ANNUAL REPORT
AND
RECORD OF RESEARCH

July 1999 - June 2000

Kenya Forestry Research Institute (KEFRI)
P O. Box 20412, Nairobi.

ANNUAL REPORT

AND

RECORD OF RESEARCH

July 1999 - June 2000.

Kenya Forestry Research Institute (KEFRI)

Kenya Forestry Research Institute
P. O. Box 20412, Nairobi, Kenya
Tel: 254 154 32891/2/3
Fax: 254 154 32844
Email: kefri@arcc.or.ke

Compiled by Sheila S. Mbiru
Edited by P.K. Konuche, B.N. Kigomo and S. W. Mwanycky
Typeset by Mary Kasango and Carolyne Akal
Design and Layout by Sheila S. Mbiru
Cover Photo: *Tricilia ementia* at KEFRI Headquarters, Muguga (F.Gachathi)

ACRONYMS AND ABBREVIATIONS

AFREA	Association of Forestry Research Institutions in Eastern Africa
AIDGUM	Association for the Development of Natural Gums
ASALs	Arid and Semi-Arid Lands
BAT	British American Tobacco
CRC	Collaborating Research Centre
DMP	Desert Margin Program
DPM	Directorate of Personnel Management
DRSRS	Department of Resource Survey and Remote Sensing
DTM	Digitized Territory Model
EC	European Community
EMI	Embu, Meru, Isiolo
EVC	Environmental Village Committee
FAO	Food and Agricultural Organisation
FD	Forest Department
FORNESSA	Forestry Research Network for Sub-Saharan Africa
GFIS	Global Forest Information Service
GIS	Geographical Information System
GoK	Government of Kenya
GTZ	German Technical Cooperation
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	International Centre for Research in Agroforestry
IFRI	International Forestry Research and Institutions
INCO-DC	Industrialized Countries-Developing Countries Cooperation
IPGRI	International Plant Genetic Resources Institute
IUFRO	International Union for Forest Research Organisations
JICA	Japan International Cooperation Agency
KAKI	Kenya Agricultural Research Institute
KCMNET	Kenya Community Media Network
KEBS	Kenya Bureau of Standards
KEFRI	Kenya Forestry Research Institute
NGARA	Network for Natural Gums and Resins in Africa
RELMA	Regional Land Management Unit
SADC-FSTCU	Southern Africa Development Community -Forestry Sector Technical Coordinating Unit
SAFORGEN	Sub-Saharan Forest Genetic Resources Network
SIDA	Swedish International Development Agency
SOFEM	Social Forestry Extension Model

FOREWORD

The past year was a dynamic one for KEFRI with the launch of the Institute's Strategic Plan for the period 1999-2004. The plan sets the direction for KEFRI's research program in the next five years. It also presents the priority problems identified during the 1997 stakeholders workshop and has a flexible research structure, based on the following as core research programmes: Farm forestry, Natural Forests, Forest Plantations and Dryland Forestry. The new structure has also a Service Program, which coordinates activities on information dissemination, outreach training, tree seed production and income generating activities.

The main implementation strategies of the plan include: undertaking problem-oriented research; decentralizing research activities to facilitate improved interaction and linkages with the users; developing beneficial partnerships and enhancing information exchange and dissemination.

Implementation of the plan started during the year and considerable progress was made in reorienting and streamlining past research and development activities.

In an effort to further strengthen linkages with other organisations outside the country the Institute participated in establishment of various regional and subregional networks such as FORNESSA, AFREA, NGARA and SAFORGEN. During the re-organisation of government ministries towards the end of 1999, KEFRI was transferred back to the Ministry of Environment and Natural resources after a period of eleven years in the former Ministry of Research, Science and Technology. The changes further strengthened the closer working relationships between KEFRI and the Forest Department.

This report presents research and development activities of the Institute undertaken during the year. Activities of the management services are also highlighted.

I wish to thank the KEFRI Board of management and members of staff for their contribution during the year and our donors and collaborators for their continued support.

Dr. P.A.Konuche
DIRECTOR, KEFRI

Table of Contents

1 .0 Research Activities By Programmes

1.1 Farm Forestry Research Programme

1.1.1 Introduction

Growing trees on-farm is now considered as the key to improving the livelihoods of the rural poor and protecting the natural resource base and environment in Sub-Saharan Africa. In Kenya and the eastern African region, various agroforestry technologies have been developed to tackle the food security and environmental concerns. Agroforestry technology research and development is a continuous process. The work of KEFRI and its partners is beginning to bear fruit in the realization of food security and environmental conservation. The challenge is to scale-up the utilization of these technologies, while developing new ones, to reach a larger mass of farmers in Kenya. In this report, we highlight some key activities carried out by KEFRI scientists in applying various agroforestry technologies in diverse and agro-ecological conditions, encompassing both the high potential areas with ample rainfall to the marginal areas, where moisture availability is the single factor limiting on-farm and rangeland productivity.

1.1.2 Research Focus

The main focus of the Farm Forestry Programme is to contribute to the current efforts of tree planting, conservation, and utilization by farmers, to diversify farm products and improve living standards. In order to achieve this objective, Farm Forestry Programme strives to strengthen the linkages amongst extension agents, researchers and farmers through development of effective technology transfer approaches as well as production of appropriate management guidelines. Our research is focused on domestication and development of fast growing species with high value and market demand and their management practices. The main research thrust areas during this reporting period were soil fertility improvement, fodder production and utilization, and wood and fruit research. Marketing research, facilitation on establishment of on-farm tree based seed sources, evaluation and improvement of traditional tree management practices and policy research are among the many other activities that will continue to be addressed.

Table 1 outlines the programmes' research sites and the emphasis of research activities.

1.1.3 Research Activities

A. Soil fertility improvement research using Agroforestry trees and shrubs

Continuous land use due to shortage of land coupled with lack of resources to apply chemical fertilizers, has induced a decline in small-scale farm productivity. Therefore, the overall objective of soil fertility improvement research is to find low input ways of sustainable land production using agroforestry trees and shrubs that are likely to be adopted by small-scale

farmers. Maseno Agroforestry Centre is the flagship for soil fertility research. The principal activities covered during-this period include:

Selection of tree and shrub species for various technologies
Microsymbiont research focusing on rhizobial selection for potency
Fertility regeneration of low phosphorus and high aluminum toxic soils
Biological N-fixation by trees and shrubs
Contour hedges intercropping
Fodder production and utilization

Table 1: Farm Forestry Programme Principal Research Sites and Main Research Activities

Centre/Site	Research Emphasis
Maseno	On-farm research focusing on improved fallows
Muguga	On-farm wood production; microbiological research
Embu	On-farm fodder production and utilization
Kibwezi	Improved land management and on-farm agroforestry research
Gede	On-farm wood production and soil fertility improvement studies
Londiani	On-farm wood and fodder production and soil conservation
Karura	Processing and utilization of agroforestry and on-farm wood products

(i) AFRENA project activities

The EU-AFRENA project has been the backbone of research and development activities in soil fertility in the region since its inception in 1987. We highlight only, but a small part of the key findings during the current reporting year.

Screening of mixed fallow species

The screening of mixed fallow species trial established in September 1997 was evaluated for above ground biomass production of foliar and wood plant components. Total above ground biomass ranged from 8.5 - 13 t/ha for improved fallow species, *Sesbania sesban, Crota/aria grahamiana, Cajanus cajan* and *Tephrosia vogelii,* compared to only 5.5 t/ha for the natural fallow. *Sesbania* and *Tephrosia* species provided the largest wood component, which is appreciated by farmers as fuelwood. Mixed fallow species showed similar total foliar yields to the single fallow species except for the combination with the understorey forage legume, *Macroptilium* that

out-yielded the other combinations. Residual benefits of the fallow species combinations to follow-on maize crop, were monitored and showed a significant doubling of maize grain yields on the improved fallow, compared to natural fallow or continuous maize cropping (Fig. 1).

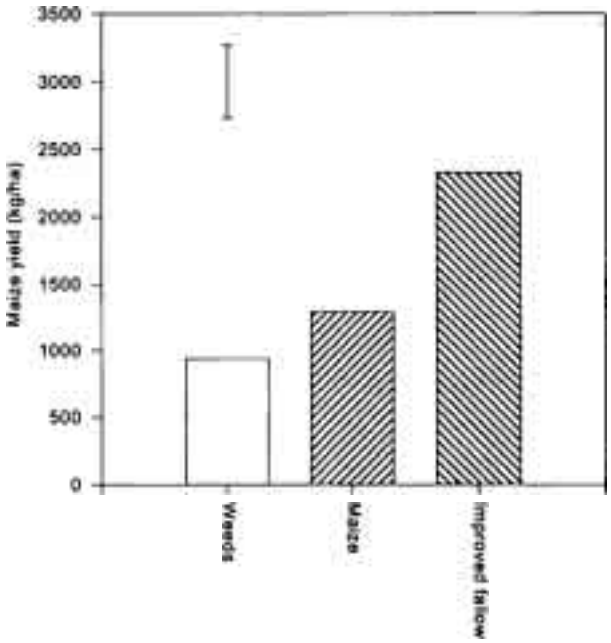

Fig. 1: Effect of improved fallow (average single and mixed species) on subsequent maize yields, compared to natural fallow (weeds) or continuous maize cropping. A bar represents standard error of mean.

(iii) Evaluation of N2-fixation using the natural ^{15}N abundance method

Significant differences in the natural 15N abundances were observed between non-N_2-fixing plants and legumes during the screening trial, thus, making it a useful tool for evaluating N_2-fixation under field conditions. Early results indicate that the leguminous fallow species contributed substantially to the overall N balance of the systems through significant inputs from biological N2-fixation. Estimates ranged from 10 to 78 % N derived from fixation (Table 2). Crota/aria grahamiana showed the best N2 fixation potential.

We therefore recommend that the choice and type of fallow species should be dictated by the maximum potential of products and services derivable as follows:

1. *Sesbania sesban* + *Crotalaria grahamiana* mixed fallow to facilitate recycling of deep soil N, high N inputs from N_2-fixation and provision of woodfuel
2. *Sesbania sesban* + *Macroptilium atropurpureum* (siratro) to maximize biomass or fodder (siratro yields up to 2 t/ha in 6 months)
3. *Sesbania sesban* + groundnut or *Cajanus cajan* + groundnut for woodfuel and protein source.

Table 2: Estimates of the proportion of N derived from N2 -fixation by different legumes (screening trial, 1998)

Species	%N derived from N_2 - fixation
Cajanus cajan	56-69
Crotalaria grahamiana	64-78
Sesbania sesban	44-59
Tehprosia vogelii	58-73
Macroptilium atropurpureum	35-52
Groundnut	33-50
Calliandra calothyrsus	10-39

(iv) Contour hedgerows intercropping

Contour hedgerows planted with agroforestry trees and shrubs play an important role in reducing loss of topsoil, particularly in the sloping topographies of the highlands. They can also be managed to replenish soil fertility in alleys for increased food crop production, such as application of leaf pruning. In the western highlands of Kenya, our past research has indicated that mineral N is moved down the profile accumulating in the deeper soil horizons. Present results indicate that hedgerows, just like improved fallow species such as *Sesbania sesban,* minimize this downward movement by capturing mineral N in the upper horizon, which is thus made available to the associated shallow-rooted food crops.

(v) Microsymbiont research

Majority of agroforestry trees and shrubs used in soil fertility improvement are nitrogen-fixing legumes. These plants are capable of converting atmospheric nitrogen into a form that plants can utilize. Nitrogen fixing trees do the conversion of nitrogen with the help of a group of bacteria known as *rhizobia.*

In the 1998/1999 report, we reported on the microsymbiont research development for fodder and soil fertility species, *Calliandra calothyrsus.* The present research activity is aimed at improving delivery of *rhizobia* inoculants to nitrogen-fixing trees and shrubs. We have demonstrated that inoculation is most effective when carried out either on seed or after germination (Table *3)*

Table 3: Effect of inoculation method, using strain KCC 17 on nodulation and of *C. calothyrsus* seedlings after 3 months of growth in Leonard jars

Method of inoculation	Number of nodules plant^{-1}	Nodule dry weight (g/plant^{-1})	Seedling height (cm)	Shoot weight (g/plant^{-1})	Root dry weight (g/plant^{-1})	Total dry weight (g/plant^{-1})
KM1 Seed inoculation	89b[b]	0.037a	13.9bc	0.312b	0.101a	0.444b
KM2 Seed inoculation	59a	0.031a	14.9cd	0.290b	0.088a	0.393b
KM3 Seedling inoculation	67a	0.034a	17.1de	0.343b	0.097a	0.482b
KM4 seedling inoculation	54a	0.028a	11.5b	0.263b	0.089a	0.381b
KM5 control	NA[c]	NA	7.8a	0.136a	0.085a	0.227a

[a] KM1, inoculation of pre-treated seeds prior to sowing in germination trays; KM2, inoculation of pre-treated seed immediately after sowing in germination trays; KM3, inoculation after 50% seedling emergence in germination trays; KM4, inoculation of seedling immediately after transplanting; KM5, control - uninoculated seedlings

[b] Values in a column followed by the same letter are not significantly different according to the Newman and Keuls test at $P<0.05$.

[c] Not applicable.

Most agroforestry practices rely on the use of nitrogen fixing trees and shrubs, but there is still remarkably little quantitative information on their contribution under smallholder conditions in the tropics. Farm forestry programme in collaboration with other research partners has just began implementing an on-farm based research project to evaluate the contribution of nitrogen-fixing trees and shrubs to nitrogen nutrition of the trees and associated crops. We are using improved fallow systems as an agroforestry system, which is increasingly being adopted by the small-scale farmers in the western highlands of Kenya. The objectives of this new research are to:

- evaluate *rhizobial* and *mycorrhizal* populations in improved fallow systems
- select optimal combinations of rhizobia, mycorrhiza and trees/shrubs for use in improved fallowing
- assess success of establishment and contribution to productivity of trees/shrubs – mycosymbiant systems under improved fallows
- assess success to establishment and contribution to productivity of crops under improved fallows.

B. Fodder production and utilization

(i) Evaluation of species and provenances for fodder production

Dairy farming is a major farm enterprise in the Central Highlands of Kenya with cattle managed under a zero or semi-zero grazing scheme. Major constraint to dairy farming in this region is the lack of high quality forage, especially during the dry season when the quantity and quality of the preferred animal feed, napier *(Pennisetum purpureum), is* drastically reduced. Research to test known and promising fodder species to identify those which can maintain high fodder productivity to meet the shortfall during the dry seasons, is being undertaken.

Over 20 fodder tree species and/or provenances are being evaluated. Results from 4 harvests of fodder, indicated that Calliandra *juzepezukii,* (Cintalapa provenance) produced close to 3-fold fodder biomass than that of the naturalized Calliandra calothyrsus (Embu provenance). Other promising species are Mimosa scabrella, Choustoniana, Acacia angustissima and Trema orientalis. A selection of the fodder species tested and their corresponding yields are shown in Table 4.

Table 4: Biomass production of various species after 4 harvests

Species	Provenance	Leafy biomass in t/ha
Calliandra jitzepezula	Cintalapa	15.4
Mimosa scabrella	Rwanda	13.6
Calliandra houstonlana	Rio Hondo	12.3
Acacia angustissima	Volcum Salvader	9.3
Trema orientalis	Embu	8.4
Calliandra calothyrsus	San Rown	7.0
Calliandra calothyrsus	Embu	5.6

(ii) Fodder for drylands

Farmers upgrading their dairy cattle to increase milk production in the marginal areas, naturally shift animal husbandry practices from extensive grazing to semi-zero or zero-grazing. This switch requires the cultivation of drought tolerant and high quality forages that can supplement the traditional low quality grasses, maize, millet and sorghum stovers.

In this study, indigenous forage species, namely, Crotalaria goodiformis (Mbeere provenance), were evaluated on-station for leafy biomass production. A cutting frequency of 2-4 times a year, depending on growth of the individual species and/or provenances, was undertaken at each harvest. Cummulative results of 3 harvests undertaken during this reporting period showed that G. sepium yielded the highest leafy biomass (1,942 kg/ha) followed by L. collinsii zacapana (1,203kg/ha) at the optimal lxlm spacing. The indigenous species, T. goodiformis yielded 478 kg/ha.

C. Wood and fruit tree research

The general aim of wood and fruit tree research is to increase the production of fuelwood, poles, timber and fruit. Thus, increasing the domestic supply and generating income for the rural households.

Participatory identification and prioritization of high value agroforestry trees

High value tree initiatives aim at introducing and promoting growing of agroforestry tree species that yield quality products for cash income generation or cost saving. Farmers and other stakeholders in agroforestry research and development are involved in planning, identification, prioritization and subsequent stages. In the present reporting period, farmers' workshops, surveys and local farmer meetings were carried out in the central highlands in order to:

- Identify high value trees and their products
- Prioritize high value trees that are preferred by farmers
- Identify problems or constraints related to the prioritized high value trees

Results of this study (Table 5) indicate that fruit trees were given a high rating by farmers because of the benefits likely to be obtained within a srelatively short time. However, availing improved planting material and processing and marketing of products, were identified as areas requiring urgent redress. An on-farm survey indicated that Grevillea robusta was preferred most with 52% of the farmers planning to plant the species in the reporting year.

Table 5: Proportion of farmers that planned to plant 5 most valuable trees on their farms in the year 1998/1999 in Central Province (Central Meru, Embu, Murang'a and Nyeri Districts)

Species	Product	% Farmers (mean of the 4 districts)
Grevillea robusta	Timber	54
Macadamia tetraphylla	Fruit	22
Citrus s pp.	Fruit	12
Carica papaya	Fruit	20
Persea Americana	Fruit	10

D. On-farm evaluation of improved mango varieties under small holder farms of central Kenya.

In the 1998/1999 annual report, results of on-station evaluation of improved mango varieties, indicated that Van Dyke and Sensation varieties yielded the highest fruit production. Results of on-farm evaluations showed that fruit production was variable even between farms within the same agro-ecological zone. However, in Embu District, the highest mean fruit yield per tree were attained by Kent and Haden varieties in zones UM2 and UM3,

respectively (season 1999/2000). In Kirinyaga District, Tommy Atkins and Sensation varieties were the best in zones UM2 and UM3 respectively, in the same season.

It was concluded that Kent, Van Dyke and Tommy Atkins are the most adaptable varieties in the 2 agro-ecological zones in terms of productivity and resistance to pests. Among these productive varieties, Kent and Tommy Atkins were also the most preferred by farmers in the region.

Similar efforts are underway in a number of centres across the country, to promote the cultivation of improved fruit tree varieties and other high value tree crops.

E. ARIDSAK Project Activities

In the marginal lands, agroforestry species play a different but, equally, important role, besides soil fertility improvement. They act as moisture conservation sites, thereby raising the potential of crop production in an otherwise water deficit environment. The main objective of Agroforestry for Integrated Development in Semi-Arid Areas of Kenya (ARIDSAK) Project is to develop, implement and promote agricultural and agroforestry technologies and policies. These will elevate the status of the resource poor farmers and pastoralists in the semi-arid areas, without adversely affecting the natural resource base. In order to reach a critical mass of on-farm tree planting for various on-farm agroforestry technologies production of agroforestry species is done at various centralized and community based nurseries. Up to 110,000 seedlings were raised and distributed within the first quarter of the reporting period.

Another important factor to development and transfer of agroforestry technologies in marginal lands is that of land tenure. As part of efforts to address this problem, ARIDSAK through diagnostic and baseline farm surveys, initiated participatory discussions with farmers and stakeholders in agroforestry and natural resource management. In these discussions the most recurring themes were addressed. Pertinent questions were: 'How are tenure problems likely to affect the implementation of promising agroforestry technologies disseminated by the project?' and 'How can agroforestry contribute to the mitigation of existing tenure problems?' Results from this study will not only have direct impact locally, but also, at the national policy level on laws pertaining to land tenure in the ASALs.

1.1. 4. Technology development and transfer

Agroforestry technologies developed on-station have to reach the end-users. It is crucial to involve and strengthen the link between farmers, extensionists, researchers and markets in the whole process of technology development.

Currently, various participatory methods are being used to involve stakeholders to ensure even greater impacts of the old and newly developed technologies to the end-user community.

1.1.5 Future Orientation

The programme will continue to emphasize demand-driven research and development. The programme will also continue to focus in the short and medium term on diversification and intensification of tree production on-farm, which will closely be supported by strategic research in marketing and processing of tree and agroforestry products.

Further emphasis will also be placed on the development of ASAL-based agroforestry technologies, largely through the initiative of ARIDSAK Project in close collaboration with SOFEM, DMP and AFRENA Embu Projects.

1.2 Natural Forests Research Programme

1.2.1 Introduction

The main objective of natural forests conservation and management are to conserve soil, water, biodiversity and to exploit in a sustainable manner, the productive potential of these forests. Kenya's natural forests, which cover an estimated area of 1.2 million hectares, have been over-exploited, degraded and are currently not managed sustainably. Limited research has been done to provide information needed to guide the conservation and management of natural forests.

Research focuses on policy issues, economic valuation, and quantification of forest conservation. This is to create a better understanding and appreciation of wood properties, monitoring regeneration and growth development of rehabilitation techniques and provide information to enhance biodiversity conservation. To improve productivity per unit area, methods for the enrichment of degraded forest stands have been tested and verified. Methods for restoration of cleared sites using indigenous tree species in mixtures have been tested and demonstrated in several sites.

Established permanent sample plots in natural forest stands have been monitored over the years. This has provided a better understanding of the development and succession processes in several representative forests. Concerns on conservation and use of unique indigenous ecosystems, mangroves, bamboo and threatened tree species, have been addressed through several research methods and tools. The impact of human activities on many forest formations and ecosystems have been studied in representative forests and sites.

Research in development efforts has also been directed to:

search for suitable approaches to enhance participatory management;
conservative and sustainable use of representative and indigenous forest, mainly in partnership with local communities to the adjacent forest.

1.2.2 Research Focus

Research in natural forests is focused on:

the improvement of natural forest productivity,
strategies to improve policy in natural forest management, methods of forest rehabilitation, and
development of technologies which encourage the planting of indigenous tree species for the production of several highly valued timber and non-timber products. In order to successfully address these concerns, community and farmer friendly approaches were used.

1.2.3 Research and DevelopmentActivities

Research and development activities which were undertaken by the programme during the report period can be divided into the following:

- Policy and legislation
- Restoration / rehabilitation
- Management
- Product development and diversification of utilization

A. Policy and Legislation

(i) International Forestry Research and Institutions (IFRI) Research Project

The International Forestry Research and Institutions (IFRI) is an international research programme whose objective is to reduce the deforestation of tropical forests. The main focus of the Programme is the analysis of both human and natural causes of deforestation and how these factors can be analysed, understood and used as a means of reducing deforestation.

It was started in Kenya in 1997 and is hosted by KEFRI as a Collaborating Research Centre (CRC). The CRC-Kenya identified three forest types that are under enormous pressure due to growing population density and people's dependency on the forest resources. These are the humid forests on Mt. Elgon and Mt. Kilimanjaro and lowland dry forests at Loima, Ramogi and Gwasi.

The aim of the Programme is to reduce deforestation of natural forests through the development and implementation of sound forest policies. Preconditions to achieve this aim are collecting, analysing, assessing, developing and monitoring biophysical and socio-economic data on factors that affect the forest condition.

(ii) Incorporation of GIS in IFRI Studies

A post-graduate forestry student from Freiburg University, Germany, was seconded to IFRI Kenya to initiate and establish GIS in IFRI studies in Kenya. The German student teamed up with a KEFRI scientist and the team was given the task of accomplishing two activities namely:

Establish and operationalize a GIS system, and
Use GIS to assess the impact of adjacent communities on Mt. Elgon Forest

(iii) Establishing the GIS system

Since the CRC Kenya had not installed any GIS software, the team approached the Head of the ICRAF GIS section to lend them the Arc-View software for use during the three months of the students', attachment.

Running of the GIS system required conversion of hard copy to digital, especially for the base maps of Mt. Elgon. The geographical information on the Mt. Elgon site was digitized from the topographic base maps by Department of Resource Survey and Remote Sensing (DRSRS). The base maps and the forest inventory maps were provided by Forest Department. DRSRS provided the Digitized Territory Model (DTM) and a photo -GIS coverage with landuse information (1999) from the aerial photographs. These were imported as an electronic version and loaded into the IFRI computer. Further processing and fine tuning was done using the Arc - View-

software. Guidelines and procedure for the whole operation were published for future use by the project.

(iv) Processing of Mt. Elgon Data

The biophysical and socio-economic database for Mt. Elgon was collected in 1998 using participatory tools with communities from forest sample plots. The data was to act as the basic platform for analysis of IFRI data base. The data was already in FOXPRO and EXCEL in a d-base IV format. The basic geographical data provided in the Arc-View attribute theme tables was then linked with the IFRI database. Tabular IFRI data was then added to digitized maps and processed to assess the impact of different user groups of the forests. Thematic maps showing the distribution of key indigenous tree species like *Teclea nobilis, Olea africana, Prunus africana,* fire occurrence and grazing, were produced (Details in IFRI/CRC - K Technical Report No. 7).

(v) Piloting of joint/ collaborative forest management strategies

During the reporting period, studies were completed in the following two sites;

- Vanga Mangrove Forest Ecosystem
- West Mau (Kedowa Block) Forest Ecosystem

The findings from the two sites indicate that due to lack of appropriate forest policy and legislation;

- Human influences continue to be the major factors in forest condition. These include laxity in forest improvement activities in the Vanga Mangrove Forest Ecosystem. In West Mau Forest the local people continue to view non-resident cultivation (NRC) as a means to produce more food than forest regeneration/improvement.
- The local people are willing to participate in forest management, but their needs and decisions must be looked into first; they need to be recognized as real stakeholders. There is a deliberate effort by the local communities adjacent to the forest, to form an association to help in forest protection and conservation
- In times of drought and other economic hardships, people turn to forest exploitation by growing other crops such as *Catha edulis* (Khat or miraa). Harvesting was heavy in West Mau in 2000 following the 1999 - 2000 drought that reduced khat production in the major producing areas of Meru (Nyambene Hills). Stone mining was also carried out in this region.
- Some forest products (medicinal plants, honey, gums), previously regarded as minor, are becoming major sources of income through commercialization.

B. Restoration/ rehabilitation activities

(i) Restoration of degraded natural forests

In addition to the rehabilitation of degraded land in the Nguriunditu Valley, about 28 hectares against the planned 24 hectares, have been planted with various indigenous tree species. Among the most important species used for rehabilitation are: Prunus *Africana, Warburgia ugandensis,* Juniperus *procera, Brachylaena huillensis, Markhamia lutea , Cordia africana, Olea europea subspecies africana and Croton*

megalocarpus

(ii) Regeneration and succession studies

The objective of the study was to determine the effects of livestock grazing on the regeneration diversity and density of some important indigenous tree species. The study was carried out in Uplands (Ngobi and Karera blocks) Forest Station in an area which is frequently grazed. The two blocks are surrounded by human settlements and the adjacent communities keep many animals, which include goats, sheep, donkeys and cows.

A lot of destruction is going on and the effects of grazing cannot be separated from other human activities. The cycle starts with cutting down of trees for various purposes, fuelwood, charcoal, tool handles, fencing posts, beehives and debarking of trees for medicinal purposes.

Four 1.5 km transects were laid in an East-West orientation. Along the transects, four 20 x 10 m plots were demarcated. Sampling for regeneration was done in these sub-plots.

Preliminary results showed that although this was previously a *Juniperus procera* forest, this species is disappearing fast due to human interference and is being succeeded by *Tarchonanthus comphoratus* and *Euclea divinorium*. The two are very aggressive colonizers. Even when mainly exploited for charcoal and firewood, they regenerate very fast through root suckers. Other species which normally occur on forest edges, but are growing inside the forest are *Euphorbia candelabrum*, *Cussonia spicata* and *Cussonia holstii*. Following disturbance arising from tree cutting, wide gaps are left inside the forest and it becomes easy for these species to germinate and develop.

A preliminary survey done in the plot, showed that grazing has significantly affected the regeneration and coppicing ability of *Olea europeae subspecies* africana, but not *Juniperus procera*. The latter species seems to regenerate better where there are disturbances due to gaps which allow light to reach the forest floor.

During the reporting period, the plots were maintained and efforts were being made to turn them into permanent sample plots.

C. Product development and diversification

(i) Bamboo production to consumption

Bamboo is a multipurpose resource with the following uses:

- Food (bamboo shoots)
- Construction material (bamboo poles)
- Handicrafts (poles)
- Ornaments (poles)
- Firewood (poles).

The bamboo case study was conducted in various parts of the country with an aim of obtaining information on the bamboo production to consumption systems. Data was

collected from primary and secondary sources. These covered aspects such as social and demographic factors of the various local communities, policy and legal issues, stakeholders' analysis, constraints, employment and income opportunities from bamboo and its related activities.

It was established that bamboo has many uses. The main uses are in:

- fencing estimated at 2.4 million culms per annum,
- construction (142,000 culms),
- supports in the flower industry (634,000 culms),
- bamboo shoots (38,000 shoots), and
- toothpicks and skewers (27,000 culms).

The other products produced from bamboo are incense sticks estimated at 7,000 culms per annum, baskets (12,000 culms) and handicrafts (1,000 culms). Low processing technology and lack of awareness on the importance of bamboo production strategies have affected the utilization of bamboo.

Local people who live in urban, peri-urban and rural areas, derive their income from various activities of the bamboo production to consumption system. These activities include harvesting and assembling, transportation, processing, packaging and marketing. Toothpick production is one enterprise that is growing very fast and uses small quantities of bamboo. Most of the raw materials are obtained from natural forests.

To develop and sustain a vibrant bamboo sector in the country, the following interventions are proposed:

- create awareness on the economic potential of bamboo resource to resource managers and policy makers, so as to catalyse policy and legislative reforms,
- implementation of KEFRI guidelines on management of bamboo, through the establishment of demonstration trials,
- improve quality of products through training and use of efficient technologies
- improve marketing of products through establishment of market information system, and
- encourage bamboo growing on farms or on government land through leases.

1.3 Dryland Forestry Research Programme

1.3.1 Introduction

The period under review witnessed the launching of the Institute's Strategic Plan (1999 - 2004). There was therefore a re-orientation and re-focussing of the various problems and activities identified in the Strategic Plan. Within the Dyland Forestry Programme, the evaluation exercise revealed that the programme, through various projects, is addressing most of the problems identified. Emphasis was therefore placed on realising the set targets, while identifying gaps to be addressed during the subsequent period.

The programme was also active in regional activities, during which a number of networks were established as a way of strengthening sub-regional/regional collaboration and hence scientific capacity in undertaking research and development.

Highlights of these activities are presented in the sections which follow.

1.3.2 Research focus

The various projects were organized into three main categories:

- Adaptive research
- Conservation and reforestation of drylands
- Management and utilization of dryland resources.

A. Adaptive Research

Social Forestry Extension Model (SOFEM

The Social Forestry Extension Model (SOFEM) passed through the midway period of its implementation phase. The project underwent a mid-term review during which it was judged favourably and a revised workplan for the remaining period developed by a joint mission from]ICA and Kenya Government. The goal, objectives and components of the project remain the same.

(i) On- Station Research

Three key experiments were carried out under this component; water catchment, mulching trials, weather monitoring and soil sampling studies.

(a) *Water catchment trial*

The objective of the water catchment trial is to determine the appropriate type of water micro-catchment structure in relation to growth of *Senna siamea.* Three types of water micro-catchments were tried, namely, W-shaped, V-shaped and square-shaped structures (ground divisions). Preliminary results of growth data (height and diameter), indicate that growth in height showed remarkable performance, where ground divisions were constructed. Where W-shaped structures were used, the performance was almost similar to the ground division structures. V-shaped structures ranked lowest in performance.

The changes earlier mentioned were observed clearly after the rains, with ground divisions and W-shaped structures showing a sharp change in growth performance. The trial shows the advantage of water catchment construction, which captures a large volume of water.

However, from field observations, the ground division type of catchments are more labour intensive to construct and repair, and their efficiency is dictated by their size, the larger the better. Therefore, W-shaped structures could be recommended since their output in terms of tree growth is almost just as good, while the cost of construction is relatively low.

(b) *Mulching trial on Senna siamea*

The objective is to study the effect of mulching on growth of *Senna siamea.* Mulching encouraged better growth performance, especially, where murram was applied as compared to either sand or control plots.

However, this situation only existed up to one and a half years, after which no significant difference was observed between the three plots. This phenomenon could imply that mulching effect may only be useful up to a certain period after planting, in this case one and a half years after planting.

Thereafter, it is possible that the roots of the trees had grown and are least interfered with in terms of water availability, due to fluctuations of the surface conditions.

(c) *Weather monitoring and soil sampling*

Thirteen rain gauges were installed in the new farms located in the four project divisions, namely: Central, Chuluni, Mutomo and Kabati. Rainfall was recorded in Tiva, Kitui Central and in some of the target farms.

Soil surveys were carried out in Tiva pilot forest and selected farms and the results compiled.

(ii) On-farm research

(a) *Seed collection and seedling production*

A total of 350 kg of seed was collected during the year and most of it was for important species such as *Melia volkensii, Azadirachta indica, Mangifera indica and Grevillea robusta.* The number of seedlings raised was 35,000 out of which 15,000 were planted or distributed to farmers. In addition, 70 grafted seedlings of mango, apple and orange were produced and distributed.

(b) *Forestry Resource Survey*

Geographical Information System (GIS) mapping of SOFEM project area was conducted in May 2000. The GIS team was led by a short term Japanese Expert, Mr. Hiata. Two KEFRI counterparts, Bernard Muok and Mr. Jared Amwatta were trained in GIS Technology. The product of the study included vegetation coverage maps of

the project area, Tiva pilot forest buffer zone of roads in pilot forest area, and administrative map of SOFEM project area, target farmers' position, including the species planted and experiments established.

The software (NTN mips Ver 6) used was installed in Kitui and a copy given to KEFRI Headquarters. The software is versatile and will enable input of information in future.

(c) *Technology transfer workshop*

A technology transfer workshop was held in Kitui in October 1999. A total of 46 farmers attended the workshop.

The topics covered in the workshop included tree establishment and management, and the role of target farmers in extension.

(iii) Farm Forestry Establishment (Extension)

(a) *Farm forestry establishment and monitoring*

Most seedlings planted performed well with average survival above 80% (June 2000). Constraints to seedling establishment included moisture stress due to drought and aphid infestation in mangoes. Rain water harvesting structures were repaired and early flowering was reported in several mango and citrus trees.

- Farm forestry design

  Farm forestry designs were carried out in 37 selected farms. A total of 2087 trees were planted. The most preferred species include Grevillea robusta, *Casuarina spp., Senna siamea, Senna spectabilis, Acacia spp., Mangifera indica, Citrus simensis* and *Persia americana*. A total of 48 target farmers and 9 field technical assistants were trained on farm forestry establishment.

- Seedling information update

  In order to assist farmers market their seedlings, a seedling information update was introduced. The information was distributed to major public places in three divisions. This was aimed at creating awareness on seedling availability and sources. The farmers were able to access the seedling sources and the producers were able to increase their sales. It is hoped that this activity will in the long-run increase seedling production by the farmers.

- Demonstration plot at Tiva

  The demonstration plot was improved by providing a facelift to the farm houses, acquisition of local and indigenous flower species, introduction of new crops, addition of a bucket drip watering unit, hedgerow planting of L. leucocephalla, earthworm rearing, fish farming and introduction of a charcoal cooler. The demo-plot continued to host several visitors and was instrumental in other programmes such as farmer-to-farmer training, in addition to being the venue for the on-job training activities for organized groups (Plate 1).

Plate 1: Farmers are trained on grafting techniques at the "demo plot"

Cost sharing

The cost-sharing scheme is going on well with the cost of polyethylene tubes, soil sieves, water storage drums and other nursery working tools being shared between the farmers and the project.

- Farmer-to-farmer training

  The project organized a two-day workshop in May 2000 for farmers selected to be involved in farmer-to-farmer extension programme (Plate 2).

(iv) Information Dissemination

Various activities were undertaken under this project component.

Study on information flow between KEFRI, Forestry Department and other Land use agencies.

The objective of this activity was to study the information flow within and outside KEFRI, Forest Department and other concerned institutions. A draft report was prepared and circulated for comments from the institutions concerned. The final report will be produced after the comments have been incorporated.

Plate 2: Demonstration during farmer-to-farmer extension

(b) Collection and analysis of publications

This involves collecting publications on social forestry extension activities and extracting useful information to create information resource base for social forestry extension. One hundred and sixty three publications were registered at the Kitui Research Centre Library. Preparation of abstracts and publications from 1998 continued.

(c) *Collection of information from farmers and extension agents*

The aim of this activity is to gather useful local knowledge from farmers and extension agents and to ensure that their views are included in the development of appropriate social forestry technologies.

Most of the information collected was on plant utilization, especially medicinal uses. Analysis and verification of this information is being undertaken.

(d) *Development of extension material*

A video on *"Miti Ni Mali"* part II that covers tree establishment practices was produced. A few copies were circulated and suggestions on its improvement received. The SOFEM Project Implementation Committee (PIC) has approved its circulation.

Plans to develop a guidebook on the propagation of Melia *volkensii* are underway.

(e) *Social Forestry Conference*

The Institute, in collaboration with Forestry Department and JICA, hosted a Social Forestry Extension Seminar for the promotion of tree planting in semi-arid areas of Kenya in September 1999. A total of 29 papers were presented and 111 participants attended, including regional course participants. The proceedings are already in circulation.

(f) *Mobile shows on tree planting*

The social forestry technology dissemination activity carried out under the SOFEM project is aimed at creating awareness on tree planting technologies to farmers, schools and other members of the dryland community. The activity involves video shows, distributing of training materials and talks on tree planting. Mobile shows were held in Kabati, Central and Chuluni Divisions in August and September 1999. A total of 1218 participants attended the shows out of which 662 were adults and 556 children.

B. Conservation and Reforestation of the Drylands

The Desert Margins Programme (DMP)

Lopuski sub-location in Kakuma Division, Turkana District and Kargi, Marsabit District, remained the focus of the DMP activities.

In Turkana District, the activities identified in the community action plan and pertinent to the projects' goal were consolidated into four main areas:

- Establishment and strengthening of the Environmental Village Committee (EVC);
- Assessment of biodiversity and regeneration potential of the Tarachi riverine forest;
- Promotion of agricultural activities as alternative source of livelihood;
- Socio-economic and indigenous knowledge systems surveys.

(a) *Environmental Village Committee (EVC)*

The EVC is an important component of the project as it provides a forum for discussing a wide range of activities with a focus on the environment. The EVC has a total of eight members with three elected officials comprising Chairman, Secretary and Treasurer with the area Assistant Chief serving as patron.

The committee has formulated rules and regulations governing the management and use of natural resources, including how it should operate. Among the responsibilities of the EVC are:

- Coordination of the activities of the owners of Ekwar and hence management of the riverine forest. Good Ekwar owners are rewarded, while those where destruction is noticed are advised;
- Selection of areas for agricultural activities, livestock and settlement to avoid conflict in resource use.

To ensure that the EVC remains strong, it was agreed that assistance to the community will be channeled through it and active members rewarded accordingly.

(b) Assessment of biodiversity

The aims of the inventory were, to document biological diversity and assess the regeneration potential of the forest. Sampling was done at both forest and plot levels. Forest sampling was done through systematic sampling by laying three plots within a transect, at intervals of 20 m from the riverbank. The forest was stratified into wet, moist and dry as represented by first, second and third plots, respectively. A total of 11 transects were laid with only 5 located within the project area.

Fifty six species, of which only 8 were trees, were recorded. The forest therefore had low biodiversity, given the few number of tree species, since other species are annuals whose presence is only assured immediately after the rains. The seedlings of common tree species accounted for a mere 1.03% of the plants. This was very low and explained the absence of lower dbh from the dbh class distribution, hence deviation from the inverse J shape for all tree species.

A gradual replacement of indigenous species by Proposis juliflora in the lower dbh category was noted, which is a clear sign of disturbed vegetation as reported for similar environment by Shaltout and Mady (1996). There was consistent general increase in mean dbh of trees away from settled areas. This could be attributed to use for subsistence or charcoal burning for commercial purposes.

The study thus revealed poor regeneration capacity of the Tarachi riverine and a possible replacement of indigenous tree species with prosopis julitlora, a scenario leading to the loss of biodiversity. Community-based interventions are thus called for, to reverse the current trend which is leading to degradation.

(c) Promotion of agricultural development as an alternative source of livelihood

Farming is the main activity that can support alternative livelihood and provide food security for a family. During the last PRA, several constraints to farming in the area were identified. However, it was not possible to tackle all of them during the period. As an initial intervention, the project decided to address the immediate needs of the community by providing crop seeds for planting during the long rains in March/April. The KARI/DMP scientist demonstrated to the farmers how to prepare the farms and seed sowing techniques.

The project provided seeds of improved varieties of sorghum and cowpeas and these were planted by the farmers. The farmers had also planted the local cultivar of sorghum, Katumani variety of maize, and green gram seeds they had acquired privately. Follow-up visits were made to monitor the progress and to advise the farmers on crop tending and husbandry.

The performance of the cowpeas was satisfactory, but significant incidence of pod borer were recorded. The farmers did not plant all the seeds of the improved sorghum provided, since they had learnt from previous projects that it was late maturing, a fact which was confirmed later by comparing the yields. The local cultivar had higher yields under both catchment and flood irrigation production conditions. The local cultivar grown, threshed more easily than the improved variety. This is a

quality worth transferring into the improved variety since the Turkana community eats sorghum raw at milk stage.

Conservation and Improvement of Scierocarya birrea

It is well recognized that the future for sustainable development of the ASALs lies in the rational use of the existing resources. Indigenous fruits present alternative opportunities. Promoting the development of fruit trees has advantages in two ways; thus, improvement of food security, through diversification of the food base and conservation of biodiversity in the drylands.

Sclerocarya birrea is one of the dryland fruit tree species that has been identified as economically important. The species is a member of the mango family with a wide distribution in Sub-Saharan Africa. The fruit has a variety of uses in different communities. A well-known product is the amarula beer, a popular fermented alcoholic beverage made from ripe fruits in South Africa and sold on the international market.

Initial work being carried out involves determination of genetic diversity, appropriate propagation techniques and establishment of a seed orchard.

(a) Results

A total of 55 leaf samples were collected for DNA analysis. The sampling represented six populations across the species range in Kenya. Additionally, four leaf samples each from one population in Mali and Malawi have been obtained.

RAPD analysis method was used to assess genetic variation between and within populations of the species. Results based on NEI's unbiased measure of genetic distance showed that Malawi population occupies the most distant position from the other populations. The six Kenyan populations were more closely related genetically than to the Malawi population. This may indicate that the Kenyan and Mali populations may be of the same sub-species.

The first phase of seed collection and germination was undertaken. Average germination rate of 49% was recorded, but further work is needed on the stage of seed collection and storage requirements.

C. Management and Utilization of Dryland Resources

(i) Indigenous knowledge system on the use and management of tree fodder resources by the Maasai community of Kajiado District

A detailed survey focussed on 30 key informants in this phase of the study compared to an initial number of 60 households sampled during the baseline survey as reported previously. The informants were selected, based on their responses recorded in the baseline survey. An interactive approach was adopted during interviews to ensure all relevant details were generated.

The following results were generated:

(a) Fodder productivity and availability

Seventy five tree species were recorded offering different parts for different livestock. These resources are particularly important during the dry season when grasses and non-woody legumes have become scarce. Seasonal availability of 8 popular fodder species are given in Table 6.

Table 6: Seasonal availability of forage/fodder of popular species

Species Botanical name	Maasai name	Parts	Season
Acacia tortilis	Oltepesi	Pods	March, July, August, September Throughout
Balanites aegyptica	Osarai	Fruits	January, February, March, October, November
Grewia tembensisi	Oriri	Dry leaves	Dry season
Acacia brevispica	Orgirgir	Pods	January
Balanites glabra	Orngu'swa	Fruits Leaves	January, February, March, October, November,
Grewia bicolour	Ositeti	Pods/fruit	March, April
Boscia anguistifolia	Oloireroi	leaves	Throughout
S. Pallida	Naibor ikunya	leaves	Wet season

(b) *Fodder preference by different categories of livestock.*

Table 7: List of popular trees and shrub species eaten by different categories of livestock

Fodder tree & shrub species		Category of livestock		
Botanical name	Maasai name	Goats/ Sheep	Cattle	Donkeys
Acacia tortilis	Oltepesi			
Grewia tembensis	Oirri			
S. Pallida	Naibor ikunya			
Grewia bicolour	Ositeti			
Comboretum molle	Ormaroroi			

Table 7: Contd.

Fodder tree and shrub species		Category of livestock		
Botanical name	Maasai name	Goats/ Sheep	Cattle	Donkeys
Maerua angolensis	Olamaloki			
Balanites aegyptica	Osarai			
Commiphora africana	Osilalei			
Commiphora spp	Enkonirei			
Boscia anguistifolia	Oloreroi			

Preferred
Not preferred

Acacia tortilis is the most popular fodder, preferred by all categories of livestock. *Boscia anguistfolia is* preferred by donkeys only (Table 7).

(c) *Effects of some fodder on livestock health (Fodder toxicity)*

A number of fodder species are known to be toxic to animals at certain stages of maturity, when eaten in large quantities or when certain parts are eaten. Fodder trees known to cause deleterious effects on animals including the stage at which they are considered to be harmful are given in Table 8.

Table 8: Fodder tree species considered by informants to cause deleterious effects on livestock health

Fodder tree species	Maasai name	Stage at which toxic	Type of animal	Extent of effect
Balanites aegyptiaca	Osarai	unripe/immature fruits	Goats	miscarriage diarrhoea
Salanitesglabra	Ornguswa	unripe/immature fruits	Goats	miscarriage
Acacia nilotica	Olkiroriti	unripe pods	goats cattle	Death Miscarriage
Acacia tortilis	Oltepesi	immature	Goats	Miscarriage

(ii) The economic value of wood carving timber in Kenya

During the reporting period, data was generated on; volume of timber entering the market, prices, rules of access to carving wood and modeling of investments in the growing of neem and muhugu.

(a) Volumes of carving timber entering markets

The volumes of the wood carving timber were monitored at seven major carving centres in Kenya, namely Nanyuki, Wamunyu, Gikomba, Makindu, Malindi, Mombasa and Lungalunga. The volumes from July 1999 to June 2000 are given in Table 9.

Table 9: Volume of timber entering various markets

	Volumes Supplied m^3		
Carving centre	Brachylaena	Other species	Total
Nanyuki	15.1	51.5	66.6
Wamuyu	710.6	359	1069.6
Gikomba	115.6	486	601.6
Makindu	-	70.1	70.1
Malindi	370	395.1	765.1
Mombasa	850.5	2189.1	3039.6
Lungalunga	1833.6	64	1897.6
TOTAL	3894.8	3550.8	7509.6
%	51.8	48.2	100

During the review period, *Brachylaena huillensis* was found to dominate the carving industry in Kenya, constituting 51.8% of the volumes supplied to the markets.

(b) *Prices of wood carving timber entering markets*

There was a general rise in prices of carving wood from 1998 - 2000. This was due to the scarcity of the wood which has continued to be depleted with time. The highest price unit was observed for Dalbergia wood. Table 10 gives the unit prices of timber from 1998-2000.

Table 10: Prices of various timber species entering the market

Species	**Unit price (Ksh./M^3)**			
	1998	**1999**	**2000**	**Mean**
Branchylaena huillensis	*3,874*	*5,405*	*6,232*	*5,170.4*
Olea europea sp. africana	*5,858.7*	*6,362*	*7,545*	*6,588.9*
Dalbergia melanoxylon	*12,770.4*	*13,375*	*14,401*	*13,515.7*
Terminalia brownii	*3,146.8*	*3,081.4*	*4,825.4*	*3,684.5*
Jacaranda mimosifolia	*3,377.3*	*3,253.9*	*4,814.3*	*3,815.2*
Combretum molle	*6,358.7*	*7,287.9*	*7,672.4*	*7,106.3*
Neem	*2,109.8*	*2,648.2*	*6,790.7*	*3,849.6*
Mango	*2,139.7*	*2,190.6*	*2,464.9*	*2,784.4*
Spirostachys spps	*4,555.6*	*4,502.7*	*5,224.2*	*4,760.8*
Afzelia quanzensis	1,121	1,063.8	2,932	1,706.6
Diaspyros spps	5,439.2	5,234.7	4,717.2	4,770.2

(c) *Rules of access to carving woods*

Forestry legislation in Kenya is fairly comprehensive, but spread over various acts, which are administered without coordination by a wide range of public bodies and individuals. The lack of coordination in their enforcement has given rise to serious loopholes, which various individuals have taken full advantage of to obtain the carving

wood illegally. These policies are being reviewed as part of this study and appropriate recommendations are proposed, particularly on areas relevant to woodcarving, so that the industry is sustained. Details of the recommendations will be contained in the project report which is now in preparation.

(d) *Modelling of Investments in the Growing of Azadirachta indica and Branchylaena huillensis*

One feasible way to change the destiny of the Kenya woodcarving industry is by changing the sourcing of carving wood from unsustainable felling of slow growing hardwoods to sustainable sourcing from alternative on-farm cultivated fast growing tree species. The study has modelled these investments based on cultivation trials of these species in Kenya. The results show that *Azadirachita indica* has a very high potential for on-farm production and can be used for curving at the age of 17 years having a diameter of 16 cm. Clear felling of a neem plantation (financial rotation) can be carried out when the plantation is about 36 years old, when the diameter is about 48 cm. The study has also established that the slow growth of *Branchylaena huillensis is* the main limitation to its commercial growing on short to medium terms. This slow growth of B. *huillensis is* a reason to use the existing *Brachylaena* resources more carefully and economically, if future supply is to be assured.

D. Other Forestry Development Activities

(i) Networks

Networking has become a common means of pooling limited resources together in addressing common research concerns and issues in this era of globalization and liberalization. Recognizing the need to strengthen national institutions and promote networking, a number of regional networks have recently been established. The programme played an active role in the establishment of two regional networks;

(a) *FORNESSA /AFREA*

Forestry Research Network for Sub-Saharan Africa (FORNESSA) is a Federation of Forestry Research Institutions from 44 countries in Sub-Saharan Africa, which are members of three sub-regional forestry networks:

- The Association of Forestry Research Institutions in Eastern Africa (AFREA), representing 10 countries
- Forestry Network in West and Central Africa (CORAF), with 20 member countries
- Forest Research (SADC-FSTC), representing research institutions in the 14 SADC states.

FORNESSA was formally established and inaugurated on 7 July 2000 at the FAO Regional Office for Africa in Accra, Ghana, with the support of the FAO/EC partnership project on sustainable forest management in African ACP countries. It has a steering committee comprising nodal coordinators from the three nodes, a Chairman appointed from one of the three nodes (on a two-year rotational basis) and a Secretary. The current Chairman is also the incumbent Chairman of AFREA, while the Secretary is the Deputy Coordinator of IUFRO-SPDC. The Secretariat is hosted at FAO Regional Office in Accra, Ghana.

FORNESSA's goal is to strengthen forestry research for greater impact on the management and conservation of forest and tree resources for sustainable development in Sub-Saharan Africa. To accomplish the goal, the network has set out the following objectives:

Support sub-regional networks in sub-Saharan Africa in strengthening the capacity of their forestry research institutions
Foster cooperation in forestry research in the region
Articulate and advocate African forestry research agenda and development issues in global fora.

As mentioned earlier AFREA is the Sub-regional component of FORNESSA. To fulfill FORNESSA's goal, it has set out the following objectives:

strengthen forestry research institutions in Eastern Africa
raise awareness of the importance of forestry research for development
improve the impact of forestry research on development, and
promote regional collaboration.

AFREA has a steering committee comprising heads of forestry research institutions of member countries. A chairman on a rational basis of 2 years chairs the committee. A Secretary handles the day-to-day activities. The current Chairman and Secretary are from KEFRI.

(b) *NGARA*

The Network for Natural Gums and Resins (NGARA) is a network established to assist African countries and partners develop a system of sustainable production, marketing and improvement of natural gums and resins to international standards. The network is to promote the relationship between primary producer, processor and consumer. It should harness the opportunities inherent in these resources and commodities as well as additional opportunities available elsewhere, to develop an effective strategy for supporting livelihoods of the rural communities in producing countries.

NGARA was formally established in May 2000 with a Secretariat hosted by KEFRI. It has a current membership of 10 gum and resin producing countries through national contact points, but this will be expanded to include all African producing countries. The network's goal is to position African producer countries and partners as major global players in the production, processing and marketing of gums and resins.

To address this goal, NGARA has developed three clear objectives to:

- promote exchange of information on production, marketing, processing and quality control among producer countries as well as partners
- facilitate access to technological development and training
- undertake resource survey and data collection.

The activities of the network are formulated and overseen by a steering committee comprising representatives from four focal points (western, central, eastern Africa and SADC member countries), experts on quality control and marketing, the Secretariat and international observers represented by FAO and International Association for the

Development of Natural Gums (AIDGUM). The network expects to sustain its operations through;

- sourcing funds from governments and private sectors locally and internationally
- generating income by offering services and selling technology, where applicable
- establishing strong and committed membership.

(ii) Tiva Management Plan

Tiva Research Station, under Kitui Regional Research Centre has been the lead station for the development of a wide range of technologies for dryland forestry since 1985; thanks to the collaboration between the governments of Kenya and Japan. The technologies developed have made the Station a centre of excellence in dryland technologies. The status of the station was strengthened in 1997 when some 1050 hectares were officially given to KEFRI by the Kitui County Council for research and development. To preserve the technologies developed and transform the station into a model demonstration site, the KEFRI Board of Management recommended development of a 10 years management plan.

A draft management plan was prepared and is being refined.

1.4 Forest Plantations Programme

1. 4.1 Introduction

This was the second year of restructuring and research activities started gaining momentum as ways and means of implementing the programme continued to be streamlined. As the main objective of the programme is to meet the country's demand for industrial wood, the problems identified by stakeholders were kept in mind, while implementing and discussing future research projects to address the problems. The problems identified were: Inadequate supply of high quality propagation material, low rate of replanting in harvested areas due to poor application of silvicultural practices, reliance on a few exotic species, which are being threatened by pests and diseases; and inefficient use of wood. Various projects were undertaken concurrently to address these problems and achievements are summarized later.

1.4.2 Research Focus

The research focus in the year under review was as follows:

- Collection and analysis of data from progeny trials for use in the establishment of seed sources of various species, so as to improve the supply of genetically improved seed;
- Importation of genetically improved material from other countries for broadening the genetic base of plantation tree species;
- Collection and analysis of data from species and provenance trials for diversification of plantation species;
- Establishment of trials for identifying the most economical way of plantation establishment;
- Use of biological control and monitoring to reduce damage due to pests, especially cypress aphid.

1. 4.3 Current Research Projects

A. Plantations Development

(i) Promotion of Sustainable Forest Management Project (PSFM)

The project was started in 1994 and funded by the Government of Kenya (GoK) and the Federal Republic of Germany through GTZ. The funding by GTZ was stopped in 1998. Most of the activities of the project, however, continued to be implemented through GoK funding and later minimum funds were released by GTZ for some activities. Although funding from GTZ was finally stopped in November 1999, the project continues to be implemented through GoK funding.

The project is multidisciplinary, encompassing, Silviculture, Ecology, Tree Improvement, Forest Mensuration, Social Economics and Agroforestry. Initially, 27 activities were undertaken and some have already been completed. The following research was undertaken during the period under review.

(a) Nursery experiments

Raising of healthy seedlings is one of the most important activities for successful establishment of plantations. If unhealthy seedlings are used for establishing plantations, the chances of survival are minimal as they may not be able to withstand harsh conditions such as weed completion and drought in the field. With the current tough economic conditions, it is also important to consider the cost of raising seedlings. To address some of these issues, a nursery experiment was undertaken and completed during the year under review.

The study was on optimum sowing density of seeds so as to minimize wastage in terms of seeds and space and also produce healthy seedlings. The study involved sowing seeds of C, *lusitanica* and P. patula in Swaziland beds at densities of 625, 400, 278 and 156 seedlings per square metre at Muguga.

Results showed significant differences among treatments for both species with densities of 204 seedlings per square metre showing the best performance, while those at 156 were the worst (Tables 11 and 12). However, considering the space utilized, the cost of raising seedlings and the health hazard that may be caused, the best density was 278 seedlings per square metre. Other densities of 204 and 156 produced good strong growing stock, but the space was underutilized, while densities of 625 and 400 seedlings per square metre produced overcrowded and weak seedlings.

It is therefore recommended that the sowing density for C. *lusitanica* and Pinus patula should be 278 seedlings per square metre in Swaziland beds.

Table 11: Mean height and survival of C. lusitanica sown at different densities at Muguga

Density of Seedlings/m^2	Mean Ht (cm)	Mean Survival (%)
625	31.7 a	60.0
400	30.1 b	70.0
278	31.7 a	78.0
204	34.2 c	57.0
156	30.2 b	80.0

(b) *Effects of different site preparation, on growth and survival of planted seedlings*

As a result of the current issues arising from the use of the shamba system for establishment and tending of plantations, especially on government land, it was found necessary to identify methods to be used that could be cost effective, with high survival and growth rate. As C, lusitanica is the major plantation species in Kenya, a study was undertaken in Uplands with the main aim of developing suitable site preparation and tending methods that can lead to higher survival at minimum cost.

Table 12: Mean height and survival of Pinus patula sown at different densities at Muguga

Density Seedlings/ M^2	Mean Ht (cm)	Mean Survival (%)
625	*29.4* a	*61.6*
400	*26.7 b*	*78.3*
228	*29.6* a	*61.5*
204	*26.6 b*	*57.6*
156	*24.6c*	*80.0*

Note: Treatments with the same letter are not significantly different at 5% level.

The site preparation methods (main treatments) used were:

(a) slash entire plot
(b) strip cultivation, one metre along the planting line
(c) total cultivation
(d) spot hoe, one meter around planting spot and slash entire plot
(e) control

The tending methods sub-treatments were:

(i) control
(ii) spot hoe, one metre around the tree and slash whole plot
(iii) slash whole plot
(iv) total cultivation

From the results in Table 13, seedling establishment was best when all the site preparation methods (main treatments) were in combination with sub-treatment 4, which was total cultivation. The best combination for the highest growth rate was C4 (Table 13), where both the site preparation and tending methods were total cultivation. The mean height for this combination was 5.7. The worst combination was A2, where entire slashing and spot hoeing were used for site preparation and tending, respectively and the mean height was 2.9m (Table 13). Mean survival for all treatments was medium to high.

(~) *Delineation of provenances of P. kikuyuensis and P. fulva*

Polyscias kikuyuensis and P. *fulva* are members of the Araliaceae family. The genus Polyscias contains some of the fastest growing indigenous tree species in Kenya; P. *kikuyuensis and P. fulva* being the best known examples. These species are economically and environmentally important in Kenya, but their potential has not been fully exploited.

Table 13: Mean height for a combination of five site preparations and four tending methods **for C, lusitanica** at the age of 4 years

Site Preparation Treatments	Tending Treatments				
	1	2	3	4	Mean
A	3.6	2.9	3.5	5.6	3.9
B	3.8	3.7	4.5	5.4	4.4
C	4.6	4.9	4.9	5.7	5.0
D	3.7	3.8	4.8	5.4	4.4
E	3.0	3.4	2.9	5.3	3.2
Mean	3.1	3.7	3.4	5.5	4.2

Both P. *kikuyuensis and P.* fulva occur in the wet upland forests. P. *kikuyuensis is* believed to be endemic to central Kenya and P. fulva to the region west of the Rift Valley and also in some parts of central Kenya. However, information on their distribution and specific locations is fragmented and in general largely lacking. Taxonomically, the distinction between these species is also not explicitly understood and therefore both names are used interchangeably in reference to either species. This confusion applies to the seeds of the species collected and distributed by the Kenya Forestry Seed Centre. Urgent action to generate reliable and correct information on their distribution and taxonomy, in order to diffuse the current confusion, is therefore essential.

Furthermore, as in most of the tropical forest tree species, little is known about the flowering, seeding phenology and in general, the reproductive biology of both P. *kikuyuensis* and P. fulva. It is therefore essential to generate this information as a management tool and to support any current or future effort on domestication and both in-situ and ex-situ conservation. Variation also occurs in the flowering and seeding phenology within a species across its geographical distribution. Thus, for any comprehensive knowledge about flowering and seeding phenology of any one species, the variation across its natural range should be determined.

To address these issues, a study was undertaken to determine the distribution of Polyscias spp. The study involved spot check surveys throughout the country, except for a small section of the Central Rift Valley. The spot check surveys were done after analysis of questionnaires sent out and also information gathered from the herbarium on these species.

The objectives of the surveys were:

(k) To collect information on occurrence of Polysclas spp. and environmental characteristics of the area of their occurrence
(l) To collect the missing data in the information already supplied through questionnaires
(m) To establish the specific localities of the two Polyscias spp, and whether they occur naturally or artificially.

Table 14 shows the distribution of P. fulva and P. *kikuyuensis* in Kenya. It is only in the Tugen Hills, where confirmation should be made as to which of the two species occurs.

The study on the phenology of P. *kikuyuensis* and P. fulva was to generate reliable information on the flowering and seeding of the naturally occurring population of P. *kikuyuensls* at Kinale and of an introduced population of P. fulva at Uplands.

This study commenced in May 1997 and was planned to take four years. The study area was located on the eastern slopes of the Abardare ranges. This area falls under the natural distribution range of P. *kikuyensis,* but is outside the natural range of P. fulva.

The P. *kikuyuensis* population studied was located at Kinale Forest Reserve where the mean annual rainfall is 1200mm, mean temperature is 14°C and altitude is 2560m above sea level.

The P. fulva stand was under a mixed hardwood species plantation at Upland Forest Reserve which has a mean annual rainfall of 1400mm, mean temperature of 14.5°C and an altitude of 2438m above sea level.

To date, results on reproductive phenology show that *P.kikuyuensis* trees at Kinale form flower buds in the months of November and December. Flowering and seed formation takes place from January to March. Seed maturation comes in the months of April to June and seeds are shade /dispersed from May to August. Generally, the period between August to October is a resting period. However, slight variation to this reproductive calendar has been observed. In some years, for example 1998, though the process of flowering and seed formation took place normally, all the seed were shed prematurely. Also, not all trees come to seed in any one particular year.

In the majority of P. fulva trees, flower bud formation starts in May and reaches a climax in August and September. The flower and seed formation has been observed to increase from August to December. Seed maturation and dispersal (dropping) occurs between December and April, unlike P. *kikuyuensis,* where there is a distinct resting period. However, individual trees appear to have a resting period, which varies from year to year. Another interesting observation is that throughout the year, it is possible to find different individuals at different reproductive stages. This could be explained by the fact that as an exotic to this area, P. fulva has not yet completely adapted to the new environment. The seeds used in this plantation could also have been from different provenances or this is the normal flowering pattern for this species.

Table 14: Distribution of *Polyscias kikuyuensis* and *P. fulva* by forest areas in Kenya

Species	Forests or Forest Area of Distribution	Remarks
P.fulva	West Mau, North-West Mau, South Mau and Western Pulsimoru	*Natural Forest*
P.fulva	Kakamega and Malava	*P. fulva* in Kakamega Forest exists both in natural forest and also in plantations
P. fulva	Nandi Hills Forest along the Nandi Hills Escarpment	Natural forest; Some commercial exploitation has been reported in some areas
P. fulva	Western Charangani Hills, Saiwa National Park, and around Kapenguria	Natural forest
P. fulva	Mt. Elgon, (Swarm)	Plantations only No *Polyscias* observed in the natural forest
P. fulva	Aberdares (Zaina Uplands)	Plantations
P. fulva	South Marmanet Forest	Plantations
P. fulva	Mt. Kenya (Ragati)	Plantations (firebreak between hardwood plantations)
P. fulva?	Tugen Hills	*P. fulva* was reported to occur but should be confirmed
P.kikuyuensis	Southern and Northern Aberdares	Natural forest and a few scattered plantations
P.kikuyuensis	Mt. Kenya	Natural forest and a plantation at Ragati
P. kikuyuensis	Marmanet Forest	Natural forest
P.kikuyuensis	Mau East	Natural forest
P.kikuyuensis	Eastern Cherangani Hills	Natural forest
P.kikuyuensis	Along the Elgeyo Escarpment	Natural forest
P.kikuyuensis	Lembus and Tinderet	Natural forest
P.kikuyuensis	Nyambene	Reported to occur here by National Museums of Kenya

(n) Regeneration of Ocotea usambarensis through roots and stem cuttings

Ocotea usambarensis is a very valuable hardwood timber species in Kenya. It grows in the wet highland forests of eastern Aberdares, Mt. Kenya and it has also been reported to grow in Taita Hills (Wimbush 1950, and Dale and Greenway, 1961). This species is classified as endangered due to high exploitation pressure and difficulties in natural regeneration. It has been observed that it produces useful seeds once every ten or so years (Kigomo, 1987) . However, majority of such seeds are dropped pre-maturely due to attack by gallfly. This problem is so acute that since the inception of Kenya Forestry Seed Centre in 1985, no collection from this species has been possible. In order, therefore, to save this species from extinction, other means of regeneration should be studied, understood and exploited for the conservation and even domestication of this species. Vegetative propagation is one way of ensuring the regeneration of this species and studies undertaken have been on rooting of stem cuttings and also regeneration by roots.

Through previous studies, suitable vegetative propagation technologies were developed to root O. *usambarensis* stem cuttings cheaply and effectively. In the year under review, the already rooted cuttings were used to establish a hedge at Muguga. The objective of this was to develop management practices for the hedge, which will then form an important source of stem cuttings for further experimentation on rooting of cuttings for mass propagation.

The experiment on regeneration of O. *usambarensis* using roots was carried out at Mt. Kenya and Aberdare Forests on standing trees and stumps. The results showed that exposure of roots on stumps increased the rate of root swelling differentiation into shoots.

Such differentiation was not apparent on roots of standing trees. However, a low number of stumps and trees were available for use in the study and there was trampling by humans and livestock. More work will be undertaken in disturbed and undisturbed sites within the natural range of *Ocotea usambarensis*

(o) Evaluation of Pro venances of Casuarina equisetifolia

Seed from the two best provenances identified in trials were received from CSIRO and issued to Gede Centre for propagation. The best provenance will be retained as a seed bank.

(ii) Seed Stands and Seed Orchards Development

(a) *Seed orchards expansion for P, patula and C. iusitanica*

The current supply of genetically improved seed of P. *patula* and C. *lusitanica* in Kenya does not meet the demand for seed for the establishment of commercial plantations by the clientele. To address this problem, a project aimed at expanding the current hectarage of seed orchards was initiated. This project aims at selecting outstanding trees of each species using data from existing progeny trials, collecting scions from these trees and raising 1,500 grafts for use in establishing seed orchards.

To date, 30 plus trees of C. *lusitanica* have been selected and it is planned that at least 50 grafts will be raised for each tree for use in establishing seed orchards. Grafts have already been raised for some of these trees. However, due to the prevailing drought, no grafting was done during the main grafting season of April, May and June 2000. This has adversely affected the 2000/2001 planting programme, which will now be delayed by one or two years, depending on whether suitable grafting conditions will occur.

(b) *Establishment of Do vyaA5 caffra seed stand*

The demand for D. *caffra* seeds is very high and the current supply falls short of demand. In addition, no seed production areas have been developed for this species. Although general collection of seeds is done from hedges located in various sites, these hedges are regularly trimmed, thus, keeping most of the branches in a juvenile state and out of seed production. There is need, therefore, to establish stands for seed production for this species.

Use of grafts shortens the life cycle. Thus, seed from grafted trees may be harvested earlier than those from ungrafted trees. However, the most suitable method for raising grafts has not been developed.

An experiment was set to determine the most suitable grafting method and the treatments (different grafting methods) included: - top cleft, side veneer and whip and tongue. Each treatment was applied on a set of 12 seedlings in three replicates. The grafted seedlings were kept in a non-mist propagator for a period of 8 weeks, after which they were removed and kept under 75% shade. The progress on survival was closely monitored and final data was collected after 20 weeks. Table 15 gives a summary of the grafting success in *D. caffra* using different grafting methods

Table IS: Survival of grafts for the different grafting methods

Type of Grafting	Success (%)
Whip and tongue	31%
Side Veneer	5.4%
Top cleft	2.7%

From the results, the whip and tongue grafting method was found to be the most suitable in *D.caffra.* It will, therefore, be exploited to raise grafts for seed stand establishment.

In addition, to determine the most suitable grafting method, two thousand seedlings were raised as rootstock for grafting.

(c) *Introduction of new germplasm of E, grandis and P, patula and establishment of seed stand using improved seed from Zimbabwe*

Improved seeds from seed orchards and selected seed stands were received from Zimbabwe and distributed to the following centres for establishment of seed stands: Londiani, Muguga (Muguga Estate and Muguga Centre - Kinale, Kamae and South Kinangop), Nyeri and Kakamega. It was planned that each centre would receive a small portion of seeds for planting several hectares over a period of years as it was not possible to establish these stands in one year. Unfortunately, apart from Muguga

Estate, all centres recorded poor germination of both *E, grandis* and P. patula, probably due to poor germination media and low temperatures. For example, in Nyeri, it was reported that germination per cent was high, but seedlings started dying soon after germination. Investigations revealed that this may have been due to frost. Muguga Estate recorded low germination for seeds sown in the open, but high germination for those sown in the green house. In Turbo, Kakamega and Muguga Centre, forest soil was used instead of sand as the germination medium and this may have caused the low germination percentage. More seeds have been issued to these centres, and it is hoped that higher germination percentages will be recorded. Sand will be used as germination medium and seeds will be germinated in green houses whenever possible.

The following are some of the activities that continued in these centres:

In Turbo Sub-centre, the 1045 seedlings raised were combined with the 474 raised in Kakamega to establish approximately 1.3 ha of plantation in May 2000 in Turbo Compartment 2(K) at 3 x 3m^2. Survival count will be done next year

A total of 92 g of the same seeds were received in Turbo and sown for raising seedlings to be used in expanding the seed stand. Germination per cent was reported to be high after using pure river sand as the germination medium.

In Nyeri, seedlings of P. *patula,* enough to establish about 1 ha of seed stand, are available in the nursery. Planting will take place during the short rains. Germination per cent of *Eucalyptus grandis* was too low in both Nyeri and Muguga Centre and seedlings raised were not enough to establish a seed stand.

In Muguga Estate, 5 ha of *E. grandis* seed stand was established. Survival rate was, however, below 30% due to the drought experienced countrywide.

(d) *Seed stand recruitment*

Three Cupressus *lusitanica* seed stands were recruited; two stands at Mt. Kenya region and one at the Aberdare ranges. In addition, two Vitex *keniensis* seed stands were recruited at Ragati Forest Station. Management plans of these stands will be drawn next year.

(iii) Industrialized Countries-Developing Countries Cooperation (INCO-DC) Seedling Project

This project began in September 1997 and ended in October 2000. It was under the auspices of the INCO-DC Programme funded by the European Union. The project had ten partner organizations, five from Africa (Kenya, Namibia, Tanzania, Zambia and Zimbabwe), and five from Europe (Germany, Portugal and three partners from Finland). The project aimed at changing the research of the partner organizations in the fields of planting, stock production, growth, yield, establishment and management of plantation forests.

The three fields of research were, nursery management, growth and yield studies

During 1999/2000, the following was accomplished:

(a) *Nursery Management*

A review was made on the current state of nursery practices in Kenya and the following was noted:

The history of seedling production in Kenya dates back to 1907 when the first forest plantations were established. However, systematic research was not initiated until 1951 when the need for standardized nursery procedures was realized by the East African Agriculture and Forestry Research Organization (EAAFRO). In 1962, seedling production guidelines were published in EAAFROs Technical Note. In the recent past, the number of seedling nurseries has increased in order to cope with diverse forestry and amenity needs. However, the quality of planting stock is also very diverse. Therefore, the need for seedling quality control has been recognized, but is constrained by the large number of nurseries involved in seedling production, even in the case of the forest plantation nurseries. Amalgamation of nurseries with similar objectives is one of the proposed approaches for improving seedling quality, since it is economically viable to study few nurseries and set appropriate seedling standards for them. The areas requiring immediate research attention were:

- identification of superior genotypes for commonly grown species
- identification and adoption of appropriate seedling preconditioning techniques
- seedling nutrition studies.

(b) *Growth and yield studies*

Cupressus lusitanica and Pinus patula are the major plantation species in Kenya constituting about 80% of forest plantations. These species have been mainly established by raising seedlings in the nursery and transplanting them in areas already prepared by farmers under the shamba system. The realization that the shamba system, the most commonly used method of establishing forest plantations in Kenya, may not be sustainable in the long run, has made stakeholders to seek for tested alternatives to the shamba system, for establishing forest plantations. Coupled with labour constraints in the Forest Department, the use of the shamba system in plantation establishment is becoming unsustainable. In addition, the high mortality of transplants has resulted in an extremely low rate of plantation forest establishment.

Trials were established in Londiani in 1998 with the main aim of developing guidelines on the management of natural regeneration for establishing plantations.

The specific objectives were:

- to establish the most appropriate age and height at which to select and thin the regenerates; to obtain optimal spacing for the selected trees
- to recommend other silvicultural procedures that could be unique to naturally regenerated stands.

Based on these trials, it was shown that it is possible to establish stands of cypress and pines through careful management of natural regeneration.

Guidelines on establishing plantations using natural regeneration of P. patula and C. *lusitanica* have been developed using interim results from these trials. Critical factors necessary for using natural regeneration for establishing plantations were noted as follows:

- There should be good natural regeneration, above 1600 per hectare
- Commercial thinning of the previous plantation should leave only superior trees to act as parents of the regenerates
- Fire must be kept out of the stand as much as possible to avoid damage to the regenerates
- First cleaning should be done at a mean height of between 1.5 and 2m
- The selected seedlings should be pruned to half height and spaced as 2.5 x 2.5 m
- Subsequent silvicultural procedures should follow those contained in the technical orders.

At the moment, however, this method of establishment is only possible in high altitude areas where the natural regeneration of cypress normally occurs. Occurrence of a suitable natural regeneration, even in these high altitude sites, however, depends on the timing of harvesting and the impact of the chosen harvesting method on the physical and biological attributes of the site. This stand establishment method is fairly cheap, compared to the traditional method that involves raising seedlings in the nursery and eventually transplanting them in the field. Nonetheless, one major drawback is that the method can only be used for one or two rotations, as genetic depression may render subsequent generations inferior.

(iv) Genetic improvement of *Eucalyptus grandis*

This project commenced in March 2000 in collaboration with Forest Department and Mondi Forests, South Africa. The project is funded by GoK and Gatsby Foundation (Britain). It aims at introducing and testing improved clonal material of *Eucalyptus grandis X E. tereticornis* and E, *grandis X E. camaldulensis* hybrids from Mondi Forests, selecting the best material and establishing clonal seed orchards to be used for supplying clonal propagation material to end-users. At the same time, outstanding trees will be selected from local material of *E. grandis, E. tereticornis* and *E, camaldulensis* and used for establishing progeny trials, results of which will be used for establishing seed orchards. The selected trees will also be used for other breeding activities.

To date, selection of outstanding trees has commenced and plans to import material from S. Africa are at an advanced stage.

B. Integrated Pest Management

(v) Biological Control of Cypress Aphid

(a) *Cypress aphid parasitoid monitoring activity*

The monitoring of cypress aphid and its parasitoid, Pauesia *juniperorum* continued to be carried out on the strategically located permanent sample plots (PSPs) countrywide. Table 16 shows the list of PSPs, where sampling has been going on.

Table 16: List of PSPs where sampling has been undertaken

Region	Compartment	Plot Size
Kiambu	Muguga IIBC	20R x 20T
	Muguga Resistant	20R x 20T
	Kinale 4K	20R x 20T
	Keriita 1L	30R x 30T
Nyandarua	Kiamweri 4D(Njabini)	20R x 20T
Mt. Kenya	Gathiuru 2V	20R x 20T
Londiani	North Molo (Mau Summit 50)	20R x 20T
	Makutano 4C	20R x 20T
Turbo	Kaptargat	20R x 20T
	Turbo Ex. 1H	20R x 20T

The main objectives of monitoring was to find out the impact of the biological control agent. The impact will later be assessed through:

- the population trend of cypress aphid
- the abundance/density of the parasitoid, P. *juniperorum*
- the trend of damage on the host tree species

The PSPs were sampled for:

- cypress aphid population trend;
- the parasitoid abundance; and
- host tree damage levels once a month.

However, those PSPs located in Kiambu region were sampled twice a month, as more detailed data will be collected to provide more information that will assist in the interpretation of the data collected from other PSPs countrywide.

(a) Countrywide survey of parasitoid

The countrywide surveys of *P. juniperorum* continued to be carried out. The objective of the surveys was to monitor the cypress aphid population trend as well as the damage level. This was carried out in major host tree species where there are no PSPs.

During the reporting period, surveys were carried out in Mt. Elgon/Turbo region in the months of October 1999 and March 2000. In October 1999, the Mt. Elgon/Turbo surveys revealed that the parasitoid had not spread to this region, and thus a release of the parasitoid was made in the area in March 2000. In July 1999 a survey was carried out in Mt. Kenya region and the parasitoid was found to be well established. The aphid population trend, the parasitoid abundance and damage levels, continue to be monitored through a PSP located at Gathiuru Forest Station.

(b) *Release of Pauesia juniperorum*

Releases of the mass-reared and locally-adapted strains of *P. juniperorum* have been carried out in certain parts of the country. The objective of the releases is to hasten the spread of the parasitoid to all major host tree growing areas.

During the reporting period, a total of 1776 paired (male and female) individuals of locally reared p. *juniperorum* were released in specific sites in Kenya. Table 17 shows the date of release, the sites, and number of paired individuals that were released in different areas.

(c) *Mass rearing of P. juniperorum*

Mass rearing of locally adopted *P. juniperorum* strain continued to be carried out in the two insectaries at Muguga and Londiani. The objective of this activity was to provide the parasitoid populations to be released in areas where it has not been found, as this helps to hasten the spread. During the reporting period, about 2000 paired individuals of the parasitoid were reared and over three quarters released in the field.

Plans are at an advanced stage to supply the parasitoid to Mauritius and Tanzania.

A technical bulletin on the techniques of rearing *P. juniperorum will* be published soon.

Table 17: Date of release, sites, and number of paired P. *juniperorum* individuals that were released in different areas

Date of release of parasitoids	Sites	No. of pairs released
16 Dec. 1999	Keriita Forest, Kiambu region	95
17 Dec. 2000	University of Nairobi Forest,Ngong	272
1-2 March 2000	Kisima Farm Forest Timau/Nanyuki Region	504
22 -23 March 2000	Mt. Elgon region (a)Kimothoni Forest (b)Kiptogoti Forest (c) Saboti Forest	 275 260 220
12 April 2000	Turbo Forest–	250
Total released		1776

(vi) Black blister disease of *Casuarina equisetifolia*

Following reports from the coastal region of attack and death of C. *equisetifolia* trees, a survey was done in Malindi and Kilifi. Results of the survey showed that the disease was widespread in both plantations and farms. The fungus, *Trichosporium vesiculosum* was isolated from the plant tissue. A more detailed survey and a study of this disease will be undertaken.

C. Plantation Species Diversification

(i) Bamboo germplasm project

The main project objective was to introduce bamboo species from outside Kenya for establishment in several ecological zones and monitor performance of the trials. Performance of the introduced species have been followed and several reports and papers produced earlier.

No assessments were carried out in the trials for the year under review, and only routine maintenance of the plots was undertaken at the various trial sites located at Gede, Jilore, Muguga, Nyabeda and Kakamega.

D. Structural Timber Testing

(i) Efficient use of plantation grown timber

This project was a follow-up on an earlier study on derivation of permissible design stresses using small clear specimens of cypress and pines. The permissible values of bending strength and mean modulus of elasticity (MOE) obtained for structural timber design were (in N/mm^2): 7.1 and 8200 for special structural (SS) grade cypress, 5.0 and 7400 for general structural (GS) cypress, 4.3 and 11800 for SS pine and 3.0 and 10600 for GS pine. To simulate the actual conditions of fabricating roof trusses, the universal strength testing machine at Karura Forest Research Centre was modified so that it could test full size structural materials (with the inherent natural timber defects).

A countrywide sampling of four structural sizes (50x75, 50x100, 50x150 and 50x200 mm.) was graded into SS and GS according to KS02-771:1989 grading rules and then tested.

The overall objective was to establish strength properties of Kenyan Cupressus lustanica, *Pinus* patula and *Pinus* radiata. The specific objectives were to::

- establish mechanical properties of GS and SS grades of Cypress and Pine timber
- establish physical properties (moisture content and density) of GS and SS grades of cypress and pine timbers
- determine permissible design stresses to be used for drafting Kenya standard code of practice for structural timber
- establish strength-stiffness relationship to be used for determining settings of machine stress grading equipment for cypress and pine.

Tables 18 and 19 give various physical and mechanical properties for SS and GS grades of sizes 75 x 50, 100 x 50, 150 x 50 and 200 x 50 of cypress and pine. The lower percentile for Modules of Rupture (MOR) and MOE values which were determined according to EN 384 are also given. The adjusted MOR was determined using 1.059, 1.000, 0.922 and 0.871 size factors for 200 x 50, 150 x 50, 100 x 50, and 75 x 50 sizes, respectively.

Results show that the average permissible MOE for pine were 12215 N/MM^2 (SS) and 9881 N/MM^2 (GS), and MOR were 6.4 N/MM^2 (SS) and 5.6 N/MM^2 (GS), respectively.

The MOE for SS and GS were 7766 N/MM^2 and 6003 N/MM^2 respectively, while the MOR was 5.2 N/MM^2 for SS and 3.7 N/MM^2 for GS.

The results indicate that Pinus species could be stronger than C. lustanica, if it were not for spiral grain which is very common with pines. It was shown that upto 30% pines are rejected due to spiral grain compared to 2% for cypress.

The visual stress grades for SS and GS grades were 55 and 33% for cypress 25 and 30% for pine, respectively. This indicates that Kenyan grown pines could be machine graded, as there was a high relationship between stiffness and strength.

It is recommended that further sampling should be done so that a representative sample is obtained for size 50 x 200 mm, whose stress values were not obtained.

Table 18: Average strength properties of various grades of cypress

Z	N (% yield)	5% MOR N/mm²	Size Factor	5% MOR adjusted N/mm²	Mean MOE N/mm²	5 % MOE N/mm²	MC %	Density Kg/m³	Specific Gravity
SS Grade									
50x200	46(56)	14.7	1.059	15.5	12931	7654	12.2	456	0.450
50x150	160(62)	14.6	1.000	14.6	7327	4473	12.0	462	0.450
50x100	104(50)	20.1	0.922	18.5	6943	3983	14.8	457	0.467
50x75	104(47)	20.8	0.87	18.1	6979	3890	12.8	441	0.464
	-	-	-	-	-	-	-	-	-
Characteristic Value			-	**16.6**	**7766**	**4557**	-	-	-
Permissible Value			-	**5.2**	**7766**	**4557**	-	-	-
GS Grade									
50x200	28(34)	-	1.059	-	-	-	12.9	444	0.430
50x150	45(18)	9.2	1.000	9.2	5791	3896	11.8	456	0.439
50x100	61(29)	12.5	0.922	11.5	5877	3170	14.6	456	0.469
50x75	50(22)	16.4	0.871	14.3	6348	4042	12.9	433	0.467
Characteristic Value			-	**11.7**	**6003**	**3658**	-	-	-
Permissible Value			-	**3.7**	**6003**	**3658**	-	-	-

Table 19: Average strength properties of various grades of pine

Size	N (% yield)	5% MOR N/mm^2	Size Factor	5% MOR adjusted N/mm^2	Mean MOE N/mm^2	5 % MOE N/mm^2	MC %	Density Kg/m^3	Specific Gravity
SS Grade									
50x150	52(23)	18.8	1.000	18.8	11787	6484	13.1	543	0.543
50x100	53(23)	23.1	0.922	21.3	11333	5292	14.6	509	0.526
50x75	80(28	24.0	0.871	20.9	13078	5506	12.6	4542	0.589
Characteristic Value				**20.4**	**12215**	**5720**	-	-	-
Permissible Value				**6.4**	**12215**	**5720**	-	-	-
GS Grade									
50x150	78(34)	18.9	1.000	18.9	9722	5790	12.5	516	0.487
50x100	80(35)	19.7	0.922	18.2	9623	4976	14.6	502	0.508
50x75	78(27)	19.2	0.871	16.7	10306	4499	13.2	506	0.557
Characteristic Value				**17.9**	**9881**	**5087**	-	-	-
Permissible Value				**5.6**	**9881**	**5087**	-	-	-

1.4.4 Planned Activities

Various activities are planned for the next year and these include continuation of the projects highlighted and also new activities which include the following:

- Determination of the role of adjacent communities in plantation forest fire control
- Studies on propagation of *Pinus radiata* through tissue culture
- Propagation of *Eucalyptus grandis* Ex-Zimbabwe through conservation of outstanding progenies
- Determination of the strength of mechanically fastened joints for Kenya grown cypress and pine
- Recovery optimization through appropriate harvesting and pre-sawing techniques
- Assessment of spiral grain occurrence pattern and effect on strength properties in *Pinus patula* and *P, radiata*
- Growth and utilization potential of plantation grown *Araucaria cunninghamii* in Kenya
- International species/provenance trial of *Casuarina junghuniana* in Uplands and Kiandongoro
- Establishment of monitoring system for pests and diseases
- Studies on black blister disease of *Casuarina equisetifolia*
- Promotion of alternative plantation species.

Details of activities planned for some of the ongoing activities are as follows:

(a) *Promotion of Sustainable Forest Management*

The activities which were not completed will continue for the following year, and more proposals will be reviewed for funding either internally or externally.

E. Biological Control of Cypress Aphid

- Continue monitoring of the biological control programme by sampling in all the set PSPs countrywide
- Countrywide surveys will be carried out in South Nyanza, Machakos, Embu and Mt. Elgon
- Continue to maintain a culture of parasitoid in the two insectaries at low populations
- Impact assessment experiments will be set up in Kiambu region before being extended to Londiani region
- Two publications will be produced; "Distributing of *P. juniperorum* in Kenya and A Technical Bulletin on Rearing of *P. juniperorum".*
- Establishment of Mexican cypress PSP on KEFRI land at Londiani station.

F. Seed Stand and Seed Orchard Development

Seed orchards expansion for P, patula and C. lusitanica

- To raise about 3000 seedlings of each species to provide rootstock for grafting
- Graft the selected clones for both species.

F. Improvement *of Eucalyptusgrandis*

Selection of outstanding trees
Establishment of progeny trials

2.0 Service Programme

2.1 Introduction

The Service Programme coordinates the following activities:

- Information Dissemination and Public Relations
- Tree Seed Production and Supply
- Social Forestry Training
- Wood and Seedling Production
- Karura Workshop
- Consultancy and Contracted Research Services
- Research Liaison
- Donor Linkages

2.1.1 Information Dissemination and Public Relations

Information documentation, dissemination and management are the main activities of this section. During the year under review, the following were achieved:

- An annotated bibliography on theses and dissertations by KEFRI scientists was started and is in progress,
- Production of a catalogue on publications by KEFRI scientists for the period 1986 to 1998 was started. The draft is being reviewed and will be published soon,
- Three press releases on agroforestry entomology and dryland forestry were published in the local print media,
- A feature article on the cypress aphid was published in the local print media,
- Revised version of KEFRI profile was published,
- A two part video on social forestry with a focus on the semi-arid area title " Miti ni Mali" were produced,
- Attempts were made to improve services in KEFRI Library. A survey was carried out to document the state of library services in regional centres of KEFRI. Through the survey, it was established that library services in the centres need strengthening,
- To facilitate quality publication by KEFRI scientists, the programme in collaboration with the Editorial Secretariat produced a draft publication policy. The draft has been presented to the Board of Management. A brochure on the Editorial Secretariat was also produced.

2.1.2 Tree Seed Production and Supply

The Kenya Forestry Seed Centre carries out the following activities with the aim of generating revenue for KEFRI:

- Collection and distribution of high quality seeds
- Identification and selection of new seed sources
- Management and protection of seed sources in cooperation with the Forest Department
- Training in tree seed technology
- Seed quality testing

These activities are carried out by 8 collection centres, distributed countrywide.

During the review period, the 8 seed collection centres collected a total of 2028 kg of seeds of 42 different species. A total of 1400 kg of seed was supplied to various clients who included FD, NGOs, schools and farmers. The amount of 200kg was supplied to other KEFRI programmes free of charge for research and seedling production.

During the review period, 9 new seed stands were recruited in South Kinagop and Mt. Kenya Region as shown on Table 20.

Table 20: Seed stands recruited in South Kinangop and Mt. Kenya Region

Species	No. of Stands	Locality
Pinus patula	3	South Kinagop
Vitex keniensis	2	Mt. Kenya Region
Cupressus lusitanica	4	Mt. Kenya Region
TOTAL	9	

The Centre organized four courses during the year as outlined on Table 21.

Table 21: Courses organized in 1999 and 2000

Course Title	No. of participants	Date
Tree Seed Technology	5 participants from ICRAF, BAT, KFA and KEFRI	15-28 August 1999
Seed Collection and Handling	6 farmers from Laikipia West	7-8 September 1999
Tree Seed Technology	6 officers from National Tree Seed Project of Uganda	6-8 March 2000
Tree Seed Technology	6 officers from Ethiopia Tree Seed Centre	18-24 June 2000

Routine seed quality testing in 149 seed lots was carried out throughout the report period in the laboratory, glasshouse and nursery. This involved moisture content testing, purity analysis, weight determination and germination/viability testing.

2.1.3 Social Forestry Training

A. Introduction

Social Forestry Training Centre (SFTC) comprises three units, namely: Training, Audio-visuals and KEFRI House (catering and housekeeping). SFTC aims at facilitating efficient communication and promotion of the application of research findings among stakeholders and partners.

(i) Objectives

The objectives of the SFTC are:

- To generate revenue by contracting use of training resources, to facilitate its operations and support KEFRI's forestry research and development activities.
- To provide avenues for networking and outreach to development programmes aimed at enhancing KEFRI's ability to participate nationally and globally in forestry research and development.
- To provide service in human resource development at KEFRI through provision of cost-effective in-house training packages and related advisory services.

B. Activities and Achievements

(i) Use of training facilities

A total of 28 major workshops, seminars, courses and meetings were facilitated during the year as shown in Table 22.

C. Tailor made courses

Four courses and a study tour package were developed during the year. However, none was implemented due to lack of sponsorship and effective marketing strategies. These include:

- A four-week International Course on Social Forestry Extension and Development, drawing participants from Africa
- A two-week International Course on Appropriate Tree Nursery Establishment and Management Techniques
- Regional Training Course for the Promotion of Social Forestry in Africa: 2nd phase (2000 - 2001)
- Social Forestry Extension and Development Course for Burundi Forest Technicians
- A four-week Global Green Camp Technical Study tour for foreigners.

Table 22: Details of use of training facilities

No.	Activity Title	Organiser	Duration
1.	Science Writing, Editing and Oral Presentations Course	*SCIDCOM International Ltd.	2-13 Aug. 1999
2.	Kenya Community Media Network (KCOMNET) Course	*KCOMNET	12-20 Aug. 1999
3.	Launching of KEFRI Pension Scheme	KEFRI Pension Scheme Board of Trustees	Aug. 1999
4	Social Forestry Extension Seminar for the Promotion of Tree Planting in Arid and Semi-arid Areas of Kenya	**KEFRI/SOFEM/JICA	27-30 Sep. 1999
5	Regional Training Course for Promotion of Social Forestry in Africa.	**KEFRI/JICA	27 Sep.-29 Oct. 1999
6	Refresher Course on Timber Grading	*Ministry of Public Works/KEBS	Nov. 1999
7	Conservation and Sustainable Use of Forest Genetic Resources Regional Training Workshop (SAFORGEN)	***KEFRI/IPGRI	25 Nov.-3 Dec. 1999
8	Women Church Group from Uganda	Mothers Union ACK	3- 5 Dec. 1999
9	Association of Forestry Research Institutions in East and Central Africa (AFREA): Directors Meeting	**FAO	16 -19 Dec. 1999
10	Board of Trustees Meeting (Pension)	KEFRI Pension Scheme	21 Dec. 1999
11	African Forestry Research Network (AFORNET) Group Research Proposal Writing Workshop	**KEFRI/AAS	16 - 19 Jan. 2000
12	Board of Trustees Meeting (Pension)	KEFRI Pension Scheme	18 Jan 2000
13	AFRENA-ECA Phase II EU Programme Development Workshop	**AFRENA/ICRAF	23 - 26 Feb 2000

Table 22: Contd.

14	Science Writing, Editing and Oral Presentations Course	*SCIDCOM International Ltd.	28 Feb – 10 Mar. 2000
15	Handling and Storage of Recalcitrant Intermediate Tropical Seeds Workshop	KEFRI/IPGRI	26 Mar. – 1 Apr. 2000
16	Tree Health and Agroforestry Seminar	**IIBC/KEPHIS/KEFRI	20 March 2000
17	Board of Trustees Meeting (Pension)	KEFRI Pension Scheme	15 Mar. 2000
18	International Workshop on Bamboo and Rattan Livelihood Development: Analysis of Constraints and Technological Needs in Asia, Africa and Latin America	***INBAR/IFAD/KEFRI	3 - 7 Apr. 2000
19	The Effective Receptionist Course	*DPM/Office of the President/KEFRI	10 -12 Apr. 2000
20	KEFRI Security Officers Refresher Course	KEFRI	3 - 6 May 2000
21	Indigenous Forest Research Institutions (IFRI) Workshop	**IFRI/KEFRI	4 - 5 May 2000
22	Association of Forestry Research Institutions in East and Central Africa (AFREA): Directors Meeting	**FAO	10 -12 May 2000
23	KEFRI Security Officers Refresher Course	KEFRI	10 - 13 May 2000
24	Timber Grading and Promotion Course	Ministry of Public Works/KEBS	15 - 26 May 2000
25	KEFRI Consultative Forum for Scientists	KEFRI	15 - 16 Jun 2000
26	Skills Improvement Seminar for Government Drivers	DPM/Office of the President	18 - 24 Jun 2000
27	AFRENA-Kenya (NIP) Project Stakeholders Consultative and Planning Workshop	KEFRI/ICRAF	21 –23 Jun 2000
28	Workshop on Revision and Publication of Useful Trees and Shrub Species	ICRAF	21 – 23 Jun 2000

** - National ** - Regional *** - International*

D. Training reports and Papers presented

Several publications and reports were written as follows:

- Regional Training Course for the Promotion of Social Forestry in Africa 1998
- Regional Training Course for the Promotion of Social Forestry in Africa 1999
- Social Forestry Extension Seminar for the Promotion of Tree Planting in Arid and Semi-arid Areas of Kenya, 1999
- Embu, Meru Isiolo (EMI) Technical Note No. 20
- Training Report for Farmers of the Former EMI Forestry Research Plots
- Proposal for Extension of the Regional Training Course for the Promotion of Social Forestry in Africa (phase II, 2000-2004)
- Introduction to Social Forestry (Michael Mukolwe, September 1999)
- Social Forestry Nurseries, Establishment and Management Techniques (Michael Mukolwe, September 1999)
- Urban and Amenity Forestry (Michael Mukolwe, October 1999)
- Community Participation in Community Oriented Projects (Bernard Owuor, October 1999)
- Planning of Social Forestry Training Programmes (Akula Mwamburi, October 1999)
- Amhara National Regional State/Sida Co-operation in Rural Development Programme, Ethiopia. A Report of the Agroforestry Technical Study Tour by a Team from Kenya, 31 October - 10 November 1999. (D. Nyamai, F. Mbote, F. Mureithi, M. Mukolwe, J. Kimani, J. Mugwe, J. Mbogo, J. Kangara and B. Owuor)
- Tree Propagation Methods (Michael Mukolwe, May 2000).
- The Profile on Structure, Programmes and Activities of Kenya Forestry Research Institute: Training Resources and Activities. (Michael Mukolwe and Evelyn Kiptot, May 2000).

E. Visits and Visitors

(i) Visits

- The Training Officers visited Eastern, Central, Rift Valley, Western and Coastal Provinces of Kenya during the pre-study tour arrangements for the Regional Training Course for the Promotion of Social Forestry in Africa
- Mr. Michael Mukolwe and Mr. Bernard Owuor travelled to Ethiopia as part of the Agroforestry Technical Study Tour Team to the Amhara National Regional State/SIDA Co-operation in Rural Development Programme, Ethiopia. The study tour was supported by RELMA/SIDA from 31 October to 10 November 1999
- Mr. Michael Mukolwe travelled to Ethiopia to attend the Regional Planning Workshop on Strengthening Education and Training, Eastern Africa Region. The Workshop was held at the Wondo Genet College of Forestry and supported by DSO/ICRAF, from 7 - 12 May 2000.

2.1.4 Wood and Seedling Production Unit

The main objective of this unit is to meet the demand of fuelwood both locally and in areas neighbouring the Institute, by proper management of the existing Eucalyptus plantations and establishing new ones. The new plantations are being established using fast growing Eucalyptus *grandis* from Turbo and Zimbabwe, whose rotation is 6

years. The unit also runs a nursery that supplies seedlings for establishment of the plantations and for sale to the neighbouring community.

During the review period a total of 98,200 seedlings of 11 species were raised. Out of these 11,000 seedlings were sold. A total of 13 ha. was singled out and slashed at the rate of 28 stumps per manday.

Five hectares were planted using Eucalyptus seeds from Zimbabwe and 9 ha. planted with seedlings raised from Turbo seed source. The survival rate was below 30% and this was mainly due to the drought experienced at Muguga.

2.1.5 Karura Workshop

The workshop is based at the Forest Products Resource Centre in Karura and has facilities for sawing, commercial production of furniture and laminated wood products and seasoning of timber.

During the review period, the Government ban on tree harvesting in gazetted forests affected logging and consequently timber and furniture production. Nonetheless 450 m3 of cypress trees were harvested. The approximate volume of timber sawn was 190 m3, of which 185 m3 was sold and 5 m3 was selected as prime grade timber for furniture making.

The quality of furniture and laminated wood products was greatly improved and other services like timber seasoning and planing were very popular.

2.1.6 Consultancy Services and Research Liaison

The programme initiates and maintains inter-agency linkages towards support and advancement of forestry research and initiates and forges linkages with several organizations. During the review period, the following links were maintained and strengthened:

(i) Forest Department

The Forest Department is the major client of research findings from KEFRI. Collaborative and consultative linkages to facilitate the undertaking of research that is relevant to forestry development were maintained through the Technical Liaison and Policy Liaison Committees.

(ii) KEFRI/ University of Georgia

Initiatives to create collaboration with the University of Georgia, USA were reviewed by the directorate. The main objective is to set a system that will enable exchange of staff between the university and KEFRI and the hosting of students from the University of Georgia .

(iii) KEFRI/RELMA

The Regional Land Management Unit is a project funded by SIDA. An initiative to have RELMA support trainees to the Regional Social Forestry Course were started. Five trainees from Tanzania and Ethiopia were financed by RELMA and attended the 1999 course.

Contracted research and consultancy were identified as a useful strategy to generate research funds. To facilitate marketing of the institute's capacity in contracted research and consultancy, the programme finalised corporate Curriculum Vitae for the Institute.

Compilation of a database on profiles of donors was started.

3.0 Collaborators

During the year the Institute collaborated with the following institutions:

African Academy of Sciences (AAS)
Bird Life International
CAB International, Africa Regional Centre
Ethiopian Agricultural Research Organization (EARO)
Forest Department
Forestry Research Institute, Uganda (FORI)
International Plant Genetics Resources Institute (IPGRI)
International Centre of Research in Agroforestry (ICRAF)
International Union of Forest Research Organisations (IUFRO)
International Centre for Insect Physiology and Ecology (ICIPE)
Kenya Agricultural Research Institute (KARI)
Kenya Wildlife Services (KWS)
Makerere University, Uganda
Ministry of Agriculture and Rural Development
Moi University
Mondi Forests, South Africa
National Museums of Kenya
Sokoine University of Agriculture (SUA), Tanzania
Tanzania Forestry Research Institute (TAFORI)
United Nations Educational, Scientific and Cultural Research Organization (UNESCO)
University of Dundee, UK
University of)ensuu, Finland
University of Nairobi

4.0 Management Services

4.1 Supplies Division

In the last financial year, the Supplies Division had acquired a computer, printer and UPS and intends to start computerizing the stores to improve efficiency.

A. Accomplishments

In the year under review the Supplies Division has:

- assisted in procurement of computers and accessories on behalf of the Institute
- assisted in buying four Toyotas for use by the Institute officers
- compartmentalized the warehouse, allocating specific warehousing facilities to particular users and cost centres
- organized and guided the Institute, Tender Committees on matters of procurement throughout the year 1999 - 2000.

The Supplies Division has maintained contracts for service and repair of all Institute typewriters and the Institute's standing generator. Contract documents for repair, service and maintenance of the Institute computers are being organized.

4.2 Finance Division

The Finance Division is responsible for the financial management and control of the Institute's resources. It is an integral part of the management structure of KEFRI.

A. The major highlights during the year under review were:

- The timely submission of the Final Accounts to the Auditor General, Corporations. The accounts were approved by the Board of Management.
- Sound financial control and discipline was exercised during the year. It is worth mentioning that no over-expenditure occurred during this period.
- The Finance Division invested KShs 9,826,900 in Treasury Bills. Other alternative investment opportunities are being explored.

B. Future Plans

- The Division intends to intensify its efforts in investment opportunities, especially in non-utilised funds.
- The Finance Division intends to strengthen the institute's regional cost-centres by deploying qualified personnel to manage the financial and accounting transactions of these centres. This is aimed at improving efficiency.
- The division intends to computerize its records.
- Despite the limited funds, the Division encourages its members to train in accountancy. This is aimed at instilling more professionalism in the division.

4.3 Administration Division

The Division is responsible for overseeing the smooth day to day running of the Institute and thus contributes directly and indirectly to the research activities of

KEFRI. It has the following sections: Transport, Security, Office Services, Estate Management, Staff Pension Scheme, Secretarial Services and Clinical Services.

A. Achievements

During the period under review the following was accomplished:

- The Staff Clinic, headed by a Clinical Officer, opened its doors to staff and their dependants on 6th March 2000. It operates on a cost sharing basis. Consultancy and prescription are free.
- Generator power was connected to the Centre Directors' Offices in Muguga
- Various maintenance projects were undertaken to improve the drainage system, roads and water supply.
- Construction of archive shelves at the headquarters for accounts and personnel records
- Some of the Institute vehicles were fitted with "Car Track" alarm systems
- The Security Officers had a refreshers' course in Muguga and Kitui to improve their skills.
- The Security Officer in Muguga was trained in First Aid and Fire Fighting

B. Future Plans

The future plans are as follows:

- To set up a modern KEFRI Archives Centre for preservation of records for future reference at Nderi Campus through renovation of the former warehouse.
- Computerize the divisions' records, particularly in the Registry and Transport, and the water billing system.
- Retain a workforce that can be productive at a minimal cost.
- Fully operationalize the Institute's Clinic, to offer efficient clinical services to the institute's employees and their immediate families.
- Develop a training and staff development package for the workforce of all cadres including secretaries, clerks, security guards and drivers, through seminars, workshops and professional training, geared towards career advancement based on good competence and performance.

4.4 Human Resource Division

This is a service Division whose main objective is to properly manage and motivate employees so that they can give maximum contribution to the employer.

A. Achievements

During the year under review, the Division achieved the following:

- Fitted within the new structure of KEFRI
- Co-ordinated and processed promotions for staff.
- Facilitated training of members of staff - 5 in PhD; 2 in MSc; 6 Diplomas and 7 certificates in various disciplines.
- Maintained records and addressed various personnel problems.
- Recruited a Clinical Officer and a Nurse and made the clinic operational.
- Implemented a new payroll package (HORIZON).

- Held aids awareness campaigns in almost all centres and sub centres.
- Undertook a thorough staff analysis to establish the optimal level of staff for the Institute and examined various options to establish a possible retrenchment package.

During the year 31 members of staff left through natural attrition: death (21), resignation (1) and retirement (91).

B. Future Plans

To build capacity for the clinic by recruiting a Laboratory Technician
Train a number of Scientists at Masters and PhD level.
To train more Officers on Information Technology.
Computerize the operations of the Division particularly Human Resource Software.
Continue with HIV Aids, education to members of staff.

5.0 Publications, Conference Papers and Technical Reports

Amwatta C.J.M, (1999). The Disappearing Doum Palm: A tree that meets contingencies for the Turkana people of Kenya. In: *Dry/and Biodiversity.· Biannual Newsletter of the Research Programme on Sustainable Use of Dryland Biodiversity, Issue No. 3, June 1999.*

Chikamai, B.N. and G. Muturi, (1999). Two decades of Research and Development in Kenya. In *Proceedings of a Social Forestry Seminar on Promotion of Social Forestry in Africa,* Kenya Continental Graphics Ltd, Nairobi, 251p.

Chikamai, B.N.; Mbiru, S.S. and Souvounnavoung, 0. (2000). *Report of the Meeting of Heads of Forestry Research in Eastern Africa.* Westlands Press Ltd; Nairobi.

Kaudia A. A. (1999). Disseminating Forestry Technologies to Reach Rural Women. *A paper presented at the African Women in Science and Engineering Pan African Workshop.* 29th November to 3rd December, 1999 ICRAF HQ, Nairobi, Kenya.

Kaudia A. A. (1999). Response to agroforestry intervention: the case of subsistence farmers in semi-arid Lakeshore Homa Bay, Kenya. *Presented at the international Conference on Combating Desertidcation with Plants Organized by the International Program for Arid Lands Crops 1-6* November, 1999. Ben-Gurion University of the Negev, Beer-Sheva, Israel.

Kaudia A. A (1999). Dissemination of Agroforestry Innovations to Address Land Degradation. In: *Proceedings of Second General Assembly and International Conference : Women, Science and Technology for Sustainable Development, 8-11* February, 1999, Cape Town, South Africa.

Kaudia A. A (1999). Writing An Investment Worth Research Proposal: *A Seminar Paper presented at the African Women in Science and Engineering Conference,* 29th November to 2nd December 1999 at the International Centre for Research in Agroforestry, Nairobi, Kenya.

Kaudia A (2000). Enhancing Skills of Scientists: Preparing Research Proposals. IUFRO News. Vol 29 *NO. 4*

Kaudia A. and Mwanycky S. (Eds.). (2000). *Proceedings of the First Meeting of the Eastern and North Eastern Node of the African Forestry Research Network.* Academy Science Publishers, Nairobi.

Kaudia A. (2000). Forestry Research and Management. *Kenya Forestry Newsletter No. 3* May 2000

Kiriinya C.K. (1999). The Best Way to Manage *Grevillea robusta. Agroforestry Today Vol.II* No. 1 - 2: 34 - 35.

Kiriinya C.K. (2000). Effect of Stocking density on the growth of *Cryptomeria japonica. Tropical ForestryJournal.* In Press

Langat D. (1999). Variation in Basic Density and Heartwood Proportion Among Provenances of Eucalyptus grandis Hill ex Maiden in Elbugon Kenya.

Langat D. (1999). Variation in Basic Density and Heartwood Proportion among Provenances of Eucalyptus grandis Hill ex Maiden in Elbugon Kenya. Submitted for Publication.

Muchiri M.N and Omenda T.O. (2000). Interim guidelines for managing natural regeneration of *Pinus* patula in clear felled plantations. In T. Pukkala and K. Eerikainen, Eds, *Establishment and management of tree plantations in* Southern *and* Eastern Africa. University of Joensuu, faculty of Forestry Research notes 120:2000.

Oluka-Akileng I., Esegu, J. F., Kaudia, A. A. and Lwakuba, A. (2000). Agroforestry *Handbook* for *the Coffee-Banana zone of Uganda:* Farmers' Practices *and Experiences Regional Land Management Unit. Nairobi,* Kenya.

Omenda T.O., M.N. Muchiri, J. Mbinga and M. Varmola (2000). Managing natural regeneration of cypress: Practical guidelines for Kenya. In T. Pukkala and K. Eerikainen, Eds, *Establishment and management of tree plantations in* Southern *and* Eastern Africa. University of Joensuu, Faculty of Forestry Research notes 120.

Ongugo P. and Kiptot E. (1999). National Case Study on International Human Dimension of Climate Change. IHDP Report No. 4 Sep. 24-26 1999 Oslo Norway.

Ongugo P.O., Sigu G.0, Kariuki J.G.,. Luvanda A.M and Kigomo B.N. (2000). Production to consumption system: A Case Study of the Bamboo Sector in Kenya, *KEFRI/INBAR* Report.

Otieno D.O., Kinyamario J.I and Omenda T.O. (2001). Growth features of Acacia tortilisand Acacia *xanthophloea* seedlings and their response to cyclic soil drought. African *Journal of Ecology.* In press.

Sigu G.O. and Mbinga J.M. (2000). Training workshop on Bamboo Propagation, Utilization and Programme Development, *Training* Report

Sigu G.O., and Mbinga J.M. (2000). An overview of the bamboo sector in Kenya. Country Report Prepared for *INBAR Training Workshop on Bamboo* Propagation 8 May - 26 May 2000, Los Banos, The Philippines.

Sigu G.O., Ongugo P.O., Njuguna J. (2000). The Current Status of the Vanga Mangrove Forest: Policy: Implications for Future Conservation Initiatives in *Proceedings of The 2''d IFRI Regional Workshop* on "Operationalization *of* Participatory Natural Forests *Management* in Kenya." In Press.

6.0 Staff Training

A. Post Graduate Training

Jackson Mulatya*	PhD	Agroforestry
Doris Mutta*	PhD	Ethnobotany
Balozi B. Kirongo	PhD	Silviculture
Stanley Gathumbi*	PhD	Agroforestry
Kamiri Ndufa*	PhD	Agroforestry
Joseph Lelon	PhD	Soil Chemistry
Mercy Gichora*	PhD	Ecology and Resource Management
Mbae Muchiri*	PhD	Agroforestry
Henry Wakhungu	PhD	Biometrics
Joshua Cheboiwo*	PhD	Marketing
John Obiri	PhD	Forest Conservation
George Muthike*	MSc	Wood Science
Simon Wairungu*	MSc	Tropical Forestry Management
Meshak Muga	MSc	Wood Science
Bernard Owuor*	MA.	Sociology
Charles Koech*	MA.	Sociology
Dickson Makanji	MSc / PhD.	Socio-Economics
M.T.E. Mbuvi	MSc.	Socio-Economics
Emily Obonyo*	MA.	Sociology
Pauline Ondachi*	MSc.	Chemistry
Simon Choge*	MSc.	Natural Resource Economics

** - On split or part time study*

B. Short Term Training

- Mrs. Jane Njuguna attended the IFRI training in September - October 1999 at Indiana University.
- Mr. Muchiri attended a one-week course on "Forest Growth and Modelling" in Zimbabwe from 22 to 29 January 2000. The course was organized and financed by the INCO-DC Project.
- Mr. Omenda and Mr. Muchiri attended a one-week course in Forest Growth and Modelling in Portugal from 13 to 21 May, 2000. This course was also organized and financed by the INCO-DC Project.
- Gordon Sigu and Joram Mbinga participated in the International Network for Bamboo and Rattan (INBAR) Training Workshop on Bamboo Propagation held at UPLB-IPB, Los Banos, Philippines, 7 - 27 May, 2000.
- Paul Ongugo, Jane Njuguna and Gordon Sigu attended the annual meeting of the International Forestry Resources and Institutions (IFRI) network and the biennial Conference of the International Association for the Study of Common Property (IASCP) entitled "Constituting the Commons! Crafting Sustainable Commons in the New Millennium" 26th May - June 4th 2000. Indiana University, Bloomington USA.
- Mr. Muchiri was sponsored to undertake a doctoral degree by the INCO-DC Project. He proceeded to the University of Joensuu, Finland for a period of 6 months form 21 May 2000 to write the dissertation. By the end of June 2000,

he had submitted one manuscript, Yield of Grevillea robusta in the maize fields of Kenya, for publication.

Mr. Akula Mwamburi attended a financial management course at the Kenya Institute of Mass Communication.

Simon Kamonde attended a short course at the Kenya Institute oif Mass Communication.

7.0 Members of the KEFRI Board of Management

Mr. Humphrey Ngibuini	Chairman
Dr. David Kamweti	
Prof. Michael Koech	
Dr. lama Bashir	
Prof. Fred Owino	
Prof. B. N. Mitaru	
Dr. (Mrs.) Theresa Aloo	
The Permanent Secretary, Ministry of Finance	
The Permanent Secretary, Ministry of Environment and Natural Resources	
Inspector of State Corporation	
Dr. Paul K.A. Konuche	Secretary

8.0 Senior Staff Members and Scientists

DIRECTOR AND DEPUTY DIRECTORS

Director	Paul K. Konuche
Deputy Director (Research & Development)	Bernard Kigomo
Deputy Director (Finance & Administration)	Patrick N. Omesa

NATIONAL PROGRAMME COORDINATORS \ ASSISTANT DIRECTORS

Farm Forestry	Daniel Nyamai
Forest Plantations	Ebby Chagalla
Natural Forest	Paul Ongugo
Dryland Forest	Ben Chikamai
Service Programme	Alice A. Kaudia

REGIONAL CENTRE DIRECTORS

Gede Regional Centre	Caleb Mwendwa (Acting)
Karura Regional Centre	Joseph Githiomi (Acting)
Kitui Regional Centre	James Kimondo
Londiani Regional Centre	Juliet Wanyondu (Acting)
Maseno Regional Centre	Collins Obonyo (Acting)
Muguga Regional Centre	Elly Mwanza

TEAM LEADERS

Agroforestry	David Odee
Integrated Pest Management	Linus Mwangi
Natural Ecosystems	Tom Omenda (Acting)
Socio-economics & Policy	Evelyn Kiptot (Acting)
Timber and Non-timber Products	Nelly Ndegwa (Acting)
Tree Stand Management	Phanuel Oballa

HEADS OF UNITS IN SERVICE PROGRAMME

Muguga Forest Estate	William Mucheke
Information Dissemination & Documentation	Paul Barasa
Karura Workshop	Kamau Thuo
Seed Centre	Peter Angaine
Training (Muguga)	Michael Mukolwe

HEADS OF SUB-CENTRE STATIONS

Bura-Tana	Charles Ongweya
Kakamega	Johnstone Ngazi
Kaptagat	Thomas Kundos
Kibwezi	Malim Mohammed
Kuja River	Antipas Orwe
Marigat	Philip Changwony
Ramogi	Daniel Odhiambo

Turbo	Phanuel Wesonga (Acting)
Turkana	John Oyugi

LABORATORIES, GREEN HOUSES & NURSERIES

Demonstration/Amenity Nurseries	Clement Muchoki
Ecology & Dryland	Joash Gichana
Forest Genetics	Peter Wanjawa
Muguga Arboretum	Samuel Thogo
Nderi Research Nursery	Joseph Kioko
Non-timber Products	Moses Katuva
Pathology & Entomology	Luke Gibera
Soils, Agroforestry & Biotechnology	James Gitu
Timber Engineering	Dominic Mikile

FINANCE & ADMINISTRATION DIVISIONS

Accounts & Finance	Charles Mungai
Administration	John Gisemba
Human Resource	Ruth Macharia
Internal Audit	Ibrahim Momanyi
Supplies	Michael Karumba

SCIENTISTS

Embu (KARI Centre)	Paul Tuwei Jane Mugwe
Gede	Kaleb Mwendwa (Acting Centre Director) Tito Mbuvi
Karura	Nellie Ndegwa George Muthike James Onchieku Joseph Githiomi (Acting Centre Director) Meshack Muga Micheal Njenga
Kibwezi	Ahmed Mohammed (Head of Sub Centre) David Muchiri Dorothy Ochieng Edward Mengich Linus Wekesa David Muchiri
Kitui	Bernard Kigwa Bernard Muok James Kimondo (Centre Director) Josephine Kamene Joshua Cheboiwo Robert Nyambati
Londiani	Joram Mbinda Juliet Wanyondu (Acting Centre Director) Jonanthan Njuguna
Maseno	Collins Obonyo (Acting Centre Director) Emily Obonyo James Kamiri Ndufa Joseph Machua Stanely Gathumbi

Muguga	Albert Luvanda	Jason Karuiki
	Charles Kiriinya	John Kiambaa
	Charles Koech	Joram Kagombe
	David Langat	Joseph Ahenda
	David Odee	Joseph Lelon
	Doris Mutta	Josephine Wanjiku
	Elly Mwanza (Centre Director)	Kavaka Mukonyi
	Eston Mutitu	Linus Mwangi
	Evelyn Kiptot	Mbae Muchiri
	Gitehi Giathi	Mercy Gichora
	George Ondoro	Pauline Ondachi
	Gordon Sigu	Phanuel Oballa
	Francis Gachathi	Sheila Mbiru
	Jacinta Kimiti	Simon Choge
	Jane Njuguna	Simon Wairungu
	Jared Amwatta	Tom Omenda
	James Maua	William Omondi
Nyeri	James Maua	
Outreach Training and Information Dissemination	Paul Barasa	
	Pauline Bwire	
	Michael Mukolwe	
	Jesse Lugadiru	
	Bernard Owour	
	Akula Mwamburi	

9.0 Addresses of Regional Centres and Sub-Stations

9.1 Regional Centres

Muguga Forestry Research Centre,
P. 0. Box 20412,
NAIROBI.
Tel: 254-32891/2/3
Fax: 254-32844
E-mail : kefri@arcc.or.ke

Londiani Forestry Research Centre,
P. 0. Box 382,
LONDIANI.
Tel: 0361-64028/64082
Email:kefri_in@africaonline.co.ke

Gede Forestry Research Centre,
P. 0. Box 201,
MALINDI.
Tel: 0123-32022
E-mail sokoke@africaonline.co.ke

Maseno Forestry Research Centre,
P. 0. Box 25199,
KISUMU.
Tel: 035-51245/51163/51164
Email:afresmaseno@africaonline.or.ke

Kitui Forestry Research Centre,
P. 0. Box 892,
KITUI.
Tel: 0141-22311/22626
Fax: 0141-22471
E-mail : kefrikiti@wananchi.com

Karura Forest Products Research Centre,
P. 0. Box 30241,
NAIROBI.
Tel: 02-761063/721246
E-mail : kefri@africaonline.co.ke

9.2 SUB-CENTRES

Kakamega Seed Sub-Centre,
P. 0. Box 462,
KAKAM EGA.

Nyeri Seed Sub-Centre,
P. 0. Box 12069,
NYERI.
Tel: 0171-2268

Ramogi Forest Research Sub-Centre,
P. 0. Box 184,
USENGE.

Turbo Forest Research Sub-Centre,
P. 0. Box 5,
TURBO.
Tel: 0323-53011

Turkana Forest Research Sub-Centre,
P. 0. Box 468,
LODWAR.
Tel: 0393-21230

Baringo Forest Research Sub-Centre,
P. 0. Box 57,
MARIGAT.
Tel: 0328-51280

Bura Forest Research Sub-Centre,
P. 0. Box 102,
BU RA-TANA,
VIA GARISSA
Tel: 0124-2274

Kuja-River Research Sub-Centre,
P. 0. Box 223,
SARE-AWENDO.

Kaptagat Forest Research Sub-Centre,
P. 0. Box 4028,
ELDORET.
Tel: 0321-61472

Kibwezi Forest Research Sub-Centre,
P. 0. Box 892,
KIBWEZI.
Tel: 50

10.0 Financial Report

BALANCE SHEET AS AT 30TH JUNE 2000

	2000 KSHS.	*1999* KSHS.
Fixed Assets	**1,011,297,047**	**1,047,517,742**
Current Assets:		
Stock	11,093,900	14,753,147
Debtors	3,058,135	3,842,698
Cash at Bank	19,934,720	18,824,303
Investments: Treasury Bills	9,826,902	-
	43,913,657	37,420,148
Less: **Current Liabilities:**		
Creditors	3,322,056	2,409,810
Pension Fund	-	6,532,537
	3,322,056	8,942,347
Net Current Assets	40,591,601	28,477,801
	1,051,888,648	*1,075,995,5*
Financed by:		
Government Grant for Capital Assets	1,127,290,554	1,165,364,920
External Grant for Research	11, 555,652	10,461,118
Asset Revaluation Account	131,442,930	131,442,930
Accumulated Deficit:	(218,400,488)	(231,273,425)
	1,051,888,648	*1,075,995,543*

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30 TH 3UNE 2000

	2000 KSHS.	1999 KSHS.
Surplus Before Depreciation & Deferred Income	16,672,978	21,257,647
Less: Depreciation	*44,493,852*	*(48,708,981)*
Add: Deferred Income:	*42,398,721*	*46,708 120*
	14, 577, 847	*19,256,786*
Add: Closing Stock of Seeds, Seedlings - Forest Plantations	*8,813,393*	*11,349,441*
Less: Opening Stock Seeds & Seedlings	*11,349,441*	*(7,917,603)*
Surplus (Deficit) For the Year	*12,041,799*	*22,688,624*
Operating Deficit b/f	*(231,273,425)*	*(261,922,578)*
Prior Period Adjustment	*831,146*	*7,960,529*
	(218,400,480)	(231,273,4251)

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING 30TH JUNE, 2000

INCOME	2000 KSHS.	1999 KSHS.
Recurrent Government Grant	253,027,080	244,464,441
Development Government Grant	200,000	500,000
External Grant for Research	17,757,823	19,169,712
Sale of Forestry Produce	1,930,761	4,410,544
Other Income	383,508	325,574
Commission Income	107,973	111,118
Bus Charges (Income)	394,127	451,494
House Rent, Water & Electricity	339,401	295,171
Interest on Treasury Bills	544,168	-
Surchages	78,570	216,697
Hire of KEFRI Facilities	8,387,200	3,188,908
Gain on Sale of Motor Vehicles & Stores	1,849,121	3,029,914
Clinic Revenue	14,446	-
Insurance Compensation	837,000	-
Pension Refund (Dismissed employees)	1,832,806	-
	287,683,984	276,163,573
EXPENDITURE		
Salaries and Wages	135,966,080	134,077,271
Gratuity & Pension Contribution (Employer)	22,963,244	21,695,611
Other Personal Allowances	5,161,461	4,695,593
House Allowances	23,701,480	24,376,026
Motor Running Expenses	13,570,669	11,373,708
Travelling & Accommodation Expenses	10,354,469	8,290,572
External Travelling	2,549,925	2,425,251
Telephone, Telex and Postage	2,422,245	2,502,270
Office Entertainment	12,910	67,527
Printing, Publishing & Stationery	3,886,313	2,878,200
Staff Uniform	841,623	232,355
Library Expenses	105,360	71,590
Electricity, Water & Conservancy	5,769,954	3,423,512
Medical Al lowa nce(Non-Accountable)	11,332,466	12,185,977
Staff Medical Allowances	97,450	9,149
Repairs & Maintenance	3,766,890	4,952,791

INCOME CONT.

	2000 KSHS	1999 KSHS
Bank Charges	183,119	311,658
Purchase of Supplies for Production	6,319,164	3,097,755
Cost of Conference & Meetings	1,813,140	1,236,630
Miscellaneous Charges	75,398	254,489
Audit Fees	200.000	200,000
Contracted Professional fees	768,947	766,609
Advertising & Publicity	697,826	223,770
Training Expenses Food & Ration	5,136,578	3,539,704
Honoraria	1,270,534	191,651
Insurance of Property	1,365,689	1,769,829
Leave & Passage Expenses	2,507,539	3,331,655
Contribution to Statutory/ Member Organisations	43,036	95,919
Compensation and Ex-Gratia	847,176	1,117,896
Investigation, Planning & Design	-	100,055
Computer Expenses	1,192,612	526,064
Appropriation in Aid	-	520,000
Life Insurance Premium and Personal Accident	3,328,205	4,364,479
Clinic Drugs & Dressings	117,489	-
Medical Scheme Contribution (Employer)	2,642,015	-
TOTAL EXPENDITURE	271,011,006	254,905,926
SURPLUS BEFORE DEPRECIATION & DEFERRED INCOME	)x,672.978	21,257,647