it is distributed in Kwale, Taita Taveta, Makueni, Kitui, Machakos, Tharaka, Isiolo, Marsabit, Baringo, West Pokot and Turkana Counties.

The essential oil is extracted from the seeds and used in cosmetic and softening leather products. The oil is effective in skin hydration, increases skin elasticity, management of stretch mark as well as hair conditioner. The oil is good in managing arthritis, varicose veins and abdominal pains.

Ximenia seed were harvested from Kwale County and oil extracted used as a major raw material for refining the facial cream. The Kenya Bureau of Standard **(KS 580:2006)** was used for quality assurance to contribute to manufacturing and optimising of high quality cream. Previous results for 2019/2020 trial had failed to reduce the value of total viable count to less than 100 Cfu/g. During the process of product refining, the results demonstrated that the cream fully conformed to the standard, making it suitable for use as a skin care product. The facial cream verification results showed that the product conformed to the standard and therefore is suitable for skin use.

The study recommends refining of the procedure for processing the cream needs to be developed. Training community members where the *Ximenia americana* resources are available to enhance environmental conservation and contribute to community economic empowerment.

Fig.21: Illustration of *Ximenia* products; kernel extracted from seeds, oil and lotion

4.3 Training on Marula Jam Production and Lotion Production from Neem Oil

In a bid to improve the quality of products, KEFRI through the National Forest Products Research Programme (NFPRP) offers trainings to communities to develop their local capacity for accelerating the country's shift to industrialization. Overall, KEFRI designs such capacity building to increase community participation in the product development and value addition sector.

KEFRI promotes the utilization and commercialization of indigenous fruits to develop various products including juices, jams, candies, wine and herbal extracts and oils from forest products to make skin care products.

In order to link refined products to SMEs, a 3-day practical workshop was organized to train on value addition to Marula jam and neem oil lotion benefiting members of community group in Tharaka Nithi County.

Fourteen women from Tharaka Green Gold Capacity Enhancement Network were taken through practical - step by step processing of Marula jam from fruits (*inset: photo source:demandafrica*) and Neem oil lotion, including development of action plans to guide in further production and marketing the products.The overall lesson learnt is that branding, labelling and marketing of these products to be undertaken so as to improve and attract uptake in the market.

Fig.22: Group members learning the process of preparing Marura jam and Neem lotion

4.3.1 Building Capacity on quality control for gums resins producers and traders

In the year under review, KEFRI in collaboration with Mercy Corp, a non-profit organization, working together on the frontline of crisis, disaster, poverty and climate change, undertook capacity building on quality control for gums and resins producers and traders in Turkana County. Mercy Cop works agency to shape the future of the youth who desire to improve their lifestyle through access to, financial literary training, life skills, and the ability to influence decision making, drive peace and development.

The aim was to equip youth, households and community with skills on sustainable production and utilization of gums and resins, promote gums and resins trade as a meaningful work opportunities to improve livelihoods in Turkana County; and address some of the challenges including; lack of clear policies and strategies on the development of gum arabic value chain, low prices due to overreliance on middle men, incapacity to bulk enough quantities and lack of aggregation centers and co-operative to market the product.

Turkana County has a huge potential of commercializing gum arabic which is available in sufficient quantities. KEFRI has the technology on quality assurance and value addition is available in. However, the trade is yet to significantly benefit the people of Turkana where this resource is present. A training curriculum was developed on gum arabic and 85 gum arabic TOTs across five sub-counties in Turkana County and over 1000 *Gum arabic* traders and collectors, were trained. 42 gum arabic self-help groups were formed, 18 of which fully registered and gum arabic collectors and traders were connected to markets at competitive prices. Over 5 tonnes of Gum have been collected by March 2021.

Some of the recommendations to improve the sector include; formation of a *Gum Arabic* co-operative to consolidate and aggregate gum from the collectors and traders; promote the marketing and pricing by selling directly to the exporters; an exchange visit especially between Gum collectors and traders in Kenya and Sudan the biggest exporter in the world; establishment of *Acacia senegal* plantations in the suitable regions for sustainable production of gums resins.

Fig.23: Trader sorting gum arabic in Kaaleng and tapping *Gum Arabic* from *Acacia seyal*

4.3 Capacity building in sustainable charcoal production using efficient charcoal kilns in Mirangine, Kitui and Mtwapa Energy Centres

In the year under review, KEFRI was contracted by the Ministry of Energy to implement the project entitled *"Capacity building in sustainable charcoal production using efficient charcoal kilns in Mirangine, Kitui and Mtwapa Energy Centres".* This included capacity building of staff at the selected three Energy Centres and the technical assistance in setting up the various kilns.

Through KEFRI, three portable metal kilns made of stainless steel and accessories for the casamance and improved earth kilns were procured from identified local fabricators who have been collaborating and developing the technolgies based on KEFRI specifications. The procured items were delivered to the three Energy Centres and received by the Centre Managers.

Fig.24: The newly procured portable metal kiln (left) and the kiln being loaded with wood at Mtwapa Energy Centre (right)

Adams retort kilns were constucted in all the three Energy Centres using locally available materials (fired bricks sand, water and cement). A trained mason and local artisans/local labour were engaged in the construction of the kiln. The constructed kilns were cured for twenty one days (three weeks) before being used for the carbonization trials. The performance of the kilns improves as it dries up completely. The constucted retort kilns were tested during the staff training.


Fig.25: Construction of Adam Retort Kiln in Kitui Energy Centre

Training was conducted at the three energy centres from April through to May 2021, with a total of 61 participants trained, comprising of staff and community stakeholders. The training focused on:

- Efficient charcoal production technology for increased recovery rates,
- Briquetting technology as alternative source of bioenergy while addressing environmental issues like waste management and climate change and
- Establishment of tree nurseries and woodlot management for sustainable production of woodfuel.

The trainings were conducted through presentations, demonstration and actual practicals sessions. The sessions was successfully implemented thus recommending that this activity be extended to the other energy centres in the country. This will enhance staff capacity in promoting sustainable bio-energy technologies including efficient charcoal production tchnologies, briquetting technology and improved cook stoves for improved livelihoods and environmental conservation


Fig.26: Training of community in theory and practical sessions at Kitui Energy Centre-Kitui

5.0 DISSEMINATION AND PUBLICITY ACTIVITIES

Fig.27: Cabinet Secretary for Environment and Forestry Keriako Tobiko visiting KEFRI exhibition at Hon. John Michuki Memorial Park during the Annual Bamboo Day, 2020

5.1 Raising KEFRI Profile

During the Financial Year 2020 - 2021, KEFRI intensified profiling of its image and visibility at national, regional and international levels. Notably, the corporate undertook dissemination of research findings and sharing information to diverse stakeholders through; branding, publicity, advertisement of products and services.

Additionally, the Institute through Corporate Affairs and Quality Assurance coordinated drafting, negotiating and vetting of Performance Contracting (PC) activities in 17th Cycle Guideline (2020-2021). As a result of cascading, monitoring and evaluating implementation of targets, the institute was eventually rated 'Very Good' with a score of 3.4, making it the leading parastatal at the Ministry of Environment and Forestry. Likewise, monitoring and evaluation of Strategic Plan (SP), citizens' service delivery charter for customer care and hospitality; corporate social responsibility, and public complaints and feedback were executed in compliance to national statutory obligations and legal requirements. Further implementation of Intellectual Property Rights; quality assurance of systems (ISO Standards; EMS, 14001:2015; QMS 9001:2015), Work Environment and OSHAs, public relations, National Cohesion through Choir presentations were entrenched in all operations to profile the image.

5.2 Communication to stakeholders

During the Fiscal Year 2020/2021, the Institute disseminated forestry technologies and shared related information through various platforms to reach diverse audiences. The objective was to relay information and engage stakeholders on adoption and upscaling of forestry developed technologies that include - seed production, nursery establishment, tree propagation and improvement, silvicultural practices, rehabilitation and conservation of biodiversity, processing and utilization of wood and non-forest products and allied natural resources, to facilitate sustainable forest development and mitigate against the effects of climate change.

Normally, the Institute applies various platforms to share information and technical advice on forestry matters. The platforms to mobilize and awareness campaigns include exhibitions, open days, farmers field days, demonstration sites, centre research advisory committee (CRAC), verbal, physical and virtual meetings, forums, telephones and e-mailings, letters/ memos and posters and postcards, mainstream media (print - magazines, newspapers, newsletters, brochures, Annual reports, booklets etc and electronic media - radio and television talks, social media (Facebook, Twitter, Linked-in, WhattsApp, Website and support software's for public consumption.

5.3 Exhibition and publicity of technologies with socio-economic impact

Kenya plans to achieve 10 per cent forest cover by 2022 as per the Constitutional target under Article 69 (1) (b). As such, exhibition of forestry technologies and innovation with socio-economic impact is crucial since forestry contributes immensely to Kenya's economic development and achievement of the Big 4 Agenda.

During the year under review, KEFRI had plan to display its technologies in 11 Agricultural Society of Kenya shows countrywide and reach diverse economic sectors including agriculture, mining, energy, tourism, and wildlife among many other sectors. The show proposed were Machakos, Makueni, Nakuru, Kisumu, Kakamega, Mombasa, Nyeri, Nairobi, Kabarnet, Eldoret and Migori. However, the activity was significantly interrupted by measures to control the COVID-19 pandemic.

5.4 Open Day and Field Day

The Institute therefore planned to disseminate information at six open days one per each eco-regions to showcase research, products and services to ultimately contribute towards enhancing environmental conservation. To encourage tree and forest cover to curb land degradation:

Despite interruption of some events by measures to control the COVID-19 pandemic, Coast Eco-Region Research Programme, CHERP and DERP held an Open Day in Gede and Garissa. In Gede the open day held on 25th June 2021 aimed at sensitizing stakeholders on Bamboo commercialization, including: production of high-quality tree seeds and seedlings, rehabilitation of Mangrove and utilization/value addition to forest products. In normal circumstances, the event targeted farmers, private sector representative, students and teachers from local schools, representatives from government department and NGOs. The open day and field day aimed at enhancing public awareness in tree growing for environment conservation, management of invasive woody species, climate change mitigation and livelihood improvement.

KEFRI scientists and technical staff, through public private partnerships approach, shared skills and experiences on tree growing with local communities and other stakeholders in order to strengthen uptake of forest technologies. Generally, the events included display of seed collection and processing, propagation of bamboo and valuable tree species, value addition to wood and non-timber forest products, information dissemination and entrepreneurship. Demonstrate technologies for conservation of hilltops using indigenous tree species, benefits of Participatory Forest Management (PFM) to the Community Forest Associations (CFAs) , Bamboo in Protection of Riparian areas. Demonstrate tree growing and utilization technologies developed by KEFRI at Wambugu Farm, Nyeri County

5.5 Participation in National and International events

The Institute participated and exhibitions in national and international events to publicize and collate concerns for promoting and adoption of forestry and related technologies (Table 7.)

Table 7: Participation in partners, national or international events

Name of the Event	Date	Venue
International Day for Combating Desertification and Drought	17th June, 2021	Korolle Oasis, Marsabit County
World Environment Day	5th June, 2021	Garissa University
International Day of Biological Biodiversity	22nd May, 2021	Nasaru Oloshoro Conservancy, Kajiado County
World Wetland Day	2nd Feb, 2021	Sabaki estuary, Kilifi County
International Day of Forests (IDF)	21st March 2021	Virtual
World Ozone Day	16th Sep, 2020	Sabaki estuary, Kilifi County JMM Park, Nairobi County
World Bamboo Day	18th Sep, 2020	
National Tree Planting in: Maasai Mara, Kanjeru and Gitutha, Muhoroni, Karima hills-Nyeri, JMM Park among other areas	30th April, 2020	Various Counties

5.6 Publicity through Mainstream and Social media

The Institute developed information and packaged technologies for publicity and promotion through mainstream media including newspapers, radio talks, TV shows, excursions and demonstrations trial. Apart from traditional communication mainstreams, social media networking platforms; website, Facebook with over 14,000 followers, YouTube, Twitter, LinkedIn, WhatsApp, Emails and SMS was used to engage with stakeholders; share latest forest information to increase the reach and visibility of KEFRIs knowledge products, and to market products and services or extend business.

Fig.28: KEFRI staff participating in a virtual meeting necessitated by measures to control the COVID-19 pandemic

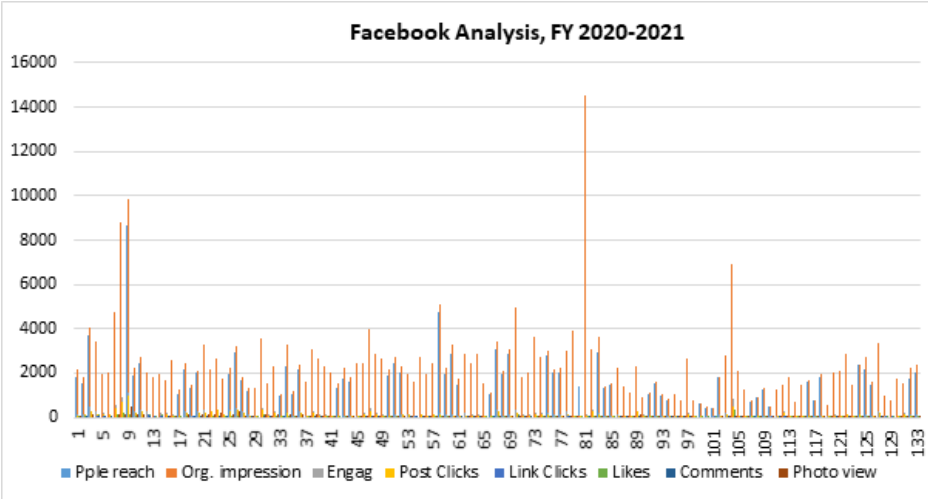

Fig.29: Bar graph showing analysis of interaction reach through KEFRI Facebook page

5.7 Branding, publicity and marketing materials

During the Fiscal year under review, KEFRI developed publicity and marketing materials including: Brochures, flyers, postcards, business cards, etc. Promotional marketing materials: Corporate wears (T-shirts1000 and 100 Jackets), Buntings (50mtrs), congratulatory cards, certificates, etc. Signs & Banners: Vision, 15 Mission pull-up banners, Tear drops (20), KEFRI flags (18 pieces), including back drop banners and distributed across all centres and sub-centres, Signboards and paintings,

KEFRI Choir publicized the Institute through performances during internal and national events sensitizing public on various forestry and environmental issues as well as creating public awareness on national cohesion and values. The events included national tree planting events, county national celebrations, and training of choir lead members.

5.8 Corporate Social Responsibility

KEFRI undertook corporate social responsibility (CSR) activities grouped in three categories as follows:

a) Advisory and excursions visits to provide information, technologies for use by stakeholders to improve their environment, livelihood and adaptation to mitigate effects of climate change

b Provision of planting materials seed/seedlings and tools to the public in support of development of forestry and means to achieve 10% tree cover as part of for attainment of Big 4 agenda.

c) Support and donations to charitable events, institutions and to less privileged members of society

5.9 Intellectual Property Rights (IPR)

KEFRI has been in the forefront to formulate an institutional IPR policy to spur creativity and stimulate innovations, discoveries, protecting data, Copy rights, and dissemination of Knowledge and to provide scientists and institutional rights associated with ownership and distribution of benefits that may be derived from the creation of intellectual rights.

5.10 Capacity Building of partners and communities for adoption of forestry technologies

Building capacity of both KEFRI staff and partners - through conducting interactive seminars, internship and attachments of students from Universities and Tertiary colleges. The initiative is expected to gain impetus once operationalizing of KEFRI Graduate Research School (KGRS) takes effect. According to approved KEFRI work plan 2020-20214 external students (1 PhD and 3 MSc) were awarded research grants, 38 KEFRI Scientists on MSc and PhD study programmes were mainstreamed into the KGRS initiative.

Some members of staff trained on data mining organized by Jomo Kenyatta University of Agriculture and Technology (JKUAT) in partnership with University of Hasselt, Belgium.

Through Social Forestry Training Centre, KEFRI identified, developed and implemented one (1) workshop entitled: Global Land Outlook: Future Perspectives on Land Use for Kenya - Pilot Phase. The introduction, objectives, outputs and recommendations/way forward of the workshop conducted by SFTC are summarized as follows: Short term course on Resource Mobilization, lobbying and proposal writing

5.11 Publication and Information Documentation

The main achievements were made through editing and production of publications and information acquisition. A total of 52 publications were produced during the year (Table 8) and (Appendix I.)

Table 8: Types of publications produced in 2020 - 2021

Type of Publication	Number
Peer reviewed journal papers	23
Technical Notes/Research notes	4
Guidelines/extension materials	17
Policy briefs	3
Annual report and record of research 2019/2020	1
Quarterly Newsletters	4
Total	**52**

The publications were distributed mainly to KEFRI Regional Research Centres for further re-distribution to stakeholders in the respective eco-regions and also through other dissemination avenues including; agricultural shows, field days and open days. The publications were also issued during trainings and to interested parties who visited eco-regions and sub centres.

5.12 Publicity, Upload of resources into KEFRI Institutional repository

During the reporting period, a total of 1,376 publications were compiled under KEFRI Knowledge Products Master List, and 30 information resources were availed into the institutional repository. The uploaded resources can be viewed or downloaded via KEFRI Repository URL at http://197.248.75.118:8282/jspui.

5.13 Structures and platforms to increase forest information flow to stakeholders

KEFRI information repository and Knowledge Base were enhanced with social media tools for sharing including; Facebook, WhatsApp, Twitter, LinkedIn, Email and SMS. These tools will increase the reach and visibility of KEFRIs knowledge products.

5.14 Knowledge Management Unit

Knowledge Management Unit is involved in; identifying, capturing, evaluating, retrieving, and sharing KEFRI's knowledge assets. These assets include both explicit knowledge (databases, documents, policies, procedures) and tacit knowledge (individual expertise and experience). During the year under review, the unit achieved the following:

5.15Monitoring of KM System Usage

During the year under review a total of 91 users were registered in KM system, 233 topics created, 34621 topics viewed, 2673 topics updated and 353 uploads added. A monthly average of 8.08 users were registered, 33.08 topics created, 10860.75 topics viewed, 260 topics updated and 33.67 uploaded (Table 2).

6.0 PARTNERSHIP AND RESOURCE MOBILIZATION

KEFRI establishes strategic networks and linkages that leverage on collaborative and funding partners willingness to compliment research and development initiatives.

During the financial year 2020/2021, KEFRI accomplished 3 specific objectives under Partnership and Resource Mobilization which are as follows:

5.7: Enhance linkages and partnerships with stakeholders.
5.8: Increase revenue
5.9: Improve resource mobilization strategies

At the close of the financial year 2020/202, KEFRI had interacted with 126 strategic partners categorized as: government ministries, state corporations, universities, international organizations, county governments, non-governmental organizations, private companies and community based organizations.

6.1 Enhance linkages and partnerships with stakeholders

Under KEFRI strategic objective 5.7, to enhance linkages and partnerships with stakeholders, six activities were implemented in the year under review. The process of identifying strategic partners or partnership is usually guided by exclusive mutual interest and entailed various meetings to pick on specific area of cooperation which are concretized through memorandum of understanding (MoUs) and memorandum of agreements (MoAs).

KEFRI held diverse meetings whose discussions focused on collaborations with development partners, fundraising for conservation and management of urban green spaces including Hon. John Michuki Memorial Park and City Parks in Nairobi. Further advanced meetings held with Lamu and CIRAD (Agricultural Research for Development) in collaboration regarding implementation of a project titled; Mikoko whose objective is to promote conservation and resilience of mangroves in Kenya; CIRAD; Kenya Medical Training College, National Environment Trust Fund (NETFUND) through African Climate Change Fund (ACCF) Project that focuses on building the capacity of the ministerial resource mobilization committee (RMC); and KCIC.

6.2 Coordinate KEFRI-KFS research and management Liaison activities

- Both TLC and PLC committee's membership Redefine and reconstituted with 9 members each from KEFRI and KFS. Held 4 TLC and 1PLC committee meetings
- Redefine and re-constituted membership drawing with 9 members from KEFRI and KFS.
- Two (2) TLC meetings held at KFS and KEFRI headquarters
- 2 meetings were held to discuss land for research allocation to KEFRI
- 2 planning meetings held for joint activity on land demarcations and excision

6.3 Improve resource mobilization strategies

Within the reporting year, twenty six (26) Memorandum of Understanding were develop, shared and some signed between various strategic partners at national and regional level. These partners had similar interests for joint research and resources mobilization in forestry and allied natural resources.

Strengthen uptake of forest technologies through public private partnerships.
In this activity office of PRM supports development of frameworks to actualize these PPP but real implementation of this activity is at thematic level.

KEFRI developed MoU for bamboo treatment with a Private Company in Migori Coordinating activities of various networks hosted by KEFRI, making in total eleven (11) International Commitments and MoUs. All active networks that KEFRI hosted has been undertaken and status review and validity of registration to these networks done.

Additionally, the status and implementation progress report of all the Commitments and MoUs has been shared with the National Development Implementation and Communication Cabinet Committee (NDICCC) per their directives.

Fig.30: Signing an MoU with One Acre Fund and relevant collaborators for shared efforts in forestry activities

6.4 Increase Revenue

Under KEFRI strategic objective 5.9 to improve resource mobilization strategies, the activity was achieved through identifying, developing and submitting 14 project proposals and concepts for consideration at national and international grants. Three 3 proposals developed on consultancy bids in forestry Research &Development /NRM and submitted as follows;

I. Consultancy Service to Undertake an Assessment of Existing Analyses/Studies of Forest Value Chains in Kenya, with Identification of Main Opportunities and Obstacles to their Development and their Main Contributions to SDG's. (We-Effect but were dropped at stage 2)

II. Consultancy to Undertake Mapping of Financing Sources/Initiatives that are Targeting Smallholder Producers, their Organizations, and SMEs. (We-Effect but were dropped at stage 2)

III. Consultancy Service to Develop a Forestry Business Sustainability Action Plan for Kenya
Kenya Association of Manufacturers (KAM)

7.0 HUMAN RESOURCE MANAGEMENT, ADMINISTRATION AND IMPROVEMENT OF WORKPLACE ENVIRONMENT

During the year under review, the KEFRI Human Resource Division undertook both routine activities and those signed in the performance contract for 2020/2021 Financial Year. The activities undertaken included: Policy development and implementation, human resource planning, recruitment and selection of staff, training and development of staff, Performance management, reward management, employee relations, personnel administration, employee separations and provision of medical services at the KEFRI clinic.

7.1 Staff Strength

The Institute as at 30th June 2020 had **874** employees out of which **744** are on permanent and pensionable terms of service whereas **130** are on contract terms.

Table 9: KEFRI staff strength FY 2020-2021

S/No	Cadre	No. of staff
1	Research Scientist	117
2	Technologist	48
3	Technicians	42
4	Foresters	31
5	Finance	41
6	Audit	7
7	HR	7
8	Administration	22
9	Supply Chain	29
10	Other professional Support	300
11	Other Support	230
Total		**874**

7.2 Recruitment and Selection

During the fiscal year, the Institute's replacement plan for the FY 2019/2020 was approved by the National Treasury, which led to the filling of the sixty (60) approved positions as advertised. KEFRI Board of Directors also approved for appointment of thirteen (13) candidates from marginalized areas and special constituencies on affirmative action in order to boost the Institute's diversity profile. The new employees reported to KEFRI Headquarters for induction from 1st to 4th December, 2020.

Other positions that were filled include: Eight (8) drivers, one (1) nurse on Locum appointment, one (1) clerical officer - a person living with disability as well as a personal aide, two (2) officers for KEFRI Graduate Research School (KGRS) i.e. the Administrator and Knowledge Management Officer; and thirty one (31) interns.

7.3 Training and Development

The Institute through the division facilitated training of various staff including PhD scholars, leadership trainings and induction of newly appointed officers and attachees who were on attachment during the period under review.

7.3.1 Supports on PhD Training

During the period under review, the institute supported seven (7) Research Scientists who had fulfilled all the requirements for the sponsorship such as submission of progress reports to pursue PhD programme.

7.3.2 Leadership Training

Further, the Institute supported the Directorate ie. Director, SDD R&D and SDD CS to attend and participate in a training dubbed 'Managing Institutions during crisis' as part of the leadership training. Eight (8) members of staff were supported on professional training at the Kenya School of Government and further, seventy three (73) newly appointed officers and one hundred and three (103) attachees who were attached in the year under review were inducted.

7.4 Internship

The Institute engaged thirty one (31) interns for the year 2020/2021 as per the Government directives to transfer knowledge by offering internship programme. The interns were posted to various Regional Centres and Sub-centres.

7.5 Other Human Resource Management Policies and Guidelines

Two HR Policies were approved during the period namely:

(i) KEFRI Volunteerism Policy whose main aim is to give graduates an opportunity to work at KEFRI in without pay (volunteer) to gain knowledge and skills in their respective area of specialization,

(ii) KEFRI Covid-19 Emergency Medical Response Policy whose aim is to offer support to staff who may be affected by Covid -19 pandemic.

Human Resource Training and Development Policy was deliberated by the Board of Directors, approved and has been circulated to staff through the Institute's website. During the same period, the Mentorship Policy which had been approved by the KEFRI Board of Directors for implementation during FY 2019/2020 was enacted through the appointment of Mentors to sixty seven (67) newly appointed officers.

7.5.1 Human Resource Instruments

During this period, the Division presented the SCAC approved Human Resource Instruments to the Human Resource Committee (HRC) and subsequently to the Full Board for approval for implementation. The full Board sitting on 26th November, 2020 approved the implementation of the Instruments but deferred the same owing to the Institute's dire financial position. The approved HR Instruments included:

(i) KEFRI Organizational and Grading Structure;

(ii) KEFRI Staff Establishment;

(iii) Career Progression Guidelines; and

(iv) Human Resource Policies and Procedures Manual.

7.5.2 Succession Planning and Management

During the period, the following scientists were appointed to higher ranks to enhance research:

Dr. M.T. E Mbuvi – appointed as the Deputy Director - Forest Research Support Services

Dr. James K. Ndufa – was re-appointed as the Acting Deputy Director Forest Biodiversity and Management for a further period of six (6) months up to September 2021

Dr. John M. Otuoma – appointed as the Regional Director Lake Victoria Eco-region Research Programme, Maseno

Dr. Vincent Oeba – appointed as the Head of the Biometrics and Remote Sensing Unit

Dr. Stephen Omondi – appointed as the Head of Tree Breeding

Sheila Shefo Mbiru – appointed as the Head of Knowledge Management Unit

Joseph Machua – appointed as the Head of Biosciences Research

Mr. Paul Tuwei – appointed as the Coordinator of Research Support Services

7.5.3. Job Evaluation

During the second quarter, the Institute participated in the Salaries and Remuneration Commission (SRC) Job Evaluation for 2021/22- 2024//25 Remuneration Review Cycle for the Public Sector. The Division coordinated the description and compilation of all the 233 KEFRI jobs into one Job Description Manual and forwarded the same to SRC.

The SRC invited the institute for a to discuss the institute's Job Evaluation results through a virtual clinic that was held on 27th May, 2021. The Institute thereafter received a hard copy of the Job Evaluation results on 30th May, 2021 and prepared a counter-proposal of the same dated 11th June, 2021 in which the HR Division forwarded the reviewed Job Descriptions to SRC for consideration. The Institute has received a verbal communication that our request has been considered favourably. We are therefore awaiting a written communication of the same from SRC.

7.6 Infrastructure Development

In the financial year 2020/2021, KEFRI through the Administration Division, anchored at Corporate Services Department that oversees provision of services in the areas of infrastructure development, security, transport, registry and records management, maintenance of buildings, plant, equipment and fleet management as well as management of utilities. implemented various activities as highlighted below.

7.6.1 KEFRI Headquarters

Successful completion of construction of an ablution block, fencing of the HQ and the Directors residence, Installation of closed-circuit television (CCTV) cameras, construction of bollards, paint works and replacement of 38 toilets. These facility improvement measures were geared towards improving the outlook of the institution as well as enhancing security of KEFRI staff

Fig.31: Ablution block, Bollards and paint works, renovated Director's residence

7.6.2 KEFRI Lamu Sub-centre

Installation of closed-circuit television (CCTV) cameras was installed together with its supporting infrastructure to enhance security at the Centre. The required documentation to aid in procurement for the completion of kitchen and dining as well as repair of the roof in the office block was done. However the actual works did not commence due to repeat tendering which affected the timelines for the works.

7.6.3 KEFRI Marigat Sub-centre

Emergency preparedness is a critical issue of consideration in safeguarding investments in infrastructural development. The Institute has put in place measures to progressively invest in installation of fire hydrants and water reticulation works to ensure readiness in the event of fire. So far, the Institute has successfully completed these works at KEFRI Headquarters, Kitui and recently in Marigat. In addition to the works, staff have been trained on proper handling of the equipment as well as on fire incidents preparedness and response.

Fig.32: Fire pumps and commissioning of the completed works

7.6.4 KEFRI Kitui and KEFRI Kibwezi

Securing of KEFRI land and property is essential for the achievement of the Institute's mandate of conducting research in forestry and allied natural resources. The Division oversaw fencing of KEFRI Kitui Regional Centre and Kibweizi Sub-centre to secure property and research experiments in the nurseries of these facilities. The fencing was done using concrete poles and chain link which are durable and tolerant to weather conditions.

Fig.33: Fencing of KEFRI Kitui Centre and Kibwezi Sub-centre

7.6.5 Construction of KEFRI Rumuruti Sub-centre

KEFRI Rumuruti Sub-centre which is a new Centre under the Central Highlands Eco-Region Research Program is located in Laikipia County.

The Centre is approximately 13 Km from Rumuruti town and 1.5 km off the Rumuruti-Maralal road. So far the centre has benefitted with construction of a tree nursery house supporting tree nursery activities. The block also hosts, the office block consisting of a meeting room, Officer-in-charge office, Secretary, Accounts, store and toilets.

Fig.34: The newly built tree nursery house at KEFRI Rumuruti

8.0 WORK ENVIRONMENT

8.1 Quality Assurance for improved service delivery and quality products

The Institute has embrace International Organization Standardization (ISO) as a tool for Quality and Environmental management systems [9001:2015, EMS 14001:2015] to enhance service delivery on operations and environment. For ease of management, the two systems have been integrated in implementation and now referred to as Integrated Management Systems (IMS). The system now implements processes, procedures and legal compliance obligation that are covered in the entire institutional operations both in service/product efficiency and environment integrity.

During the reporting period, KEFRI implemented the following service/product requirement;

8.2 IMS ISO Systems implementation and maintenance

The following activities were undertaken;

i) Reviewed IMS document procedures, Legal compliance laws/obligations and risks and opportunities registers, and environmental aspects for all centres and sections
ii) Carried out both Internal and External surveillance audits and areas of non-conformance and areas of improvement identified and corrective measures and plans put into action.
iii) Management Review meetings at both top management and centres were undertaken to appraise the status of system implementation and resources allocation discussed
iv) Staff sensitization online on IMS and progress/mock audits undertaken in all centres
v) OSHA safety tools displayed at KEFRI in readiness for emergency response.

8.3 Implementation of Citizens' Service Delivery Charter

The service charter is a public document that sets out basic information on the services provided within KEFRI customized to point of service delivery, indicating goods/ services, costs and timelines required to be done. The services were implemented, monitored and feedback from customers addressed

8.4 OSHA and Work environment

This is a compliance issue to Occupational Safety and Health Act, 2007 where the institute implemented its requirement through work environment survey at Kitui, Londiani regional centres and Turbo Kibwezi, Taita Taveta and Garissa sub-regional centres, testing and training on emergency response, training of OSHA committee at work place registration at the KEFRI centres.

8.5 COVID-19 Preventive Measures

KEFRI adhered to the Ministry of Health measures towards COVID-19 pandemic regulations. The Institute through Supply Chain Management Division procured and distributed personal protective equipment (PPEs) including thermo-guns for temperature check-up, face masks and hand sanitizers. Fumigation of buildings and vehicles was done fortnightly, and hand washing points established in strategic points in all centers and sub-centres.



Fig.35: Ukulima Sacco manager donating COVID 19 kit, Fumigation of buildings at KEFRI headquarters, Nairobi County Fire Rescue and Disaster Management Unit and KEFRI team after a drill to gauge staff on fire rescue and emergency/ disaster management preparedness and response at KEFRI headquarters

8.6 Security and Cleaning Services

The Institute outsourced security, cleaning and grounds maintenance services from private service providers whose services were satisfactory during the period under review. This was done in a bid to to enhance security as well as clean and safe work environment.

8.7 Sensitization on Terrorism and Counter Violent Extremism

KEFRI partnered with the National Counter Terrorism Centre and conducted sensitization/awareness on terrorism and counter-violent extremism (CVE) in Kitui, Kibwezi, Migori and Marigat. This is an important aspect in emergency preparedness as well as a performance management target on safety and security measures a requirement of all government agencies.

8.8. Mainstreaming Road Safety Measures

In the year under review, the Government introduced Road Safety mainstreaming as a multi-sectoral approach and Performance Contract requirement to MDAs. KEFRI customized the National Transport and Safety Authority (NTSA) policy and developed her Road safety policy to guide concerted efforts to reduce Road Traffic Injuries (RTI's) and Road Crashes (RC's) within institutes work environment.

APPENDIX I

List of Publications FY 2020 - 2021

1. Angaine, P.M., Onyango, A.A., and Owino, J.O. (2020). Morphometrics of *Pinus patula* crown and its effecton cone characteristics and seed yield in Kenya. Journal of Horticulture and Forestry, 12(3), 94-100.https://doi.org/10.5897/JHF2020.0635.https://academicjournals.org/journal/JHF/article-abstract/EA3616F64129

2. Kaigongi Magrate M., Lukhoba C.W., Yaouba Souaibou, Makunga Nokwanda P., Githiomi J. and Yenesew Abiy. 2020. In Vitro Antimicrobial and Antiproliferative Activities of the Root Bark Extract and Isolated Chemical Constituents of *Zanthoxylum paracanthum* Kokwaro (Rutaceae). Plants 2020, 9, 920; doi:10.3390/plants9070920 www.mdpi.com/journal/plants

3. 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. Received: 28 April 2020. Accepted: 26 May 2020. Journal of Horticulture and Forestry. Vol.12 (2), pp. 63-69. April 2020. https://doi.org/70-83

4. KEFRI 2020. Research Data Management Regulations. KERI. Muguga, Kenya.

5. Kaigongi M.M. (2020). Review of Botanical Name Change of Trees, Shrubs, and Herbs in Kenya. Technical Note No 29. KEFRI. Muguga, Kenya.

6. Kagombe J., Kiprop J., Langat D., Cheboiwo J., Wekesa L., Ongugo P., Mbuvi M.T. and Leley N. (2020). Socio-economic Impact of Forest Harvesting Moratorium in Kenya. KEFRI. Muguga, Kenya.

7. Ndalilo L., Wekesa C. and Mbuvi M.T.E. (2020). Indigenous and Local Knowledge Practices and Innovations for Enhancing Food Security Under Climate Change: Examples from Mijikenda Communities in Coastal Kenya. Chapter 3 In: Gasparatos A. *et al.* (eds) Sustainability Challenges in Sub-Saharan Africa II. pp 63-82. Science for Sustainable Societies. Springer, Singapore. https://doi.org/10.1007/978-981-15-5358-5_3

8. Tarus G.K. and Nadir S.W. (2020). Effect of Forest Management Types on Soil Carbon Stocks in Montane Forests: A Case Study of Eastern Mau Forest in Kenya. Research Article. Hindawi. International Journal of Forestry Research. Volume 2020, Article ID 8862813, 10 pp. https://doi.org/10.1155/2020/8862813.

9. Wafula G., Tole Mwakio, Dharani Najma and Nadir S. (2020). Effectiveness of a Wastewater Treatment Plant located at EPZ in reducing Pollutants Discharged into River Athi, Kenya. Journal of Environmental Science and Engineering B9 (2020): 261-276. doi:10.17265/2162-5263/2020.06.004

10. Nyambati R.O., Odhiambo G.D., Serrem C.K., Othieno C.O., Mairura F.S. (2020). Effects of Integrated Use of *Calliandra calothyrsus* and Maize Stover with Urea on Maize Yield Components under Striga Infestation in Western Kenya. Universal Journal of Agricultural Research. 8(5): 165 - 172. DOI: 10.13189/ujar.2020.080504.

11. Muthike G. and Githiomi J. 2020. Value chain analysis of farm grown *Melia volkensii* (Gurke) timber in the South Eastern Dry lands of Kenya. *Full Length Research Paper.* Journal of Horticulture and Forestry. Vol. 12(4): 115-121. October-December 2020. DOI: 10.5897/JHF2020.0641. Article Number: 120CC7765645. ISSN: 2006-9782.

12. Choge S. (2020). Trends in Commercialization of Prosopis Products In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp 49 - 56

13. Kariuki J. G., Muturi G.M. and Choge S.K. (2020). Estimation of Prosopis Biomass in Kenya: Development and Use of Allometric Equations and Application of Remote Sensing. In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp 14 - 17

14. Muturi G.M., Kariuki J. and Choge S.K. (2020). A Synthesis of Ecological and Socio-economic Consequences of Land Rehabilitation with Prosopis Tree Species in Kenya. In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp 18 - 33

15. Oduor N.M. and Kimwemwe J. (2020). Charcoaling of Prosopis. In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp. 46 - 47

16. Oeba O., Choge S., Kiama S., Mwangi G., Mwaura J. and Sayah A. (2020). Prosopis Biomass Assessment for Estimation of Carbon Sequestration. In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp 62 - 74.

17. Wahome R.G., Choge S. and Kyuma R. (2020). Overview of Nutritional and Feeding Value of *Prosopis juliflora* Pods. In: Unlocking the Economic Potentials of Prosopis in the Face of Changing Climate: Proceedings of the 2nd National Prosopis Management Workshop at Soi Safari Lodge, Lake Baringo 18th - 23rd May 2015. pp. 34 - 45

18. Mutta, D.; Mahamane, L.; Wekesa, C.; Kowero, G. and Roos, A. 2021. Sustainable Business Models for Informal Charcoal Producers in Kenya. Sustainability 2021, 13, 3475. https://doi.org/10.3390/su13063475. Academic Editor: Richard Blanchard.

19. KEFRI, 2021. KEFRI Tree Seed Information Leaflets – No 53 *Berchemia discolo*r (Klotzsch) Hemsl. (compiled by P. Angaine). KEFRI, Muguga, Kenya

20. KEFRI 2021. KEFRI Tree Seed Information Leaflets – No 54. *Ehretia cymosa* Thonn. (compiled by P. Angaine) KEFRI, Muguga, Kenya

21. KEFRI, 2021. KEFRI Tree Seed Information Leaflets – No 55. *Trichilia emetica* Vahl. (compiled by P. Angaine) KEFRI, Muguga, Kenya

22. KEFRI, 2021. KEFRI Tree Seed Information Leaflets - No 56. *Sclerocarya birrea* (A.Rich.) Hochst. (compiled by P. Angaine). KEFRI, Muguga. Kenya

23. KEFRI, 2021. KEFRI Tree Seed Information Leaflets - No 57. *Olea capensis* L. subsp. welwitchii (Knobl.) (compiled by P. Angaine). Friis & P.S. KEFRI, Muguga. Kenya

24. KEFRI, 2021. KEFRI Tree Seed Information Leaflets – No *58. Xymalos monospora* (Harv.) Baill. (compiled by P. Angaine). KEFRI, Muguga, Kenya

25. Kamondo B.M., Kariuki J.G., Nyamongo D.O., Giathi G., Wafula A.W. and G.M. Muturi G.M. Effect of Temperature and Storage Duration on Viability of East African Sandalwood Seed. E. Afri. Agri. For. J (pg. 10 -17 Special Issue)

26. D., Langat, J., Cheboiwo, S., Okoth, J., Kiprop, A., Kisiwa, A., Guzha, N., Smith, T., DeMeo, J., Kagombe, S., Gatama, J., Kerkering and B., Doud. The Value of Forest Ecosystem Services of Mau Complex, Cherangany and Mt. Elgon, Kenya. E. Afri. Agri. For. J (pg. 91 -100 Special Issue)

27. R., Mwadalu, M., Gathara, G., Muturi, and M.T.E Mbuvi. Potential of *Casuarina equisetifolia* and *Melia volkensii* Tree Species in Improving Soil Fertility in Kwale and Kilifi Counties, Kenya. E. Afri. Agri. For. J (pg. 18-30 Special Issue)

28. M.O., Muga, B.N., Chikamai, V.A., Oriwo, F.N., Gachathi, S.S., Mbiru, A.M., Luvanda, L., Wekesa, C., Wekesa, S., Omondi and J., Lelon. Synthesis of the Development in Gums and Resins Sub-Sector in Kenya. E. Afri. Agri. For. J (pg 154-165 Special Issue)

29. L., Wekesa, J., Maalu, J., Gathungu and G., Wainaina. Status and Growth Determinants of Non-Timber Forest Products Firms in Kenya. E. Afri. Agri. For. J (pg 126-135 Special Issue)

30. C. Obonyo, M. Muga J. Kiprop, R. Othim, V. Oriwo, C. Ingutia and N. Bor. Priority Non-Wood Forest Products in Cherang'any Hills Ecosystem. E. Afri. Agri. For. J (pg. 195 -204 Special Issue)

31. E., Kitheka, C., Ogutu, N., Oduor, C., Ingutia, M., Muga, and J., Githiomi. Piloting Biomass Energy Audit for Energy and Environmental Conservation in Homa-Bay County, Kenya. E. Afri. Agri. For. J (pg 136-146 Special Issue)

32. P. Gachie*, J., Kipsat, J., Cheboiwo, M., Esitubi, J., Mwaura, P., Wairimu and M., Gathogo. On-Farm Tree Growing Opportunities and Constraints in Murang'a County, Kenya. E. Afri. Agri. For. J (pg. 53 - 65 Special Issue)

33. D., Langat, T., Khalwale, A., Kisiwa and P., Ongugo. Indigenous Traditional Knowledge on Landscapes, Biodiversity Use in Mt. Elgon Forest Ecosystem and Implications for Conservation. E. Afri. Agri. For . J (pg. 101 -112 Special Issue)

34. J., Kagombe, J., Kungu, D., Mugendi and J., Cheboiwo. Evaluating Willingness to Pay for Watershed Protection in Ndaka-Ini Dam, Murang'a County, Kenya. E. Afri. Agri. For. J (pg. 66 -79 Special Issue)

35. Muthike G., Karega S. and Githiomi J. Extent, Distribution and Causes of Defects in Soft Wood Plantation in Kenya. E. Afri. Agri. For. J (pg 166-171 Special Issue)

36. B., Mandila, J., Hitimana, K., Kiplagat, E., Mengich and T., Namaswa. Cost-Benefit Analysis of Agroforestry Technologies in Semi-Arid Regions of West-Pokot County, Kenya. E. Afri. Agri. For. J (pg. 113-125 Special Issue)

37. N.C Bor, M.N Muchiri, J.N. Kigomo, P. Hyvönen, M. Muga, P.N. Nduati, H.Haakana and N.O Owuor. Compartmentalized Allometric Equation for Estimating Volume and Biomass of Eucalyptus in Agroforestry Systems in Kenya. E. Afri. Agri. For. J (pg. 1 -9 Special Issue)

38. A., Kisiwa*, K., Langat, S., Gatama, S., J., Kiprop, J. Cheboiwo and J., Kagombe. Community Perception of Ecosystem Services and Management Implications of Three Forests in Western Pat of Kenya. E. Afri. Agri. For. J (pg. 80 -90 Special Issue)

39. Mutitu Eston, Njuguna Jane, Kimondo James, Amwata Jared, Mwangi Linus, Cheboiwo Joshua, Gathogo Miriam and Kariuki Barbra (2020). Guidelines for Dodder Weed Management in Kenya. KEFRI, Mugua, Kenya

40. KEFRI/CADEP/ JICA (2021). Production of Aloe bitter gum from *Aloe secundiflora*

41. KEFRI/CADEP/ JICA (2021). Production of Soap from Aloe vera

42. KEFRI/CADEP/ JICA (2021). Production of Livestock Feed from *Prosopis juliflora* Pods

43. KEFRI/CADEP/ JICA (2021). Making Briquettes Using Charcoal Fines

44. KEFRI/CADEP/ JICA (2021). Charcoal Production from Prosopis using Improved Earth Kiln

45. KEFRI/CADEP/ JICA (2021). Reclaiming Land Invaded by Prosopis for Agricultural Production in Marigat, Kenya

46. KEFRI/CADEP/ JICA (2021). Growing *Melia volkensii* for Improved Livelihood and Environmental Conservation in Makueni County, Kenya

47. KEFRI/CADEP/ JICA (2021). Natural Pasture Improvement for Enhanced Livestock Productivity in Makueni County, Kenya

48. KEFRI Annual Report and Records of Research 2019/2020

49. KEFRI Newsletter issue No. 34, 35, 36, 37.

Appendix II

STATEMENT OF FINANCIAL PERFORMANCE FOR YEAR ENDED 30TH JUNE 2021

	Note		2020-2021 Kshs.	2019-2020 Kshs.
REVENUE				
Revenue from non-exchange transactions:				
Government Grants	**3**		1,499,769,674	1,642,248,013
External Grant for Research	4		107,277,969	89,662,908
Deferred Income from Donors	5(b)		21,692,463	24,014,149
Revenue from exchange transactions:				
Other Income	6		103,470,615	140,314,648
TOTAL REVENUE			**1,732,210,720**	**1,896,239,718**
EXPENSES				
Employee Costs	7		(1,173,537,905)	(1,170,506,714)
Operating Expenses	8		(398,078,680)	(613,024,565)
Board of Directors Expenses	9		(13,505,560)	(17,218,626)
Establishment Cost (Sinking Fund)	10(a)		(10,000,000)	(4,000,000)
Depreciation charge	5(a)		(78,823,318)	(84,397,518)
Amortization on Intangible Asset	11		(3,239,096)	(3,109,734)
TOTAL EXPENSES			**(1,677,184,558)**	**(1,892,257,157)**
OTHER GAINS/(LOSSES)				
Exchange Gain/(Loss)	12		(803,551)	(650,779)
			(803,551)	**(650,779)**
Surplus/(Deficit) for the Year			**54,222,612**	**3,331,782**

Appendix III

STATEMENT OF FINANCIAL POSITION FOR YEAR ENDED 30TH JUNE 2021

			2020-2021	2019-2020
			Kshs.	Kshs.
ASSETS	**Notes**			
CURRENT ASSETS				
Cash and cash equivalents	13		454,393,320	316,838,433
Receivables from exchange transactions	14(a)		9,235,981	23,003,847
Receivables from non- exchange transactions	14(b)		4,551,142	3,178,600
Inventories	15		74,336,007	35,194,364
			542,516,450	**378,215,244**
NON-CURRENT ASSETS				
Property, Plant & Equipment	5(a)		5,713,058,366	5,750,406,850
Intangible Assets	11		12,956,382	12,438,938
			5,726,014,748	**5,762,845,788**
TOTAL ASSETS			**6,268,531,198**	**6,141,061,032**
LIABILITIES				
CURRENT LIABILITIES				
Payables from exchange	16		4,189,322	6,293,886
Auditor General- accrued audit fee	16(c)		1,173,969	513,969
Payables from non-exchange transactions	16(d)		8,124,400	8,124,400
Unxpended External Donor Grants	4		144,274,626	157,302,625
Medical Scheme Funds	17		345,205	742,883
			158,107,523	**172,977,763**
NET ASSETS				
Government Grants for capital assets	18(a)		1,143,349,103	1,043,537,781
Deferred Income on Donated Assets	5(b)		514,261,545	535,954,008
Sinking Fund	10(b)		34,494,191	24,495,256
Revaluation Reserves	18(b)		4,467,199,488	4,467,199,488
Revenue Reserves	18(e)		(48,880,653)	(103,103,264)
			6,110,423,675	**5,968,083,269**
TOTAL NET ASSETS & LIABILITI ES			**6,268,531,198**	**6,141,061,032**

Appendix IV:

STATEMENT OF CHANGES IN NET ASSETS FOR THE YEAR ENDED 30TH JUNE 2021

	Notes	Deferred Income on Government Grants for Capital Assets Kshs	Deferred Income on Donated Assets Kshs	Revenue Reserves Kshs	Revaluation Reserves Kshs	Sinking Fund Kshs	Total Kshs.
Balance as at 1st July 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	18 (e)	-		3,331,782			**3,331,782**
Adjustments		-					-
Transfers from Sinking fund							-
Sinking Fund expenses	18(c)					(1,065)	**(1,065)**
Sinking Fund additions during the year	18(c)					4,000,000	**4,000,000**
Development Grants during the year	3	92,053,850					**92,053,850**
Dev grants-to Income & Expenditure	3	(179,267,016)					**(179,267,016)**
Deferred Income for the year	5(b)	-	(24,014,149)				**(24,014,149)**
Balance as at 30th June 2020		**1,043,537,781**	**535,954,008**	**(103,103,264)**	**4,467,199,488**		**5,968,083,269**
Balance as at 1st July 2020		**1,043,537,781**	**535,954,008**	**(103,103,264)**	**4,467,199,488**		**5,968,083,269**
Prior period adjustment							
As restated		**1,043,537,781**	**535,954,008**	**(103,103,264)**	**4,467,199,488**		**5,968,083,269**
Surplus/(Deficit) for the year	18(e)	-		54,222,612			**54,222,612**
Adjustments		-					-
Transfers from Sinking fund		-					-
Sinking Fund expenses	18(c)					(1,065)	**(1,065)**
Sinking Fund additions during the year	18(c)					10,000,000	**10,000,000**
Development Grants during the year	3	149,000,000					**149,000,000**
Dev grants-to Income & Expenditure	3	(49,188,678)					**(49,188,678)**
Deferred Income for the year	5(b)	-	(21,692,463)	-	-	-	**(21,692,463)**
Balance as at 30th June 2021		**1,143,349,103**	**514,261,545**	**(48,880,653**	**4,467,199,488**	**34,494,191**	**6,110,423,675**

Appendix V:

STATEMENT OF CASHFLOWS FOR THE YEAR ENDED 30TH JUNE 2021

	NOTES	2020-2021 Kshs.	2019-2020 Kshs.
Cash Flows from Operating Activities			
Surplus(Deficit) for the Year		**54,222,612**	**3,331,782**
Adjustment for:			
Depreciation	5(a)	78,823,318	84,397,518
Amortization for Intangible Asset	11	3,239,096	3,109,734
Deferred Income	5(b)	(21,692,463)	(24,014,149)
KEFRI Surcharge		(730,483)	(310,669)
Commission Income		(209,951	(217,092)
Adjusted Surplus		**113,652,129**	**66,297,125**
Working Capital Changes:			
Decrease (Increase) in Debtors	14	(12,395,324)	(7,857,822)
Decrease (Increase) in Stock	15	(39,141,643)	23,272,475
Increase (Decrease) in Creditors	16	(14,870,240)	20,314,447
Net Cash from operating activities		**(66,407,207)**	**35,729,100**
Cash Flows from Investing Acticities:			
Purchase of Assets	5(a)	(41,474,834)	(82,041,956)
Purchase of Intangitable	11	(3,756,540)	(1,592,840)
Establishment Cost (Sinking Fund)	10(a)	(10,000,000)	(4,000,000)
Net Cash from Investing activities		**(55,231,374)**	**(87,634,796)**
Cash Flows from Financing Activities:			
Development capital grants	3	99,811,322	(87,213,166)
Research Grants Received	4	93,033,039	106,851,398
Transfers/Adjustments		59,974,947	(9,016,884)
Research Grants Paid	4	(107,277,969)	(89,662,908)
Net Cash from Financing activities		**145,541,340**	**(79,041,560**
Net Increase (Decrease) in Cash & Cash Equivalent		137,554,887	(64,650,132)
Opening Cash & Cash Equivalent		316,838,433	381,488,565
Closing Cash & Cash Equivalent		**454,393,320**	**316,838,433**

Appendix VI:

STATEMENT OF COMPARISON OF BUDGET AND ACTUAL AMOUNT FOR THE YEAR ENDED 30TH JUNE 2021

	Notes	Original budget	Adjustments/ Supplementary	Full budget	Actual on Comparable basis	Performance difference	% of utilisation (Actual/Budget)
		2020-2021	**2020-2021**	**2020-2021**	**2020-2021**	**2020-2021**	**%**
Revenue		**Kshs**	**Kshs**	**Kshs**	**Kshs**	**Kshs**	
Recurrent Grants	3	1,450,580,996	-	1,450,580,996	1,450,580,996	-	100
Development Grants	3	164,000,000	(15,000,000)	149,000,000	149,000,000	-	100
Research Grants	4	100,000,000	-	100,000,000	107,277,969	7,277,969	107
Deferred Income from donors	5b	21,692,462	-	21,692,462	21,692,462	-	100
Other Income	6	110,000,000	-	110,000,000	103,470,615	(6,529,385)	94
Total Income		**1,846,273,458**	**(15,000,000)**	**1,831,273,458**	**1,832,022,042**	**748,584**	100
Development Grants: Income Recognised		125,000,000	(15,000,000)	110,000,000	99,811,322	(10,188,678)	91
NET TOTAL INCOME		**1,721,273,458**	**-**	**1,721,273,458**	**1,732,210,720**	**10,937,262**	
Expenses		**Kshs**	**Kshs**	**Kshs**	**Kshs**	**Kshs**	
Employees Costs	7	1,187,000,000	(10,000,000)	1,177,510,000	1,173,537,905	(3,972,095)	100
Operation Expenses	8	400,100,000	-	400,100,000	398,078,680	(2,021,320)	99
Board Expenses	9	16,500,000	(2,000,000)	14,500,000	13,505,560	(994,440)	93
Establishment Cost (Sinking Fund)	10	10,000,000	-	10,000,000	10,000,000	-	100
Depreciation	5a	80,000,000	-	80,000,000	78,823,318	(1,176,682)	99
Amortization Expenses	11	3,300,000	-	3,300,000	3,239,096	(60,904)	98
Total Expenditure		**1,696,900,000**	**(12,000,000)**	**1,685,410,000**	**1,677,184,559**	**(8,225,441)**	
Other Gains/(Losses)							
Exchange Gain/(Loss)	12b	(803,551)	-	(803,551)	(803,551)	-	100
Sub-Total		**(803,551)**	**-**	**(803,551)**	**(803,551)**	**-**	**-**
without capital assets		**25,177,009**	**12,000,000**	**36,667,009**	**54,222,615**	**67,465,422**	-
Capital Expenditure		55,000,000	(13,000,000)	42,000,000	41,474,834	525,166	99
Notes.							
1. GoK : Development Grant						**Kshs**	
Budget Estimates						164,000,000	
Less:Supplementary Budget Adjustment						(15,000,000)	
Received from Exchequer						149,000,000	

Kenya Forestry Research Institute (KEFRI)
P.O. Box: 20412-00200, Nairobi - KENYA
Tel: +254 724 259781/2, 722 157414
Email: director@kefri.org **Website:** www.kefri.org