KENYA FORESTRY RESEARCH INSTITUTE

Annual Report and Record of Research

2021 - 2022

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

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ACRONYMS

AHRC/IIED	Arts and Humanities Research Council / International Institute for Environment and Development
ASALs	Arid and Semi-Arid Lands
CABI	Centre for Agriculture and Bioscience International
CADEP	Capacity Development Project for Sustainable Forest Management in Kenya
CBOs	Community Based Organizations
CETRAD	Centre for Training and Integrated Research in ASAL Development
CFAs	Community Forest Associations
COVID-19	Corona virus disease caused by sars -2 virus
CPTs	Candidate Plus Trees
DBH	Diameter at Breast Height
ERP	Enterprise Resource Planning
FAO	Food and Agricultyure Organization
FY	Fiscal Year/Financial Year
GATSBY Africa	Lord David Sainsbury Private foundation engaging in East Africa across government, business and society on commercial forestry
GoK	Government of Kenya
GTZ	Germany Technical Cooperation
HR	Human Resources
IMS	Integrated Management Standards
INBAR	International Bamboo and Rattan Organization
ISO	International Organization for Standardization
ISTA	International Seed Testing Association
KALRO	Kenya Agriculture and Livestock Research Organization
KCSAP	Kenya Climate Smart Agriculture Project supported by GoK and the World Bank
KEBS	Kenya Bureau of Standards
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KFSC	Kenya Forest Seed Centre
KWTA	Kenya Water Towers Agency
MAI	Mean Annual Increment
MDAs	Ministry, Departments & Agencies
NEMA	National Environment Management Authority
NETFUND	National Environment Trust Fund
NGOs	Non-governmental Organizations
PIP	Performance Improvement Plan
RCBD	Randomized Complete Block Design
SCAC	State Corporations Advisory Committee
TVET	Technical and Vocational Education and Training Institutions
TLUD	Top-Lit Updraft
TWENDE	Towards Ending Desertification Emergencies
UNDP	United Nations Development Programme

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 722157414, 724259781/2 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

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HUDUMA BORA NI HAKI YAKO

Remarks by Chairman KEFRI Board of Directors

On behalf of KEFRI Board of Directors, I am delighted to present the Annual Report and Record of Research for the Fiscal Year 2021-2022 ending 30th June, 2022. I acknowledge the Board continued to provide oversight role and in particular ensuring the Institute carried its mandate of forestry research and development in accordance with the provisions of Section 28 of the Science and Technology Cap 250 of the Law of Kenya which was repealed by the Science and Technology and Innovation Act of 2013).

Above all, the Board of Directors also ensured that the Institute's strategy was aligned with statutory mandate and national strategic direction, policy guidelines on financial matters; internal control, ethical leadership and good corporate citizenship in accordance with Mwongozo - the Code of Governance for State Corporation 2015.

During the reporting period, the Board through four committees namely: Research and Development; Finance and Development; Human Resource; and Audit; undertook its business till May 2022 when the term of the Independent Board members ended. That left the Chairman and Non-executive directors representing the Institute. Subsequently, the Institute successfully carried out the implementation of the 6th Strategic Plan 2018-2022 and ensured alignment with national government Big Four Agenda, Vision 2030 Flagship Projects as well as the annual Performance Contract targets.

To mention but a few achievements, KEFRI continued to implement strategic intervention on tree improvement, tree seed technologies and infrastructure development. This was achieved through doubling efforts in tree seed collection and distribution, expanding and maintenance of high-quality seed sources to support the accelerated achievement of the 10% national tree cover by 2022.

The Institute operated with 90% GoK funding and 10% generated internally as well as from development partners/donors. Despite dwindling exchequer releases, the Board appreciates the support from the national government through the parent ministry, Ministry of Forestry and Environment, the National Treasury and donors and development partners. However, future intent to expand strategic partnership and linkages to increase resource capacity is significant priority areas.

In conclusion, I convey special gratitude to the Board members for the valuable commitment of ensuring the Institute's maintained the high level of governance. I wish also to acknowledge KEFRI fraternity led by the Directorate, external stakeholders whose steadfast support made the Board perform its role and service delivery even within the very uncertain times when the country faced the effects of COVID-19 global pandemic.

It is my hope and desire to steer the institute forward and surpassing targets set in the Performance Contract for the next Financial Year 2022/2023.

Prof. Gatebe (PhD)
Chairman - KEFRI Board of Directors

Foreword by the Director KEFRI

During the Financial Year 2021/2022, KEFRI guided by its 6th Strategic Plan (2018 - 2022), implemented its research and development agenda, majorly by providing technologies and information for sustainable development of forestry and allied natural resources for socio-economic development.

The Strategic Plan aligned to the Government Big Four Agenda Initiative, Vision 2030 Flagship Project and Sustainable Development Goals, enabled the Institute fulfil its mandate through five research thematic programmes: Forest Productivity and Improvement (FPI); Forest Biodiversity and Environment Management (FBEM); Forest Products Development (FPD); Forest Research Support Services (FRSS); Socio-economics, Policy and Governance (SPG) supported by the Corporate Services (CS), and Corporate Affairs and Quality Assurance (CA&QA).

I am happy to report that seed production yielded 49,229.31 Kg from 125 different tree species, and 74,733 planting materials of difficult to propagate trees were raised to support the ambitious National 10% Forest Cover Strategy that aims to plant 1.8 billion seedlings by 2022. Additionally, 39 forestry technologies covering various thematic themes were generated and demonstrated at different agro-ecological zones. KEFRI App for tree site matching guide, aerial seeding to accelerate production of seedlings for restoration of degraded landscapes, and mitigate negative impacts of climate change.

The Institute continued to empower staff through capacity building and creating enabling and safe environment to motivate and retain competent human capital. KEFRI hosted the 1st Commercial Forestry Conference in Africa that was physical and virtual with all health protocols for COVID-19 pandemic waves observed. Implementation of an Enterprise Resource Planning (ERP) - a digital automation platform was initiated to ensure improved service delivery to the customers, expansion of linkages and partnerships to improve resource mobilization and technical capacity. Four (4) Human Resource Management instruments were approved by State Corporations Advisory Committee (SCAC) whereas facelifting of existing facilities in headquarters, regional and sub-regional programmes were accomplished.

However, the Institute faced challenges including low funding, ageing staff, legislative support for forestry research and access mechanism to research, inadequate land and encroachment of research trials, minimal coordination framework between the county and national government over management of natural resources; and declining budget allocations.

I wish to extend my gratitude to the Government of Kenya, through The National Treasury and the Ministry of Environment and Forestry; the Board of Directors, development partners and all other stakeholders for their cooperation and support in accomplishing the Institute's mandate.

Joshua K. Cheboiwo (PhD)
Director - KEFRI

CHAPTER ONE

1.0 TREE SEED DEVELOPMENT AND PRODUCTION

Quality tree seed is crucial in achieving the ambitious National Forest Cover Strategy that aims to plant trees to rehabilitate 325,000 hectares of forest land each year while meeting demands for forest products and services. The Strategy commits to planting of approximately 1.8 billion tree seedlings by 2022 requiring a concerted effort to collect sufficient quantities of tree seed. The collected seed must also be of high quality. Quality seed is guaranteed through use of dedicated seed sources and deployment of appropriate technology and practices in tree seed collection, handling and storage. In this regard, 150 ha of seed sources were maintained in the year with an additional 6 ha established for production of seed of high genetic quality. The physiological quality of the seed is assured by subjecting collected seed to seed testing as guided by the International Tree Seed Testing Association rules.

1.1 Establishment of tree seed sources

In the Financial Year 2021/2022, 49,229 kg of tree seed was collected from 125 different tree species (Table 1, Figure 1). Within the same reporting period, KEFRI continued with expansion of its tree seed collection capacity through construction of 18 seed centres to increase production, processing and distribution of quality tree seeds and other planting materials.

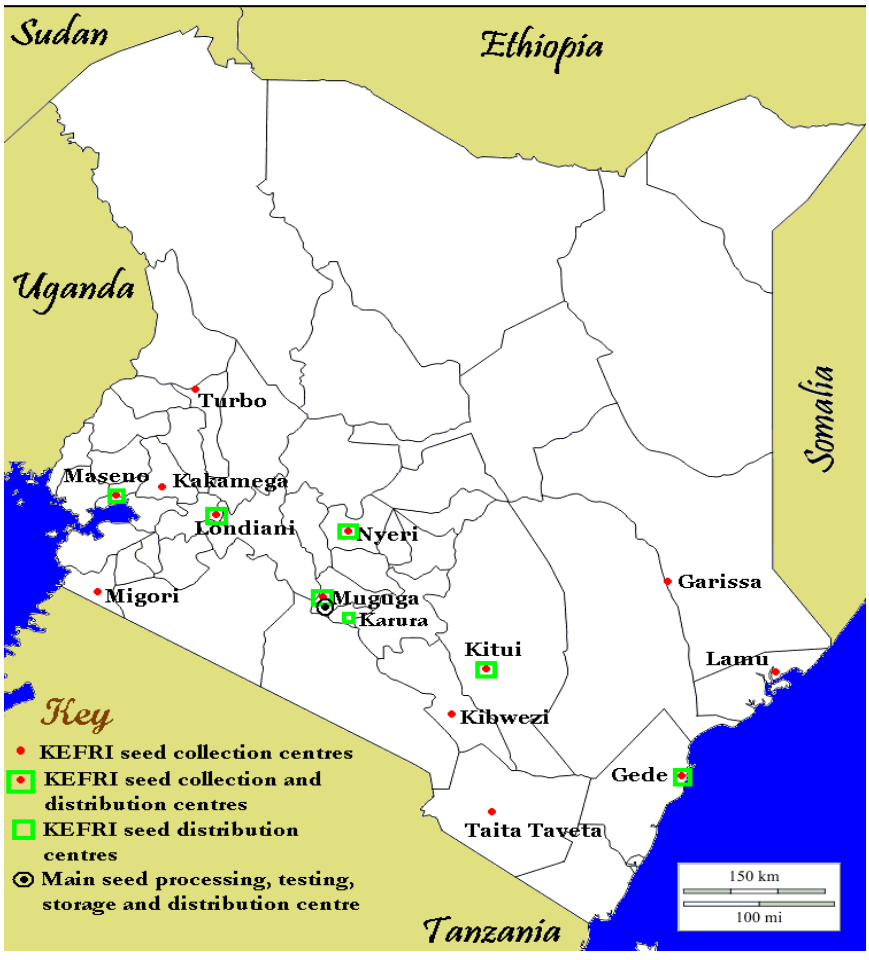
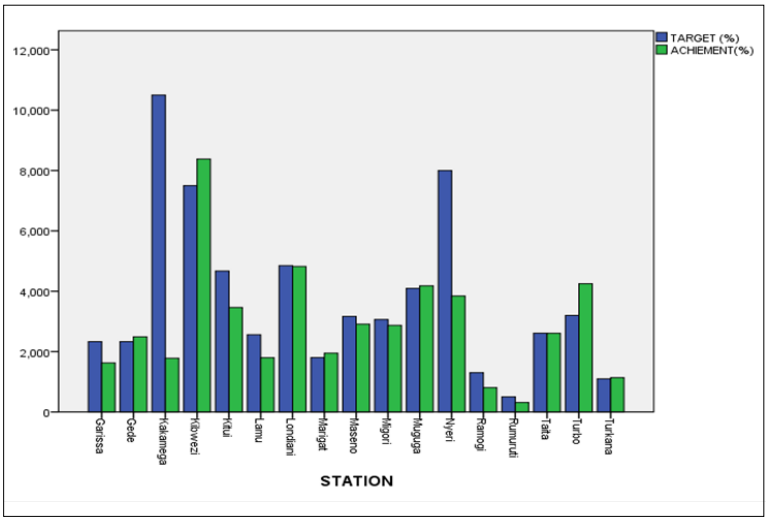


Fig 1: KEFRI seed collection and distribution centers

Table 1:
Weight of seed collected in FY 2021-22

No.	Station	Seed Weight (Kg)
1	Garissa	1626.95
2	Gede	2489.72
3	Kakamega	1781.3
4	Kibwezi	8381.7
5	Kitui	3461.72
6	Lamu	1795.95
7	Londiani	4823.6
8	Marigat	1949.15
9	Maseno	2908.98
10	Migori	2871.09
11	Muguga	4180
12	Nyeri	3843.3
13	Ramogi	806.1
14	Rumuruti	313.6
15	Taita	2607.1
16	Turbo	4250.67
17	Turkana	1138.38
	Total	**49,229.31**

Fig 2: Seed productions stations 2021-2022



1.2 National Tree Seed Distribution

The Government of Kenya through Presidential Directive of 2018 rolled out the National Tree Seed Distribution Programme implemented through the Ministry of Environment and Forestry, Ministry of Interior and Coordination of National Government, and the Ministry of Education to fast-track production of seedlings for planting and attainment of 30% forest and tree cover by 2030. H. E. President Uhuru Kenyatta flagged the National Programme on 27th May 2022 targeting to empower both public and private institutions including regional development authorities, faith-based institutions and county government to raise trees seedlings as well as fruit trees.

1.3 Tree Seed Distribution to Schools and Prisons

KEFRI embarked on distribution of tree seed and potting bags to 4,800 schools, Technical and Vocational Education and Training (TVET), institutions, colleges and universities countrywide. Nyeri County received 2.6 tonnes of tree seed for 230 schools and commissioning of Wangari Maathai 10 million tree growing challenge in support of 30% tree cover. KEFRI, KFS, NETFUND and Kenya Water Towers Agency (KWTA) offered to support with technical backstopping, monitoring and evaluation to ensure production of approximately 11 million seedlings and maximum survival of the seedlings.

The PS Ministry of Environment and Forestry Dr. Chris Kiptoo and the PS State department of Correctional Services Hon. Safina Kwekwe signed an agreement to implement a tree seedlings production programme within 66 National Prisons Service countrywide. KEFRI also provided 1.2 metric tons of quality tree seeds and technical support in terms of capacity building in tree nursery establishment and management.

Ten (10) Prison in coast region namely; Hindi in Lamu County; Malindi - Mtangani, Kilifi medium, Shimo Latewa - both Borstal and medium; Kwale, Manyani, Wundanyi and Taita Taveta benefited with 875 kilograms of assorted seeds and 500,000 potting bags. The agreement also entailed promoting tree growing and rehabilitation of degraded public community and private lands, public awareness, on forest protection and conservation.

1.5 Supporting production of high quality seed by other entities

Shortage of improved forest tree seeds is always a bottleneck for commercial forestry investments. Therefore, establishment and management of seed orchards is necessary for production of consistent, abundant and quality planting materials to support commercial plantation establishment. *Cupressus lusitanica* is one of the main highland plantation species with high demand for planting material. However, no guideline is available to support establishment and management of its seed orchard. KEFRI has developed a guideline to support forest practitioners in establishment and management of *C. lusitanica* seed orchards for production of genetically superior quality seed. The guideline describes the process of site selection, planting design that include spatial distribution of the clones and importance of isolating distance to prevent introgression of unwanted pollens from outside of the orchards. Other silvicultural requirements such as weeding, rouging, artificial pollination, top pruning and crown management for regulation of pollen and seed production are also described. The draft guideline is undergoing review for publication.

1.6 Challenges in Seed production

Seed production was faced with a number of challenges including; high production costs, diminishing and unsecured seed sources, inadequate land for establishment of seed sources, limited access to seed sources on private farms, low funding, aging workforce, inadequate seed storing facilities, and changes in seed phenology due to climate change.

Fig 2: Tree seed harvestors sorting out fresh seeds during collection

CHAPTER TWO

2.0 PRODUCTION OF PLANTING MATERIALS

KEFRI supports tree planting in the country through production of tree seedlings used in general afforestation programmes. It also produces seedlings of hard to propagate species to meet the planting needs of this special category of trees.

In the year under review, the tree seedlings raised in different KEFRI Eco-regional Programmes were as follows:

- The Coast Ecoregional Research Programme (CERP) produced 140,000 seedlings in its nurseries. CERP worked in collaboration with community based groups and through this collaboration about 1 million tree seedlings, were raised to contribute to afforestation programmes in the coastal region. Of these, 73,000 seedlings were of mangroves. CERP raised 12,052 seedlings of difficult to propagate tree species that included Bambusa vulgaris (3,242), Dalbergia melanoxylon (3200) and Milicia excela (5600)

Fig 3: Tree seedlings in KEFRI-Gede nursery

Fig 4: Tree seedlings in Msitu women group

Fig 5: Mangrove seedlings raised by community group at Mida Creek, Kilifi County

- The Drylands Ecoregional Research Programme (DERP) raised 134,724 tree seedlings suited for growing in the marginal areas of the country including *Azadirachta indica , Melia volkensii* (Improved) *Senna siamea , Acacia tortilis, Moringa oleifera, Terminalia brownii, Acacia mellifera , Acacia, polyacantha, Croton megalocarpus, Markhamia lutea, and Balanites aegyptiaca.* Some of the difficult to propagate species raised in DERP included *Dalbergia melanoxylon* (386) *Bambusa vulgaris* (3,663), *Bambusa bambus* (500) *Ximenia americana* (1507) *Vitex payos* (720), *Dendrocalamus strictus* (200), and *Sclerocarya birrea* (39).

- The Central Highlands Ecoregional Research Programme (CHERP) raised 273,679 tree seedlings. The major plantation species produced at the nurseries were *Eucalyptus grandis, Cupressus lusitanica, Casuarina equiesetifolia, Grevillea robusta* and *Pinus patula.* The indigenous species comprised of *Vitex keniensis, Makhamia lutea, Croton megarlocarpus* and *Olea africana* among others. CHERP raised 12,016 seedlings of difficult to propagate tree species that included *Bambusa vulgaris* (5,630), *Phyllostachys aurea* (86), *Dendrocalamus asper* (1,140) *Bambusa bambos* (30), *Bambusa polymorpha* (200), *Dendrocalamus strictus* (510), *Dendrocalamus giganteus* (180), *Dendrocalamus hamiltonii* (240), *Oldeania alpina* (1,660), and *Osyris lanceolata* (2,340).

- The Rift Valley Ecoregional Research Programme (RVERP) raised a total of 411,408 tree seedlings of both indigenous and exotic tree species. The main species raised included; *Eucalyptus grandis, Eucalyptus saligna, Cupressus lusitanica, Croton megalocarpus, Cordia africana, Dombeya torrida, Hagenia abyssinica, Markhamia lutea, Juniperus procera, Olea africana, Podocarpus falcatus* and *Prunus africana.* RVERP raised 8,240 seedlings of difficult to propagate tree species that included; *Bambusa abyssinca* (1,990), *Bambusa polymova* (21), *Bambusa yumenensis* (921), *Bambusa asper* (450), *Bambusa dendrocalamus* (248), *Bambusa vulgaris* (3,410), and *Bambusa striatta* (1,200).

- The Lake Victoria Basin Eco-regional Research Programme (LVBERP) raised a total of 236,400 tree seedlings of both indigenous and exotic species. It also raised 12,000 seedlings of difficult to propagate species as follows; *Zanthoxylum giletti* (1,000), *Terminalia brownii* (2,000), *Maesopsis eminii* (2,000) and Bamboo (7,000).

CHAPTER THREE

3.0 DEVELOPMENT OF FORESTRY TECHNOLOGIES

The Institute in the Fiscal Year 2021-2022 generated 39 technologies undertaken in the regional centres for establishment and management of forest plantations, trees on-farms and enhance production of superior germplasm for priority tree species for different agro-ecological zones. Other technologies were for; rehabilitation and adaptation to climate change, and sustainable forest landscapes, woodlands, wetlands and riparian eco-systems. Some of the key innovative technologies such as application of tree site matching guide, aerial seeding using air planes, drones, and seed balls, were developed to accelerate restoration of degraded landscapes including forests, water towers, mangrove, and green spaces. Schools and other public institutions were earmarked as some of the viable sites to establish tree nurseries and woodlots, as well as to demonstrate good environmental practices that would mitigate negative impacts of climate change.

3.1 Development of optimum conditions for raising *Grevillea robusta* grafts for seed

Orchard development

Grafting is a way of asexual propagation of selected superior trees. The technique involves getting a portion from a plant (clone) and attaching that portion (scion) onto a stem, root or branch of another (rootstock) in such a way that the union is formed and the plant grows as one. Trees raised through grafting will be identical in genetic make up to the source parent tree. Grafting is therefore used to multiply or propagate selected superior trees where several scions are selected from a given tree (clone) and raised through attaching to root-stocks. Grafting also shortens the time taken for production of flowers and seed and it is therefore employed in establishment of seed orchards.

In the year under review, KEFRI continued with the work of optimising conditions for raising grafts. The method is key in production of superior planting materials for seed orchard establishment of important commercial plantation species namely among them *G. robusta.* The work aimed at enhancing the survival rates of grafted seedlings by use of high-quality rootstocks, choosing rootstock of optimal age, and improving on the art of setting up of marcots.

Grevillea robusta scions were collected from 10 clones selected from a 17-year-old seed orchard established at Turbo targeting the best flowering clones. The rootstocks were of two ages, 6 months and 8 months old. Around 70 scions that matched the size of rootstock were harvested from each clone mainly from the middle part of the crown. Scion preparation involved sizing to approximately 7-10 cm, foliage removal and then immersing in a solution of osothene fungicide for approximately 15 minutes followed by grafting on the rootstocks.

Fig 6: Grafted *Grevillea robusta* seedlings

The entire scion was then covered by parafilm, labelled and placed in the non-mist propagator under a shade net. The non-mist propagator was opened every two weeks for general maintenance which involved weeding, removal of lower branches, watering; and data collection for up to 14 weeks. At 14 weeks, it was

observed that seedlings grafted on 8-months old rootstocks had a higher survival rate (85%) as compared to seedlings grafted on 6-months old rootstocks with a survival rate of 74%. The grafts on 6-months old rootstocks increased by 5.5 cm while those from 8 months-old rootstocks increased by 5.2 cm within the same period. Grafts on 8-months old rootstocks grew more leaves from week 2 to week 14 as compared to seedlings grafted on 6-months old rootstocks.

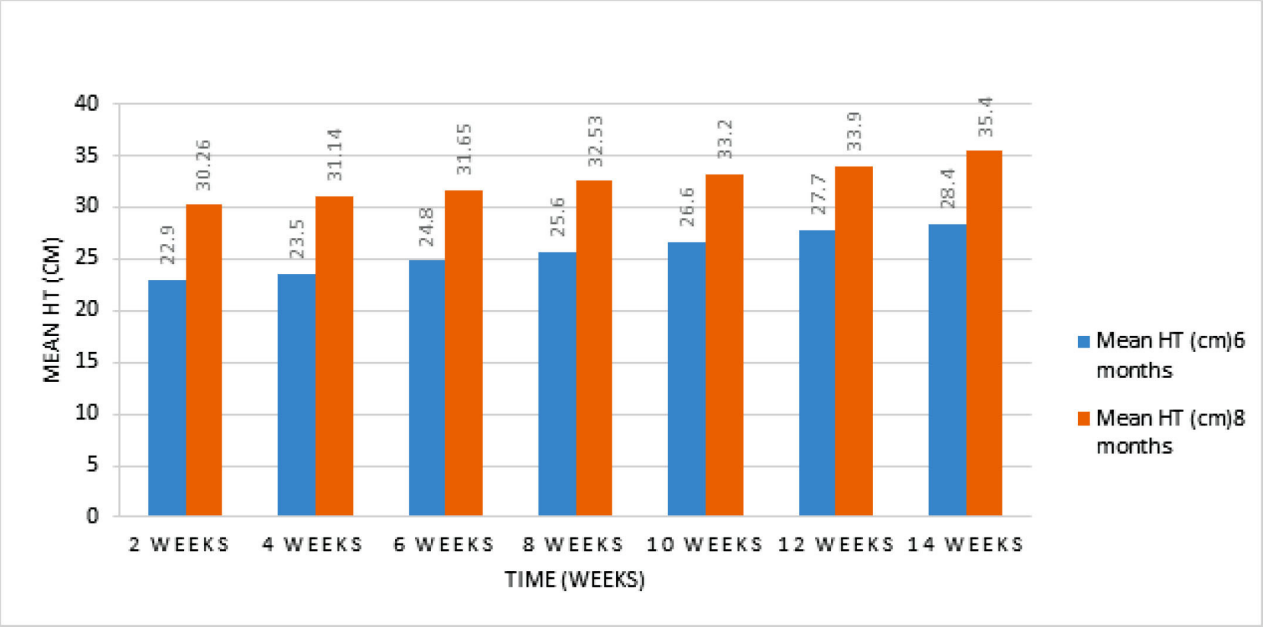


Fig 7: Mean height of *Grevillea robusta* grafts after 14 weeks

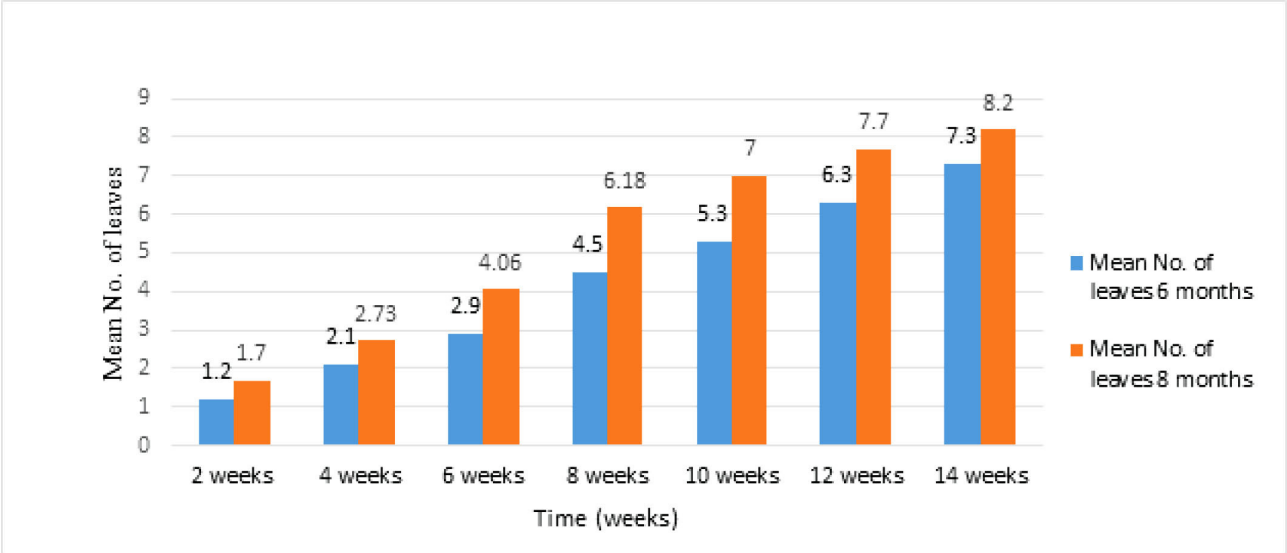


Fig 8: Mean number of *Grevillea robusta* leaves after 14 weeks

This study showed that *G. robusta* grafts set on both 6-months and 8-months old rootstocks have high chances of survival of over 70%. However, grafts on 6-months old rootstocks expressed more vigor as demonstrated by the higher mean height. However, the general performance of both sets of grafts did not differ significantly and both 6- and 8-months old rootstocks could be adopted for use.

3.2 Evaluation of growth and productivity of pine species and hybrids in Turbo, Kenya

In Kenya, *Pinus patula* is the commonly planted commercial species with a few other potential candidates including *P. tecunumanii, P. maximinoii, P. oocarpa, P. kesiya.* Hybrids between *P. patula and P. tecunumanii* and *P. patula* and *P. maximinoii* are grown only on trial basis. Large scale planting of *Pinus radiata* was suspended due to its susceptibility to pine needle blight *(Mycosphaerella gibsonii)* a disease caused by *Dothistroma pinii* fungus.

A study was carried out to evaluate the performance of pine species and the hybrids grown in Turbo, Kenya, with specific objectives to:

(i) Determine and rank the rate of growth in terms of height and diameter increment of *P. patula, P. tecunuminii, P. maximinoi,* and *pine hybrids*,
(ii) Determine their productivity in terms of wood volume accumulation and, specifically for *Pinus patula,*
(iii) Track the performance in terms of productivity gains made in its improvement program over the years.

Diameter and height measurements to answer specific objective (i) and (ii) have been collected from experiments in Turbo overtime. For specific objective (iii) data continues to be collected from Timboroa, Nabkoi and Kaptagat forest stations to track productivity/yield of *P. patula* at 10 yearly intervals. Results of this study will go a long way in guiding decision making on whether to approve large scale planting of potential best performers in order to broaden the pine species diversity in the country and improve productivity.

3.3 Establishment of *Cupressus lusitanica* progeny trials from selected candidate plus trees

Cupressus lusitanica (Mexican cypress) as the common name implies is native to Mexico. A number of varieties and subspecies are recognized with a diversity of habitat preferences and growth characteristics. *Cupressus lusitanica* is an important industrial and plantation crop in areas of high elevation of between 1500 to 3000 m above sea level where its grown for timber and pulpwood with a mean annual increment (MAI) of 20 m^3/ha/yr. Intensive genetic improvement of *C. lusitanica* in Kenya started in early 1950s through selections of superior mother trees from the general population. In 1950, 74 superior mother trees were selected in three registered seed areas of *Cupressus lusitanica*. Open pollinated seed was collected from each tree, raised separately and planted out in progeny trials for evaluation purpose in an isolated situation. The selection was for rapid growth, light branching and occlusion of pruning scar through which the heartwood borer *Oemida gahani* was known to enter the tree, and on resistance to Cypress Canker caused by *Monochaetia unicornis*. The trial provided a ranking for the mother trees in respect of vigour and resistance to Cypress Canker and was converted, by highly selective thinning in three stages, to a seed stand of exceptional quality. To broaden the genetic base of the species in the country, new introductions were undertaken in 1965 for provenance trials from, New Zealand, Costa Rica, Mexico and Australia.

Generally, plantations raised from selected seed sources has led to improved performance with trees attaining a mean height and diameter at breast height (DBH) of 12 m and 15 cm, respectively, compared to plantation established form general collections at 8.5 m of height and 12 cm dbh. The progeny trials results showed an encouraging trends of heritability and genetic gains of key traits required in timber production.

For example, heritability for diameter, height and volume is 0.89, 0.77 and 0.89, respectively, at 25 years while the genetic gain estimations is at 7%, 6% and 12% for height, diameter and Volume/ha respectively.

Demand for improved cypress planting materials (seeds and seedlings) has been increasing hence the need for more seed orchards and genetic improvement of the germplasm. Furthermore, the orchards that were established in 1960s have become old, others have been wind thrown and the remaining individuals do not produce sufficient seeds. The objectives of the work undertaken in the year under review was to estimate genetic parameters within and among sites related to survival, growth and stem quality traits, and to predict genetic gains for growth based on second generation progeny tests of *Cupressus lusitanica* in Kenya.

Selection of candidate plus trees (CPTs) from progeny trials in Rift-valley was made on phenotypic assessment of desirable characters of economic interest such as stem straightness, branch size, clear bole height, low branching habit, and disease resistance. In addition, 35 CPTs used in the establishment of seed orchards in Muguga were also included in the list of families for trial. A total of 123 CPTs of *Cupressus lusitanica* i.e. phenotypically superior trees according to growth and stem quality, were selected from progeny trials in Rift valley and Muguga with the intention of establishing progeny tests based on open-pollinated half-sib families. Seeds were collected from the 120 CPTs and kept separate for progeny trial. Seedlings (progenies) have been raised from the seed (120 families) and are ready for planting. Land for establishing the progeny trial has been identified in Muguga, Londiani and Nyeri with planting planned for 2022/2023 financial year.

Fig 9: The *C. lusitanica* progeny trial, established 2013

3.4 Development of allometric model for estimating growth and biomass of *Grevillea robusta*

The ecological function and economic values of forests, which are often expressed in terms of forest biomass and volume, require a reliable method of estimation. Direct measurement of volume and biomass in most cases gives a reasonable accuracy, however, employing field measurement especially in large-scale plantation projects is quite expensive, labor-intensive, mostly destructive, time-consuming and sometimes impracticable. Thus, estimation of volume and biomass using allometric equations is highly advisable. Allometric equations provide a way of estimating biomass of trees by measurement of easier to measure parameter such as diameter at breast height (DBH).

Like many tree species, there is lack of predictive allometric equation for the total volume and aboveground biomass of *Grevillea robusta* plantations in many parts of the country. Therefore, the focus of this activity was to develop and select best fit total volume and aboveground biomass allometric equations and estimating the biomass expansion factor for *Grevillea robusta* plantations.

In the 2021/2022 financial year, destructive sampling of the *Grevillea robusta* in Turbo was carried out on 4 hectares stand with a population of 2,652 trees at a spacing of 2.5 m x 2.5 m. Ten plots of 100 trees each were demarcated and a tree of 18 years was randomly earmarked for destructive sampling in each plot totaling to ten trees. Each tree identified was felled and length measured. The branches were trimmed and foliage stripped. The fresh weight of leaves was recorded and sample of 5 kg was preserved. The branches were classified into diameter classes and each weighed and total weight recorded per class. The trunk was cross cut into sizes that could easily be handled during weighing and total weight taken. Excavation of roots was done cleaned and their fresh weights taken and recorded. The collected data is undergoing analysis to develop appropriate allometric equation for estimating biomass and yield. Once developed, tree growers will be in a position to easily estimate the biomass of their *G. robusta* tree crops.

3.5 Guideline for forestry pest and disease monitoring and management in Kenya

Commercial tree planting as an investment offers both economic gains in addition to environmental services. Commercial forestry has the potential to bridge the wood deficit in the country and increase forest cover. In Kenya, commercial planting of exotic plantations for timber started in the early 1920's. The main tree species were *Cupressus lusitanica* Miller, *Pinus radiata* D. Don and *Pinus patula* Schlecht mostly established on Government land. There is little information documented in terms of plantations established and areas covered under private forestry. Private forestry includes plantations owned by Tea and Tobacco companies and other players where Eucalyptus species dominate. Commercial forestry in public forests will not be able to meet the growing demand for wood products in the country. There is therefore need to extend commercial forestry to private, community lands as well as arid and semi-arid lands (ASALs). In the high and medium potential areas, *Eucalyptus grandis, Eucalyptus saligna and Grevillea robusta* are most popular species while in the drylands *Melia volkensii* and *Eucalyptus camandulensis* are the preferred species. Commercial tree species are prone to attack by pests and diseases. Pests and diseases have the potential of reducing productivity and hence incurring losses in commercial forestry if not well addressed. The guideline therefore provides information on pests and diseases focusing on Pines, Cypress, Casuarina, Melia and Grevillea in Kenya. This information will enhance management of pests and diseases in commercial forestry and by individual farmers while also acting as reference material for educational purposes. The draft guideline is undergoing review for publication.

3.6 Digital platform for KEFRI forest insect reference collection

The KEFRI forest insect reference collection is a crucial part of the annals of research in forest entomology in eastern Africa dating back to the 1950s. It comprises of pinned insect specimens preserved in drawers and spirit collection in which non-scaled winged and soft bodied insects are preserved. The bulk of the collection was accumulated in the colonial era and before the break up in 1997 of the East African Community. The main collection was managed under the East African Agriculture and Forestry Research Organization in Muguga. After the formation of Kenya Agricultural Research Institute in 1980, the collection was merged with smaller collections curated under the Forest Research Conservancy of the Forest Department in Kenya. The merged collection has been under the management of KEFRI since 1986.

Records of the collections are maintained in different formats. A card index available in the insect reference collection contains information derived from labels, which accompany the insect specimens at the time they are curated and links the information to the stored specimen location in the collection. Whereas there are many fields where information on a specimen can be collected, specimen labels have not been standardized and vary widely in the details they provide to accompany the specimen. This situation requires improvement for KEFRI to collaborate with institutions hosting biological collections in Kenya, Eastern Africa Region, Africa and other parts of the world. Methods of insect collection, preservation and identification are also evolving and KEFRI is benchmarking with international best practices for dissemination purposes.

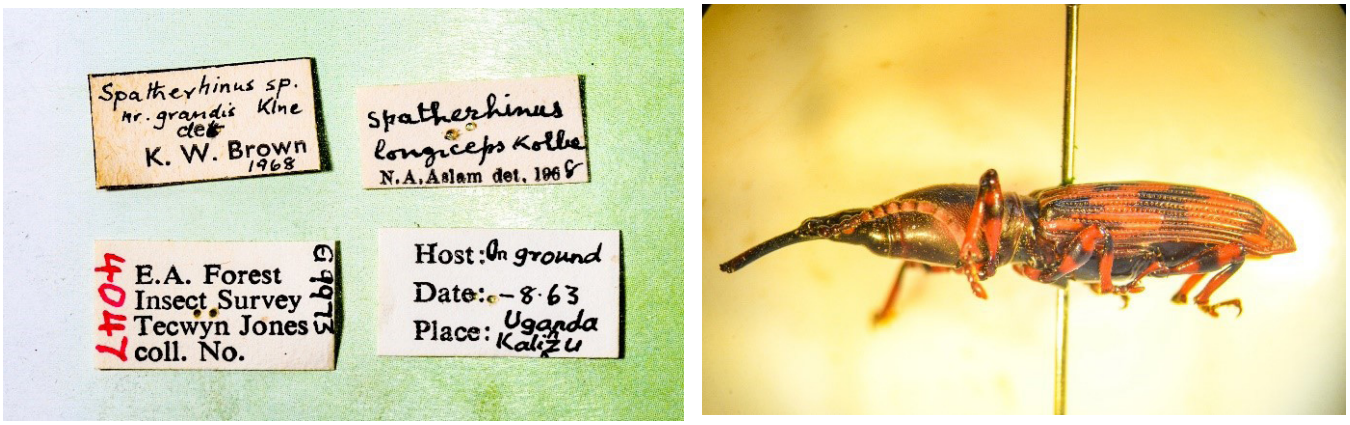


Fig 10: A card index of the insect specimens containing information derived the stored specimen

KEFRI has set out to develop a searchable database based on aging printed insect reference records by digitizing them for access in the form of a web-based electronic format. In the year under review, all team members underwent a Darwin core training exposition while the digitisation work continued with 737 new records digitized in the following families; Alleculidae, Anobiidae, Anthribidae, Apionidae, Attelabidae, Bostrychidae, Brenthidae, and Bruchidae.

3.7 Develop a standard nursery potting growth media for propagation of high-quality Sandalwood seedlings

Sandalwood is a commercially and culturally important semi parasite plant species belonging to the family Santalaceae and the genus Santalum. Sandalwood provides high value essential oil used as fragrance and cosmetic ingredients. Sandalwood can grow in a variety of soil with pH ranging from 7 to 8.5 and temperature ranging from 5°C to 50°C. Sandalwood is not region specific and can adapt to different environmental condition. Studies in India show that Sandalwood grown in plantations perform exceedingly well compared to those that grow in natural ecosystem.

Domestications of Sandalwood can reduce overexploitation of the natural populations in Kenya by providing the market with sustainable stocks grown in plantations. Availability of healthy seedlings is key to successful domestication program. In the year under review, research work on development of standard nursery soil mixtures for production of high-quality sandalwood seedlings to boost the sandalwood domestication efforts in the country was undertaken. The research design was randomized complete block design (RCBD) with 6 treatments and 3 replicates that varied the ratio of forest soil, manure and sand as well as the host plants.

The results of the study showed that sandalwood seedlings height and diameter at ground level differed significantly following the use of different soil mixtures. The soil mixture with the ratio of 5:1:1 (forest soil: manure: sand) hosted with *Acacia polyacantha* yielded the highest seedling height and collar diameter at the end of the experiment (19.23 cm and 2.74 mm respectively). This was 123.3% and 87.7% higher than the control treatment respectively. The control which was the ratio of 5:1:1 (forest soil: manure: sand) without host recorded the lowest height and collar diameter at the end of the experiment (8.61 cm and 1.46 mm respectively). The ratio 4:1:1 (forest soil: manure: sand) with host gave the second highest height and collar diameter (14.9 cm and 1.83 mm respectively). Generally, hosted seedlings had better growth attributes (height and collar diameter) than non-hosted seedlings. The study attributed the optimal growth to formation of haustoria between sandalwood seedlings and host plants.

Fig 11: Assessment of sandalwood seedlings height and diameter in the greenhouse

3.8 Development of protocols for inter-specific hybrids of *Melia volkensii*

Melia volkensii is a drought tolerant tree that occurs naturally in the semi-arid zone of Kenya, Tanzania Ethiopia, and Somalia, at altitudes between 350 and 1700 m, in areas with mean annual rainfall of 300-800 mm. Melia is a deciduous tree, 6-20 m tall with diameter typically about 25 cm with a rotation of 10-15 years. It is highly preferred in the drylands because of its high value timber. The growth rate of Melia and its drought tolerance can be improved through development of Melia hybrids.

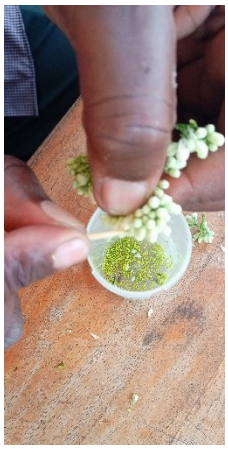
A hybrid is a cross between two or more discrete genetic sources. A hybrid can be inter-specific (between two species) or between two different provenances or even genotypes. Hybrids in trees have the potential to produce special combinations of properties that may either increase the value of the genetic resource or final product e.g. specific timber properties, disease resistance or they may be developed to increase the growth potential.

In 2028, KEFRI started artificial crossing of *Melia volkensii* with the objective of producing second generation varieties that are drought tolerant and fast growing. Pollen was collected from 10 trees of *M. volkensii* selected due to their superior form with 5 trees selected in arid and semi-arid areas and 5 trees from very dry sites. Unopened flowers were collected from the selected male trees and stored in plastic containers containing silica gel. Pollen extraction process involved drying of flowers in the shade during the day and using silica gel at night followed by sieving once the flowers were dry. The extracted pollen was then used to pollinate selected mother trees.

The crosses will be monitored for fruit formation and development until harvesting. The resultant seed will be harvested to raise trees for testing growth rate and drought tolerance.

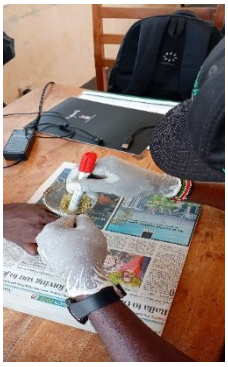
Flower collection

Pollen extraction



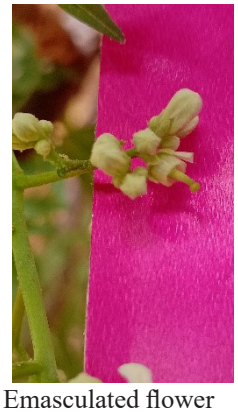
Extracted pollen

Wire structure

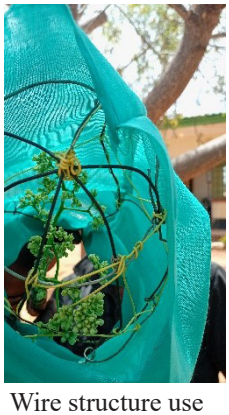


Pollen sieving

Pollen storage



Emasculated flower



Wire structure use

Pollinated flowers

3.9 Restoration of the Nairobi River Basin

Kenya Government together with stakeholders has undertaken several initiatives to rehabilitate and restore the Nairobi River basin. This includes the formation of Nairobi River Basin Rehabilitation Program (NRBP) which was launched in 2003. The objective of the program was to restore, and sustainability manage the basin to provide enhanced ecosystem services. Among these strategies, was landscaping and beautification of the riparian zones including Michuki Memorial Park formerly known as Mazingira Park.

Fig 12: Trees and vetiver grass planted at Michuki Memorial Park to stabilize the Nairobi River bank

The Ministry of Environment and Forestry formed a multi-Agency team comprising Kenya Forestry Research Institute (KEFRI), Kenya Forest Service (KFS), National Environment Management Authority (NEMA), Water Resource Authority (WRA), National Museum of Kenya (NMK) and Nairobi Metropolitan Services (NMS) to lead in the restoration and rehabilitation of the Park to provide recreational and ecosystem services.

KEFRI was tasked to conduct biodiversity assessment and ecosystem service valuation. The following ativities werre undertaken

a) An economic valuation of the Michuki memorial Conservation Park, Nairobi.

b) Assess the willingness to pay to preserve the green spaces in Nairobi.

c) Assess the perception of surrounding communities on the importance of rehabilitating and preserving green spaces in Nairobi Kenya.

CHAPTER FOUR

4.0 DEVELOPMENT, REFINEMENT, PROTOCOL/TECHNOLOGY AND LINKING OF PRODUCTS TO MARKETS

KEFRI in the Fiscal Year 2021-2022, developed technologies for efficient processing and utilization of wood and non-wood forest products. Additionally, through tree products-based enterprises these products were linked to markets for socio-economic development. Some of the key research development technologies are herreby highlighted:

4.1 Development of a composite of rice husks particle boards with bamboo facing

Rice husk has Silica as the main components, cellulose and lignin, which are good in board making. The burning of rice straw, though prohibited, has been going on, since no other acceptable uses for the waste has been found despite large quantities of these residues being generated. Studies have shown that particle boards produced from agricultural wastes, when tested, for moisture content, rate of water absorption, and tensile strength, compare well with commercial boards and the standards for such boards. The cost of such boards, however, is expected to be lower than the commercially available boards in that the raw materials are agricultural wastes.

KEFRI jointly with FunKidz, a workshop and processing plant in Kikuyu township, Kiambu County, embarked on development of the boards. The rice husks were milled and screened for size in order to eliminate large sized particles. The oversized particles were milled again for further reduction. Screening was done by use of a manually shaken screens. The mixture was moulded and subjected to hot hydraulic press. The mixture was then dried to an overall moisture level of 3-8% for the purpose of bonding with a liquid binding material. Particles were sun dried using the sun as a free source of energy. The particle board was observed to be rough on the surface and could not be used for many purposes. Bamboo strips were prepared and used to cover the surfaces of the board to make it useful in furniture making.

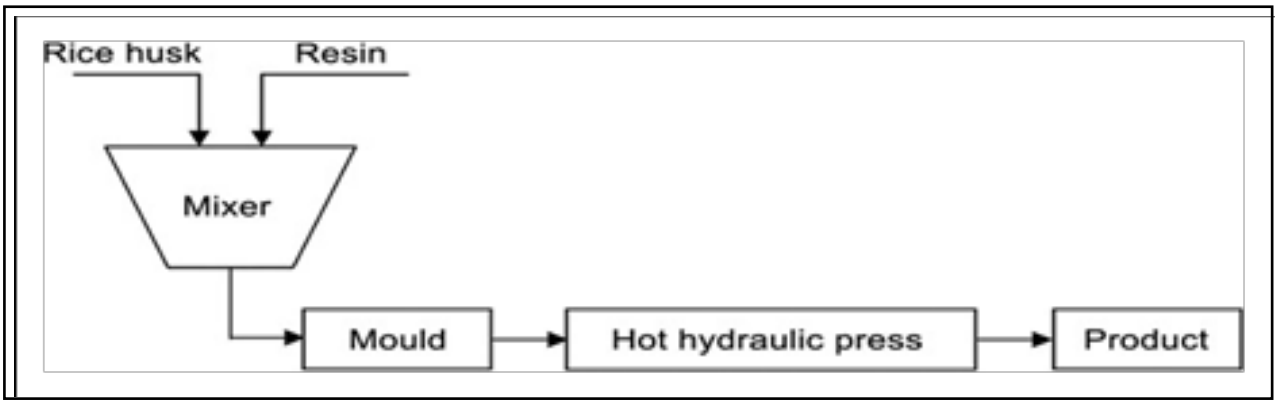


Fig 13: The procedure employed in making the rice husk particle board

Fig 14: Rice husk at Ngurubani, Mwea (Source: Chardust Ltd. & Spectrum Technical Services 2004)

Fig 15: Rice husk particle board

Fig16: Rice husk particle board with bamboo strips facing

4.2 Development of a charcoal briquette from carbonized maize cobs

The activity validated the technology of briquetting using modified drum and Top-Lit Updraft (TLUD) box kilns. Briquetting with modified drum kiln took 53 minutes while it took 66 minutes with TLUD box kilns. The recovery efficiency achieved was 27.8% for modified drum kiln and 28.5% for the TLUD box kiln. The amount of biochar were 12 kg and 28 kg respectively. The maximum temperatures recorded were higher than recommended for carbonizing maize cobs for quality biochar and improved production. This may have negatively affected the quality of biochar and efficiency of the kiln as the organic materials turn to ash and most volatile matters evaporate at high temperature. Moreover, the temperature recorded for the Improved TLUD box kiln was too high for the health of processors.

Fig17: Carbonization of maize cobs using the improved KEFRI's TLUD Box Kilns and (Right) carbonized maize cobs

Table 2: Efficiency of two carbonizers in briquetting of maize cobs

Type of carbonizer	Amount of biochar (kg)	Carbonization time (minutes)	Recovery (%)	Temperature (°C)
Modified drum kiln	12	53	27.8	631.2
Improved TLUD box kiln	28	66	28.5	837.3

Briquettes prepared using biochar from both modified drum kiln and improved TLUD box kiln and gum arabic as a binder exhibited higher calorific value compared to those prepared using cassava flour. However, briquettes prepared in TLUD box kiln using gum arabic and casava flour as binders exhibited higher ash content of 14.8 % and 14.3% respectively.

The quality of briquettes produced were within the Kenya Bureau of Standard's - KEBS (2020) requirements. However, the quality can further be improved by controlling temperatures through controlled airflow.

Table 3: Quality of Briquettes made from maize cobs using different binders

Carbonizer	Material	Type of binder (10%)	Moisture content (Mc) (%)	Calorific value (MJ/kg)	Ash content (AC) (%)	Fixed carbon (FC) (%)	Volatile matter content (VMC) (%)
Modified drum kiln	Maize cobs	Gum arabica	5.8	23.9	12.3	64.6	17.3
		Cassava Flour	6.5	23.0	13.7	64.5	14.9
TLUD box kiln	Maize cobs	Gum arabica	6.1	23.8	14.3	63.0	16.6
		Cassava Flour	6.6	22.9	14.8	62.8	15.8

4.3 Fabrication and performance testing of briquette cookstoves

An improved briquette cook stove (IBC) was fabricated using stainless steel metal sheet (Fig:18). The stove was designed in a manner that primary air passes through the grate while secondary air enters through the secondary air inlets above the grate through the space between outer and inner chambers. The outer part of the stove is insulated using fiberglass to reduce heat loss to the environment. The grate was made with larger holes of (30x30 mm) to allow easy dropping of ash and enable continuous primary air circulation to support complete combustion.

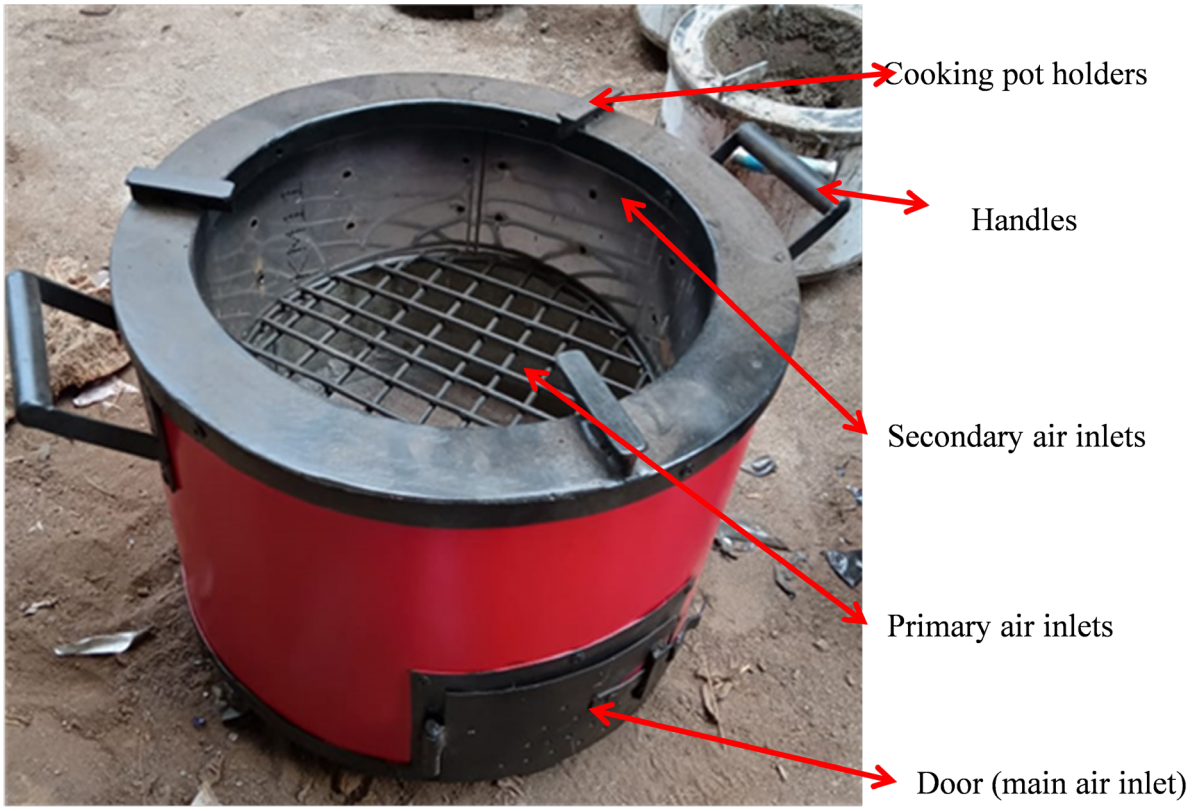


Fig 18: Improved briquette cookstoves

In testing the performance, the IBC was compared to ordinary Kenya ceramic jiko (KCJ) with ceramic lining. Kitchen performance test (KPT) based on a paired-sample without control was conducted to compare IBC with KCJ in terms of briquette consumption, cooking time and burning rate.

4.4 Linking On-farm wood sawing technology to users

Trees on farms have in the recent past become a major source of alternative income for farmers, mainly being processed using small-scale and sometimes inefficient processing systems. Sawing logs on-site therefore remains a better option and increases value and revenues to the tree farmers, encouraging them to plant more. On-farm timber processing is gaining recognition in Kenya and supports development, providing employment to many people. Timber sawing on farms is also a source of employment in rural setups. Over the years, chainsaw system has become a means for processing timber in small volumes from isolated trees and trees in difficult terrain as well as deformed logs.

These sawing systems involve simple equipment and tools than conventional saw milling. They use more manual labour than mechanised processes, while small hand-held machines are used instead of large heavy duty fixed mills. KEFRI, through the National Forest Products Research Programme adopted and customized the framed chain sawing system to improve efficiency in small-scale timber sawing on farms. The system has proven features that increase timber recovery from about 30% using free hand chainsaw to over 50% when the chainsaw is attached to a fabricated steel frame and chain cutters modified appropriately. KEFRI has continued linking this sawing technology to many users in several areas. Some of the beneficiaries include sawyers in central Kenya region (Nyeri, Kirinyaga and Embu Counties), Eastern (Kitui and Makueni Counties) as well as Nyanza region. This has been done through continued field day demonstrations and trainings offered to timber sawyers in those regions.

During the year under review, KEFRI focused on demonstrating and linking the On-farm timber sawing technology to tree farmers and sawyers in Mirangini, Nyandarua County, where Eucalyptus species is grown for timber. The training attracted members of the public, officers from Kenya Forest Service (KFS), county administration officials and other stakeholders. It acted as a sensitization activity to the members of public, government departments and the small scale timber sawyers.

Fig 19: Participant showing free hand method **(**a) and Trainer demonstrating the frame chainsaw (b)

4.5 Validating machines for briquetting Prosopis stems, withies and maize cobs

A manual (Fig: 20a) and motorized (Fig: 20c) briquetting machines were fabricated and validated in Marigat. Prosopis stems, withies and maize cobs were carbonized and resultant char from each category of materials crushed to smaller pieces. The dust were then mixed with different binders such as red soil at a ratio of 10%, Gum Arabic at a ratio of 10%, and cassava flour at a ratio of 10%. The materials were then placed in a briquetting machine and compressed to produce briquettes. The briquettes were then air dried in a shade for 5 days and subjected to cooking and proximate analysis. The machines were found to be effective in making of briquettes and offer different options depending on the scale of operations and economic ability of investors.

Fig 20: Briquetting techniques

a. manual briquetting machine,
b. briquette production using manual machine,
c. motorized briquetting machine,
d. mold briquetting

CHAPTER FIVE
5.0 DISSEMINATION AND PUBLICITY ACTIVITIES

5.1 Dissemination of forestry technologies through exhibitions, and mass media

Under the Performance Contract Fiscal Year 2021/2022, KEFRI disseminated as well as demonstrated 43 successful forestry technologies/ innovations and related information to various stakeholders throughout the Eco-regions spread countrywide. Three main approaches used were; personal level, group and mass contact as highlighted in the summary of key activities undertaken during the reporting period to enhance corporate communication and publicity

Dissemination of research findings to the public targeted farmers, entrepreneurs, students, researchers and other stakeholders who visited KEFRI stand that showcased; best practices in seed collection, and production of seedlings, nursery establishment tree improvement and management, propagation of superior germplasms and other planting materials, rehabilitation and conservation of the environment; utilization and value addition to wood and non-wood forest products, and improved charcoal briquette production techniques using modern drum kilns.

Amongst the public institutions reached were Ministry, Departments & Agencies (MDAs) including Ministry of Agriculture, Livestock and Fisheries, Ministry of Education, Ministry of Energy, Interior and Coordination of National Government, Ministry of Devolution and the ASALs, Ministry of Energy, Ministry of Lands & Physical Planning, County Governments, Regional Development Authorities, The National Environmental Complaints Committee (NECC), NEMA, NETFUND, KWTA, KFS, KALRO, University of Eldoret, Dedan Kimathi University, Permanent Presidential Music Commission, Ethics and Anti-Corruption Commission, Universities amongst many others.

Table 4. Summary of levels for dissemination of innovations with impact to MDAs

	Activities	Numbers
1	Participation at National and International events	31
2	Scientific colloquiums presentations / CRACs (5)	9
3	Stakeholders' validation meetings	6
4	Publicity through Mass media: Print media (publications and magazine articles) Radio talks TV appearances Social media (FB posts)	 54 6 19 193
5	Exhibition at ASK show	3
6	Exhibition at Open day/Farmers Field Day	6
	Total	**331**

5.2 Participation and exhibiting at the national events

KEFRI participated at national events to mention a few:

- Africa Public Service Day, held from June 21st to 23rd, KICC Nairobi - Kenya
- The 7th and Final Devolution Conference, 23rd to 26th November 2021, Makueni

5.3 Participation and exhibiting at international events

During the reporting period, KEFRI participated in planned international events (some are hereby highlighted below) and displayed technologies and innovations:

- United Nations Environment Assembly (UNEA-5) at Gigiri, Nairobi, under the theme is "Strengthening Actions for Nature to Achieve the Sustainable Development Goals".
- World Wetlands Day Celebrations under the Theme "Wetlands Action for People and Nature", held on February 2022, at Ondiri Swamp, Kikuyu in Kiambu County.
- World Environmental Day, held on 5th June 2022 at Dedan Kimathi University of Technology in Nyeri County
- World Day to Combat Desertification and Drought 17th June 2022 at Eldume Primary School, Marigat, Baringo County on June 17th 2022.

5.3 Participation at the Agricultural Society of Kenya Show (ASK)

Fig 21: Demonstration of performance and awarding of trophies by CS Agriculture Hon. Peter Munya

KEFRI participated competitively at the national ASK shows to win various awards in some categories as shown in the table below

No	Category	Position
1	The best stand in demonstrating Application of Environmental Quality Standards	1
2	The best stand demonstrating Seed production and Marketing	2
3	The best stand in Research and Development	3
4	The stand that best interprets current show theme (education/research)	3
	Total	**9**

Fig 22: Demonstration of tree seed harvesting technology and value addition to non-wood forest products

5.4 Capacity building to internal and external stakeholders

Capacity building activities for both internal and external stakeholders for adoption of forestry technologies were successfully carried out. The annual Centre Research Advisory Committees (CRACs) meetings were held successfully at the six ecoregions whereby public participants derived from both private and public sector, county governments, CBOs, NGOs and CFAs shared their opinions on research and development issues worth for incorporation into research proposals and inclusion in the 7th Strategic Plan.

The Biometricians and GIS/RS officers trained 70 staff including scientists, technical staff and interns on mobile data collection - ODK as well as data management and GIS & RS.

5.5 Scientific Colloquiums

In the year under review, the institute held three monthly institutional scientific colloquia on 5th April 2022, 5th May 2022 and 9th June 2022, which were both physical /virtual as well as open to the public.

Fig 23: KEFRI Director Dr. Joshua Cheboiwo making his presentation on timber trade and markets

Date	Colloquium Topic/ Presenter
Ist Coll. 5/4/2022 11:00am	Visibility and Impact for 21st Century Scientist: Dr. Sammy Letema. https://kefri-org.zoom.us/.../tZwpcO6przosGdBND1wWb3ZWE7w.....
2nd Coll. 5/5/2022 10:00am	The Role of Forestry Research in Trade and Socio-Economic Development In Kenya to the 21st Century: Dr Joshua Cheboiwo. https://kefri-org.zoom.us/.../tZUkcuGrrz8uHN1AboH5xSZJ51y.
3rd Coll. 9/06/2022 10:00am	Pathological Basis for Species Site Matching: The Case for Indigenous Tree Species in Restoration and Commercial Forestry in Kenya: Dr. Jane Njuguna https://kefri-org.zoom.us/.../tZUvdO...

Within the period, KEFRI held the first National Kenya Commercial Forestry Investment Conference and Expo between 23rd and 26th November 2022, which concurrently had an exhibition - side event. The commercial conference and expo brought together stakeholders in the commercial forestry sector including; practitioners, researchers, wood processors /investors, and development partners to share knowledge, experiences and opportunities in commercial forestry sector in Kenya and within East Africa region.

Within the reporting period, KEFRI hosted a stakeholders'forum to improve the draft Forest Research and Development Bill, 2023. Lack of elaborate Forest Research and Development Bill has remained one of the challenges that has hinderd effective forestry development in Kenya. In that regards, a taskforce finalizing the proposed draft Forest Research and Development Bill, 2023 envisaged to address legal gaps regarding KEFRI's establishment. The bill will provide an effective institutional framework for the promotion of research, information and sustainable development of forestry and allied resources.

5.6 Woody Weeds Project Progress in Kenya

KEFRI as the national authority for Prosopis management in Kenya is implementing the National Prosopis Strategy (NPS) and coordinating activities among the counties. This is a collaborative project with key players: KEFRI, KFS, CABI, CETRAD, Nature Kenya, Northern Rangeland Trust, and Community Based Organizations (CBOs) and financed by the Swiss Agency for Development and Cooperation and to support the implementation of the National Prosopis Strategy to sustain management of *Prosopis juliflora* locally known as Mathenge tree in Kenya.

Fig 24: Key stakeholders of MDAs in East African region

5.7 Status of Tree Seed Development in Kenya: KEFRI case study 1989 - 2022

Mr. William Omondi, on 29th June 2022 shared his 4 decades knowledge in development of both tree and other crop seed experience which has resulted into policies as well as contribution to KEFRI's improved tree seed production from 1 tonne in 1990 to current 41 tonnes per annum in 2022. Key extract from his Presentation include: -

- Kenya has great potential to increase tree and forest cover if seed distribution is decentralised and KEFRI facilitated to produce enormous tree seedlings of superior germplasm.
- KEFRI has well established the Tree Seed Centre at Muguga with seed testing laboratories, seed processing and storage facilities
- The Kenya government having realised the potential of KEFRI is supporting the expansion of eighteen seed infrastructures across ecological regions of the country to beef up seed source.
- KEFRI seed centres are being rehabilitated to handle produce and distribute quality tree seed, conserve genetic resources towards 10% tree cover and also a centre for information sharing on seed certification.

5.8 Publications 2021-2022 Financial Year

The Institute produced 1,512 different publications comprising; 15 journals, 2 technical reports, 7 book chapters, 4 policy briefs, 12 extension materials (Apendix II). The following six (6) research booklets were launched officially by the Cabinet Secretary Ministry of Environment and Forestry Mr. Keriako Tobiko.

1. Kenya Commercial Tree Improvement Framework
2. Kenya Commercial Tree Improvement Strategy
3. Biodiversity Status of Buda Forest, Kenya
4. Aerial Seeding for Rehabilitation of Degraded Forestlands and Landscapes in Kenya
5. Protocol for Aerial Seeding of Forestlands and Landscapes in Kenya
6. Commercial Forestry in Kenya; Status of Tree Breeding, Tree Seed Sources and Seed Supply chain and threats from pests and diseases

CHAPTER SIX

6.0 PARTNERSHIP AND RESOURCE MOBILIZATION

Within the reporting period, KEFRI engaged and networked with strategic partners at national, regional and international level seeking partnership and linkages for enhanced research and development output. Key accomplishments recorded within the period for strengthening institutional capacity for research and development are; updating KEFRI partnerships and linkages database, increased revenue, and improved implementation of mobilization strategy.

6.1 Update of partnerships database

The Institute notably sought strategic partnerships for joint research and development, and resource mobilization through engaging collaboration discussion with various partners, cutting across various public and private sectors. A total of 116 base partners (Table. 5) was updated with renewal or admission of new partnership getting into a new agreement for carrying out the incorporation and shared responsibilities.

Table 5: Database of partners collaborating with KEFRI 2021-2022 (MoU /Status)

	Type of Partners	**Number**
1.	Government Statutory Bodies	13
2.	Regional Development Authorities	7
3.	Research Institutions (Local and International)	17
4.	Institutions of Higher Learning (Local and International)	24
5.	Non-Governmental Organizations and Associations (Local and International)	18
6.	County Governments	10
7.	Projects and Companies	16
Total MoUs		**92**
8.	Organizations with existing collaborative activities but no formal MoUs/ MoAs	12
Partner Base Total		**116**

6.2 Operationalize engagement with strategic partners at International, national and regional level for joint research and resource mobilization

Within the reporting period, the institute developed 10 Memorandum of Understanding (MoUs) whereby, 5 were shared and 5 signed as follows:

- NGARA Gum Arabic and Resin
- Turkana County,
- Tanzania Forestry and Research Institution (TAFORI) to further research across regional borders.
- MOA and coordinated a joint work activity with Nottingham University and GCRF on Prosopis management in Kenya
- Developed a memorandum of agreement with Center for Mau conservation.
- Developed and shared MOU's with Maasai Mara University and
- Agricultural Training Centre Chebororwa in Rift Valley.
- IKOSAFI Africa on 10% tree cover and climate-smart solutions.
- Coastal region Conservation of the indigenous Boni Forest forum

KEFRI also initiated potential collaboration with:

- Scott Christian University in tree growing and environmental conservation
- Equity Bank on planting trees on 100 acres of land.
- Kaimosi University College on achievement of 10% tree cover
- Kenya Forest Working Group on Policy drafting and Advocacy

6.3 To increase revenue: Coordinate identification and development of project proposals for marketing for national and international competitive grants

During the FY 2021/2022, the Institute received support from the Government and other partners augmented its financial and research capacity. Notably, the World Bank, JICA-Capacity Development Project for Sustainable Forest Management in Kenya (CADEP), Biofuel4 Kenya Project, Dutch-Sino/INBAR-East Africa Bamboo Development Project, UNDP-FAO support to Commercial Forestry Investment and Expo Forum, AHRC/IIED, TWENDE, KCSAP, GATSBY Africa and Darwin Initiative. Two 2 potential consultancy opportunities bids in forestry Research and development in Natural resource and Mobilization were identified.

- KENGEN collaborated and supported KEFRI on 10% tree cover.
- KEFRI NETFUND partnership proposals on 10% tree cover and 1 under United Nations Development Programme (UNDP) received funding of Ksh. 58M.
- KEFRI developed 2 UK-PACT proposals with ICRAF and Nottingham University.
- KEFRI developed and responded to 2 IDRC CLARE Initiative concepts (1 regional and national countries).

6.4 Proposal Developed and Submitted within the Financial Year 2021/22

The Institute supported scientists build capacity on writing award-winning proposal which greatly contributed to development of 15 proposals and concepts some highlighted below:

- Wei-Wei River Catchment Restoration Project in Cherangani Water Tower (WRCRP) - West Pokot worth USD 1M- KES 126M
- Developed 2 Bids with KCIS&ICRAF and with University of Nottingham to response to call for proposal by UK-Pact
- IUFRO Bid to host the World Forests Congress in 2029
- MOECCF and SAGAs proposal on Kenya LEAF
- Letter of Agreement to seek 2nd year finances for GEF 6 project titled: Restoration of arid and semi-arid lands (ASAL) of Kenya through bio-enterprise development and other incentives under The Restoration Initiative" - Kshs 35M
- Social View Kenya, CONTACTICA innovation-Spain titled in Integral Forestry management and submitted it to EU - Horizon
- Letter of Agreement to FAO on commercial forestry conference and expo
- KEFRI IKEA, Kenya and Climate innovation Centre (KCIC) proposal for The Green Entrepreneurship Initiative-KES 60M).
- KEFRI Covid-19 Emergency Response Project - Darwin call for proposals-round 28
- NETFUND and KEFRI joint proposals for donor round

CHAPTER SEVEN

7.0 HUMAN RESOURCE MANAGEMENT

During the period under review, the human resource management undertook both routine activities as assigned in the performance contract for the fiscal year 2021/2022. The activities were human resource planning, recruitment and staff selection, training and development, performance management, reward management, employee relations, personnel administration, employee separations and provision of medical services at the KEFRI clinic.

7.1 Training and Development

During the period, the department undertook the following activities under the Training and Development function: Induction Coordinated an Induction for the One Hundred and Forty-Seven (147) attachee who were on attachment during the period July 2021 to March 2022 and five (5) Interns who were placed at various departments/section in the Institute. Mentorship of nineteen (19) Interns on placement by the Public Service Commission and Uasin Gishu County Public Service Board were assigned mentors to help guide them through their internship programme.

7.2 Staff Establishment

The Institute as at 30th June 2022 had 857 employees out of which 748 are on permanent and pensionable terms of service whereas 106 are on contract terms.

Table 6: Current staff strength

S/No.	Cadre	No. staff
1	Research Scientist	99
2	Technologist	42
3	Technicians	46
4	Foresters	21
5	Finance	40
6	Audit	7
7	HR	5
8	Administration	16
9	Supply Chain	32
10	Other professional Support	75
11	Other Support	474
	Total	**857**

7.3 Recruitments and Selection

During the period, the Institute's approved Staff replacement plan for the FY 2021/2022. A total of sixty-five (65) positions were advertised and interviewed. Other twenty (20) staff were recruited and appointed during the year, out of which 10 were on annual contract terms while 10 were appointed on permanent and pensionable terms. All positions were competitively recruited internally and externally.

7.4 Training and development for scientific staff

A skills gap analysis and training needs analysis was undertaken during the fiscal year 2020/2021. The Institute continued to support a total of nine (9) Scientists pursuing PhD programme at local and Universities overseas. Other staff attended continuous professional development trainings organized by various institutions including Kenya School of Government, National Transport Service Authority,

(NTSA), Kenya Institute of Management (KIM), Kenya National Secretaries Association (KENASA) amongst other training institutions.

7.5 Internship

During the Financial Year 2021/2022, under the Youth Internships/Industrial Attachments/Apprenticeships, KEFRI offered One hundred and twenty (120) attachment opportunities to students from higher institutions of learning and TIVETS. At the same period 27 internships were offered to graduates for a period of one year.

7.6 Performance Management

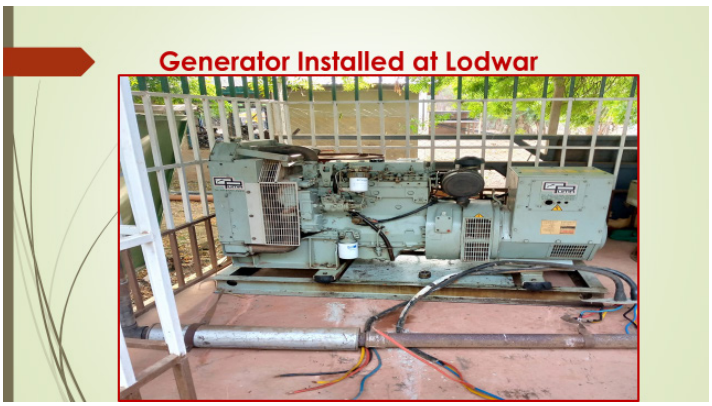
During the year under review, the division implemented the Board approval of performance evaluation recommendations for 2019/2020 whereby promotions, merit increments, commendations, cautionary letters and performance improvement plan (PIP) were enacted accordingly.

7.7 Infrastructure Development

During the period under review, the Administration Department successfully implemented various activities to provide an enabling environment for research in forestry and allied natural resources across the Institute's eco-regional research centres in the Country.

At the Headquarters construction of gabions to prevent soil erosion near the second generator house, painting of the office blocks, bollards on the walk ways as well as road repair was done.

A follow up of securing land (Title deeds) for Migori, Wajir, Lamu and Hola was ongoing at different stages of acquisition and the allotment letter for the parcel of land in Migori was successful. Other key achievemnts includes:



- Installation of power generators at Lodwar Sub Centre and Taita Taveta Sub Centres
- Construction of abulution facility, guard house, power house and installation of control panel at Rumuruti sub regional centre
- Completion of kitchen, dining and repair of roof office Block was completed and handed over to the Institute.
- Construction of the Bamboo Treatment Plant at Migori Sub-regional Centre
- Construction of tree nursery at Rongo station.

- Partitioning and alteration of Office block at NFPRP - Karura was completed
- Fencing of 2Km of Tiva research land in Kitui County was completed thus making total kilometres fenced so far to eight (8), out of thirty-two (32) Kms of the total land area.
- Construction of various tree seed centres progressed well with majority being about 30% complete (Fig. 25)

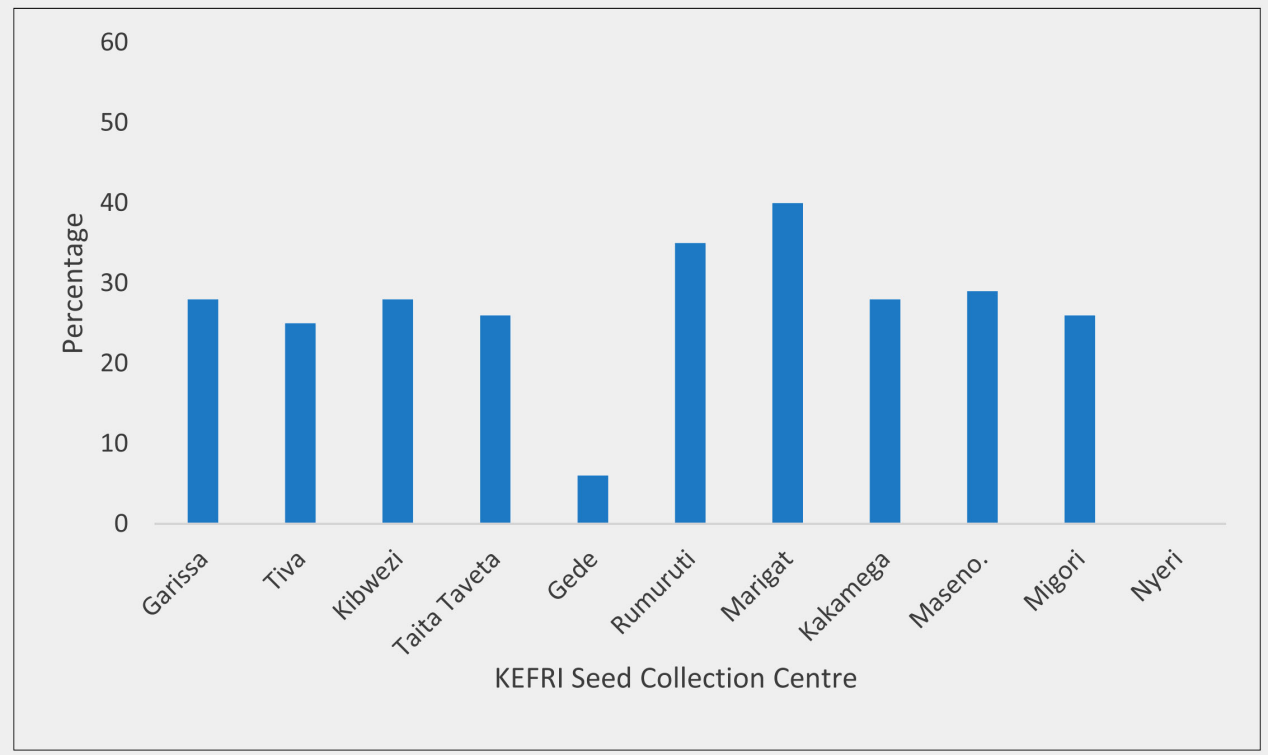


Fig 25: Status of construction of KEFRI Seed storages facilities

7.8: Work Environment Safety and Security Measures

The Institute, within the period under review, offered training to eighteen (18) officers on disaster management, Seventeen (17) Fire marshals and sensitizing staff on mitigation against terrorism and Counter Violent Extremism at Maseno, Lamu, Turkana, Kakamega and Nyeri.

7.9: Road Safety Mainstreaming

The Institute through Road Safety Committee developed an annual Road Safety Implementation Plan with the following key components:

i. Training of Road Safety Committee and twenty (20) drivers on defensive driving
ii. Sensitization of staff and clients/stakeholders on road safety
iii. Three (3) road safety activities in the Work Place Road Safety Policy
iv. Reporting on quarterly basis using the prescribed Non-compliance Reporting Template the non-compliance on road safety at the workplace.

The Department implemented the Road Safety Implementation Plan submitted quarterly reports to NTSA in the prescribed format within 15 days after the end of a quarter.

Appendix 1: KEFRI Publications Produced in FY 2021 - 2022

1. Angaine P.M., Ndungu S.M., Onyango A.A., and Owino J.O. 2021. Effect of Desiccation and Storage Environment on Longevity of Ehretia Cymosa Thonn. Seeds. Journal of Forests Vol. 8,No. 2, pp. 153-160. ISSN(e): 2409-3807. ISSN(p): 2413-8398. DOI:10.18488/101.2021.82.153.160
2. Chemuku Wekesa, Leila Ndalilo, and Krystyna Swiderska. 2021. Towards a biocultural heritage territory in Rabai Cultural Landscape: exploring Mijikenda cultural values and practices for sustainable development - Case study for the project 'Indigenous biocultural heritage for sustainable development'. IIED and KEFRI. 37 pp
3. Williams F., Constantine K.L., Ali A.A., Karanja T.W., Kibet S., Lingeera E. K., Muthike G., Rwomushana I., Godwin J. and Day R. (2021). An Assessment of the Capacity and Responsiveness of a National System to Address the Threat of Invasive Species: a Systems Approach. CABI Agriculture and Bioscience. 2:42 https://doi.org/10.1186/s43170-021-00062-7
4. Koech C.K., Njuguna J.W., Kiama S.M., Maua J.O., Kaigongi M.M., Muganda M.M., Nadir S. and Kigomo J.N. (2021). Community Use and Product Valuation of Forest Resources in Maasai Mau, Kenya. Advances in Social Sciences Research Journal, 8(10). 106-130.
5. Felix Lamech Mogambi Ming'ate, Mũsingo Tito E. Mbuvi and Nahama, Eric Tetea, 2021. Guidelines for Establishment of Partnerships, Forest Resources and Resource User's Boundaries in Kenya
6. Peter Murithi Angaine, Stephen Murithi Ndungu, Alice Adongo Anyango, Jesse O. Owino. 2021. Effect of desiccation and storage environment on longevity of Ehretia Cymosa Thonn. Seeds. Journal of Forests Vol. 8, No. 2, pp. 153-160.ISSN(e): 2409-3807ISSN(p): 2413-8398 DOI: 10.18488/journal.101.2021.82.153.160
7. Leley, N.C., Langat, D.K., Kisiwa, A.K., Maina, G.M. and Muga, M.O. (2022). Total Carbon Stock and Potential Carbon Sequestration Economic Value of Mukogodo Forest-Landscape Ecosystem in Drylands of Northern Kenya. Open Journal of Forestry, 12, 19-40.https://doi.org/10.4236/ojf.2022.121002
8. Kiama S.M., Njuguna J.W., Maua J.O. Nadir S., Kigomo J.N., Meso M. M., Koech C.K., and Kaigongi M.M. (2021). Protocol for Aerial Seeding of Degraded Forests and Other Landscapes in Kenya. KEFRI. Muguga. Kenya. 42pp
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10. Jane Njuguna and Joseph Machua (2021). Kenya Commercial Tree Improvement Framework. KEFRI, Muguga. Kemya. 17pp.
11. Jane Njuguna and Joseph Machua (2021). Kenya Commercial Tree Improvement Strategy
12. Kariuki J.G., Miyashita H., Ndufa J.K., and Kamondo B. 2021. Manual for Establishing and Managing *Melia volkensii* Seed Orchards in Kenya. KEFRI / JICA / FPRRI. ISBN 978-4-86693-553-9
13. Kariuki J.G., Miyashita H., Kobayashi T., Ndufa J.K., Ochieng D., and Wanjiku J. 2021. Guideline for Establishment and Managements of *Acacia tortilis* Seed Stands in Kenya. KEFRI / JICA / FPPRI. ISBN 978-4-86693-556-0

14. Kariuki J.G., Fukatsu E., Matsushita M., Ndufa J.K. and Kamondo B. Genetic Performance and Plus Tree Traits Table for Melia volkensii in the Drylands of Kenya. Technical Note. ISBN 978-4-86693-552-2
15. Kariuki J.G., Miyashita H., Kobayashi T., Ndufa J.K. and Kamondo B. 2021. Guideline for Clone Propagation of *Melia volkensii.* KEFRI / JICA / FPRRI. ISBN 978-4-86693-554-6
16. Matsushita M., Hanaoka So, Omondi S.F., Kariuki J.G., Cherotich L., and Ndufa J.K. (2021). Breeding Strategies, Mating Systems and Future Perspective of Indigenous Tree Species Improvement in Kenya: A Case Study of Melia volkensii. KEFRI / JICA . FPRRI. ISBN 978-4-86693- 555-3
17. Maua J.O., Mbuvi M.T.E., Matiku P., Munguti S., Mateche E. and Owili M. (2022). The difficult choice - to conserve the living filters or utilizing the full potential of wetlands: Insights from the Yala swamp, Kenya. Environmental Challenges 6 (2022) 100427. https://doi.org/10.1016/j.envc.2021.100427
18. Mbinga J.M.E., Omondi S.F. and Onyango A.A. (2021). Conifers: Species Diversity and Improvement Status in Kenya. Open access peer-reviewed chapter in the book: Conifers - Recent Advances. 12pp. DOI: 10.5772/intechopen.101111
19. Peter Murithi Angaine, Alice Adongo Onyango Stephen Muriithi Ndung'u, Shadrack K. Inoti and Jesse O. Owino (2021): Influence of *Cupressus lusitanica* Mill. Cones and seed characterization on germination in Kenya, Journal of Forests, Vol. 8 (2), pp 123-130, DOI: 10.18488/journal.101.2021.82.123.130
20. Alice Adongo Onyango, Peter Murithi Angaine, Joram Mbinga, Jesse O. Owino (2021): Variations in Cupressus lusitanica Mill. Seed Yield and Quality under Different Extraction Conditions in Kenya. International Journal of Forestry and Horticulture, Vol. 7 (1), pp 1-8, https://doi. org/10.20431/2454-9487.0701001
21. Bekele, K., EW Linders, T., Eschen, R., Shiferaw, H., Haji, J., Legesse, B., S. Choge & Schaffner, U. (2022). How well do local stakeholders' perceptions of environmental impacts of an invasive alien plant species relate to ecological data?. Ecological indicators, 137.
22. Choge, S., Mbaabu, P. R., & Muturi, G. M. (2022). Management and control of the invasive *Prosopis juliflora* tree species in Africa with a focus on Kenya. In Prosopis as a Heat Tolerant Nitrogen Fixing Desert Food Legume (pp. 67-81). Academic Press.
23. Joseph Hitimana, Edward K. Mengich, Teresiah N. Kuria and Pauline Kimani 2021. Combating Desertification through Enhancement of Woody Floral Diversity in the Drylands of Kenya: Analysis, Milestones, and Strategies, Combating Desertification through Enhancement of Woody Floral Diversity in the Drylands DOI: http://dx.doi.org/10.5772/Intechopen.100399.
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25. Leley, N. C., Langat, D. K., Kisiwa, A. K., Mullah, C. J. and Owino, J. 2021. Invasion pathways and effects of Cestrum aurantiacum Lindl. on forest-landscape ecosystems in Kenya: Case of Western Mau forest. Presented in the IUFRO international conference on Alien invasive species 20th -24th September, 2021. Prague
26. Mwirigi, P, J.Owino and J. Kemboi (2021). Nature-Based Enterprises In The Arid And Semi-Arid Lands Of Kenya: Case Studies In Loima And Turkana West Sub Counties, Turkana, Research journali's Journal of Forestry, Vol. 8 | No. 2 October | 2021

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30. Langat, D.K. Leley, N, Abdala, K, and Muga, M E. Mboko (2021). Assessment and value of ecosystem services of Mukogodo forest landscape, Kenya, accepted for presentation during XV World Forestry Congress, Seoul, Korea.
31. Williams F., Constantine K. L., Ali A. A., Karanja T. W., Kibet S., Lingeera E. K., Muthike G., Rwomushana I., Godwin J. and Day R. An assessment of the capacity and responsiveness of a national system to address the threat of invasive species: a systems approach. CABI Agric Biosci (2021) 2:42. https://doi.org/10.1186/s43170-021-00062-7
32. Muchiri Mbae and Muga Meshack. (2021). Country Profile of Climate Change Mitigation Potential of Implementing Sustainable Management for Bamboo Forests in Kenya-Technical Report. INBAR Working Paper. International Bamboo and Rattan Organisation (INBAR). Kenya Forestry Research Institute
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34. Wairagu N.W., Wachira B.M., Githiomi J.K., Oduor N. and Ng'ang'a M.M. (2022). Repellency and Toxicity of Selected Fractions, Identified Compounds and Blends of Commiphora africana [1] Resin Against Bedbugs. Natural Product Communications 17(6): 1–10. DOI: 10.1177/1934578X221106898
35. KEFRI Newsletter Issue No. 38, 39, 40, 41

Appendix II: FINANCIAL STATEMENTS FOR FISCAL YEAR ENDED 30TH JUNE 2022

	Notes	2021-2022 Kshs.	2020-2021 Kshs.
REVENUE			
Revenue from non-exchange transactions:			
Government Grants	3	1,525,757,811	1,499,769,674
External Grant for Research	4	114,835,278	107,277,969
Deferred Income from Donated assets	5(b)	19,761,368	21,692,463
Revenue from exchange transactions:			
Sale of Goods and Services	6	117,633,923	103,470,615
TOTAL REVENUE		**1,777,988,380**	**1,732,210,720**
EXPENSES			
Employee Costs	7	(1,207,442,826)	(1,154,481,167)
Operating Expenses	8	(477,197,903)	(398,078,680)
Board of Directors Expenses	9	(16,558,539)	(13,505,560)
Establishment Cost(Sinking Fund)	10(a)	-	(10,000,000)
Depreciation charge	5(a)	(77,625,146)	(79,870,957)
Amortization on Intangible Asset	11	(4,140,337)	(3,024,222)
TOTAL EXPENSES		**(1,782,964,751)**	**(1,658,960,584)**
OTHER GAINS/(LOSSES)			
Exchange Gain/(Loss)	12	(1,668,565)	(803,551)
		(1,668,565)	**(803,551)**
Surplus/(Deficit) for the Year		**(6,644,936)**	**72,446,585**

Appendix III: STATEMENT OF FINANCIAL POSITION AS AT 30TH JUNE 2022

	Notes	2021-2022 Kshs.	2020-2021 Kshs.
ASSETS			
CURRENT ASSETS			
Cash and cash equivalents	13(a)	598,185,826	454,393,320
Receivables from exchange transactions	14(a)	35,895,356	28,292,719
Receivables from non- exchange transactions	14(b)	1,271,339	4,551,142
Inventories	15	145,626,635	74,336,007
		780,979,156	**561,573,188**
NON-CURRENT ASSETS			
Property, Plant & Equipment	5(a)	5,756,715,561	5,713,085,096
Intangible Assets	11	16,561,349	12,096,887
		5,773,276,910	5,725,181,983
TOTAL ASSETS		**6,554,256,066**	**6,286,755,171**
LIABILITIES			
CURRENT LIABILITIES			
Payables from exchange transactions	16	9,343,416	4,189,322
Auditor General- accrued audit fee	16(c)	660,000	1,173,969
Unexpended External Donor Grants	4	155,800,578	144,274,626
Medical Scheme Funds	17	345,205	345,205
		166,149,199	**149,983,123**
NET ASSETS			
Government Grants for capital assets	18(a)	1,421,091,292	1,143,349,103
Deferred Income on Donated Assets	5(b)	494,500,177	514,261,545
Sinking Fund	10(b)	34,493,126	34,494,191
Revaluation Reserves	18(b)	4,467,199,488	4,467,199,488
Revenue Reserves	18(e)	(29,177,216)	(22,532,279)
		6,388,106,868	**6,136,772,048**
TOTAL NET ASSETS & LIABILITIES		**6,554,256,066**	**6,286,755,171**

Appendix IV: STATEMENT OF CHANGES IN NET ASSETS FOR THE YEAR ENDED 30TH JUNE 2022

	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 2022	1,043,537,781	535,954,008	(103,103,264)	4,467,199,488	24,495,256	5,968,083,269
Prior period adjustment			8,124,400			**8,124,400**
As restated	**1,043,537,781**	**535,954,008**	**(94,978,864)**	**4,467,199,488**	**24,495,256**	**5,976,207,669**
Surplus/(Deficit) for the year	-		72,446,585			**72,446,585**
Adjustments						**-**
Transfers from Sinking fund						**-**
Sinking Fund expenses					(1,065)	**(1,065)**
Additions during the year	149,000,000				10,000,000	**159,000,000**
To Income & Expenditure	(49,188,678)					**(49,188,678)**
Deferred Income for the year	-	(21,692,463)	-	-	-	**(21,692,463)**
Balance as at 30th June 2021	1,143,349,103	514,261,545	(22,532,279)	467,199,488	34,494,191	**6,136,772,048**
Balance as at 1st July 2021	1,143,349,103	514,261,545	(22,532,279)	4,467,199,488	34,494,191	**6,136,772,048**
Prior period adjustment						-
As restated	**1,143,349,103**	**514,261,545**	**(22,532,279)**	**4,467,199,488**	**34,494,191**	**6,136,772,048**
Surplus/(Deficit) for the year	-		(6,644,936)			**(6,644,936)**
Adjustments						-
Transfers from Sinking fund						-
Sinking Fund expenses					(1,065)	**(1,065)**
Additions during the year	362,500,000				-	**362,500,000**
To Income & Expenditure	(84,757,811)					**(84,757,811)**
Deferred Income for the year	-	(19,761,368)	-	-	-	**(19,761,368)**
Balance as at 30th June 2022	**1,421,091,292**	**494,500,177**	**(29,177,216)**	**4,467,199,488**	**34,493,126**	**6,388,106,868**

Appendix V: STATEMENT OF CASH FLOWS FOR THE YEAR ENDED 30TH JUNE 2022

	NOTES	2021-2022 Kshs.	2020-2021 Kshs.
Cash Flows from Operating Activities			
Cash from Recurrent Grants	3	1,441,000,000	1,450,580,996
Cash from Development Grants	3	362,500,000	149,000,000
Cash from donor grants	4	129,136,819	92,985,539
Cash receipts from customers		113,174,548	58,485,669
Cash receipts from Insurance		12,451,710	5,513,034
Cash receipts from employees	14(b)	20,816	-
Cash paid to employees(Salaries)	8	(1,207,442,826)	(1,154,481,167)
Cash paid for operations		(473,836,431)	(395,974,116)
Cash paid to board members	9	(16,558,539)	(13,505,560)
Cash refund to donor		(3,361,804)	-
Cash paid to employees	14(b)	(1,271,339)	-
Cash paid for Insurance (prepaid)		(21,900,000)	-
Cash paid to suppliers		-	(5,277,920)
Cash paid to employees for personal accident		(9,584,502)	(4,540,213)
Net cash from operating activities		**324,328,453**	**182,786,262**
			-
Cash Flows from Investing Activities			
Purchase of property, plant, and equipment	5(a)	(171,931,148)	(42,549,203)
Purchase of Intangible asset	11	(8,604,799)	(2,682,171)
Net Cash from Investing activities		**(180,535,947)**	**(45,231,374)**
Net increase in cash and cash equivalents		143,792,506	137,554,888
Cash and cash equivalents at beginning of period	13(a)	454,393,320	316,838,432
Closing Cash and cash equivalents at end of period		**598,185,826**	**454,393,320**

Appendix VI: STATEMENT OF COMPARISON OF BUDGET AND ACTUAL AMOUNTS FOR THE YEAR ENDED 30TH JUNE 2022							
	Notes	**Original budget**	**Adjustments/ Supplementary**	**Full budget**	**Actual on Comparable**	**Performance difference**	**Budget vs Actual**
		2021-2022	**2021-2022**	**2021-2022**	**2021-2022**	**2021-2022**	**%**
Revenue		**Kshs**	**Kshs**	**Kshs**	**Kshs**	**Kshs**	
Recurrent Grants	3	1,441,000,000	-	1,441,000,000	1,441,000,000	-	100.00
Development Grants	3	374,000,000	(11,500,000)	362,500,000	362,500,000	-	100.00
Research Grants	4	114,835,278	-	114,835,278	114,835,278	-	100.00
Deferred Income from donors	5b	19,761,368	-	19,761,368	19,761,368	-	100.00
Sale of Goods and Services	6	116,500,250		116,500,250	117,633,923	(1,133,673)	100.97
Total Income		**2,066,096,895**	**(11,500,000)**	**2,054,596,895**	**2,055,730,568**	**(1,133,673)**	**100.06**
Development Grants: Income Recognised		84,757,811	-	84,757,811	84,757,811.00	-	100.00
NET TOTAL INCOME		**2,150,854,706**	**(11,500,000)**	**2,139,354,706**	**2,140,488,379**	**(1,133,673)**	**100.05**
Expenses		**Kshs**	**Kshs**	**Kshs**	**Kshs**	**Kshs**	
Employees Costs	7	1,250,000,000	(24,802,852)	1,225,197,148	1,207,442,826	17,754,322	98.55
Operation Expenses	8	689,070,045	20,802,852	709,872,897	477,197,903	232,674,994	67.22
Board Expenses	9	14,000,000	4,000,000	18,000,000	16,558,539	1,441,461	91.99
Establishment Cost (Sinking Fund)	10	-		-			
Depreciation	5a	77,625,146	-	77,625,146	77,625,146		

	Notes	Original budget	Adjustments/ Supplementary	Full budget	Actual on Comparable	Performance difference	Budget vs Actual
		2021-2022	2021-2022	2021-2022	2021-2022	2021-2022	%
Amortization Expenses	11	4,140,337	-	4,140,337	4,140,337	-	
Total Expenditure		**2,034,835,528**	**-**	**2,034,835,528**	**1,782,964,751**	**251,870,777**	**87.62**
Other Gains/(Losses)							
Exchange Gain/(Loss)	12b	1,668,565	-	1,668,565	1,668,565	-	100.00
Surplus /(Deficit) for the period without capital assets		114,350,614	(11,500,000)	102,850,614	355,855,063	(253,004,450)	
Development Grants	3	374,000,000	(11,500,000)	362,500,000	362,500,000	-	100.00
Suplus /(Deficit) for the period		(259,649,386)	-	(259,649,386)	(6,644,937)	(253,004,450)	
Capital Expenditure		289,242,189	(11,500,000)	277,742,189	277,742,189		
Notes							
1. GoK : Development Grant						**Kshs**	
Budget Estimates						374,000,000	
Less: Received from Exchequer						(362,500,000)	

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