THE UNITED REPUBLIC OF TANZANIA

Ministry of Natural Resources and Tourism

Forestry and Beekeeping Division

National Forestry Research Master Plan (NAFORM)

Prepared by
Tanzania Forestry Research Institute

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Contents

Abbreviations and Acronyms

AF	Agroforestry
ADRI	Animal Diseases Research Institute
CFF	Community and Farm Forestry
DG	Director General
DRD	Division of Research and Development, MAC
EAC	East African Community
EAAFRO	East African Agricultural and Forestry Research Organisation
FAO	Food and Agriculture Organisation of the United Nations
FBD	Forestry and Beekeeping Division, MNRT
FORST	Forestry Research Support in Tanzania
FOU	Forest Operations and Utilisation
FRA	Forest Resource Assessment
GDP	Gross Domestic Product
ha	Hectare
HASHI	Hifadhi Ardhi Shinyanga (A land conservation programme)
ICRAF	International Centre for Research in Agroforestry
IMF	International Monetary Fund
IRA	Institute of Resource Assessment
KEFRI	Kenya Forestry Research Institute
LITI	Livestock Training Institutes
MAC	Ministry of Agriculture and Co-operatives
MATI	MAC Training Institutes
m^3	Cubic meter
Mill	Million
MNF	Management of Natural Forests
MNRT	Ministry of Natural Resources and Tourism
NAFORM	National Forestry Research Master Plan
NALRM	National Agricultural and Livestock Research Master Plan
NEMC	National Environment Management Council
NGOs	Non–Governmental Organisations
NTSP	National Tree Seed Programme
NWFP	Non-Wood Forest Products
PFT	Plantation Forests and Tree Improvement
PSP	Permanent Sample Plots
SAP	Structural Adjustment Programme
SFM	Sustainable Forest Management
SPE	Socio-economics, Policy and Forestry Extension
SUA	Sokoine University of Agriculture
sph	Stems per hectare
t	Ton (metric)
TAFORI	Tanzania Forestry Research Institute
TANRIC	Tanzania Natural Resources Information Centre
TAS	Tanzania Shillings
TFAP	Tanzania Forestry Action Programme
TTRI	Tsetse Trypanosomiasis Research Institute
UDSM	University of Dar es Salaam
USD	United States Dollar

Currency Equivalents

(October 1999)
TAS 800.00= USD 1.0

Preface

Pursuant to the approval of the new National Forest Policy by the Government in 1998, TAFORI was directed to revise the 1992 Forestry Research Master Plan to address relevant issues identified in the policy document. It is apparent that there are gaps in knowledge and information. Therefore, the role of forestry research is to bridge the gap so as to enhance decision - making that will foster sustainable forest management (SFM). This will ensure sustainable supply of forest benefits to present and future generations.

In the preparation of the National Forestry Research Master Plan (NAFORM), stakeholders were involved in research prioritisation. They should also be involved in research implementation to ensure the necessary shift from supply to demand-driven research. This will result in both better results and their more effective implementation.

The NAFORM has six research programmes and one support programme. The research programmes are indicated by disciplines but multi-disciplinary research will be emphasised to ensure a more holistic approach. The plan has spelled out the objectives, outputs, activities, indicative costs and implementation strategies. Sustainable financing and co-ordination strategies have also been outlined.

The NAFORM is envisaged to serve as a guiding document for all those involved or are to be involved in forestry research in Tanzania. The practical implication is that forestry research by individuals and institutions can now be pursued as subjects that have been identified by stakeholders. It ensures that the limited research resources are directed to the most important forestry problems. It is therefore my sincere hope that TAFORI will take the lead to ensure that this document is available to all relevant stakeholders as well as instituting effective co-ordination.

There is optimism that this plan firmly and strategically places forestry research activities in Tanzania into the limelight. Further, the NAFORM has the full support of the Government.

Philemon L. Luhanjo
Permanent Secretary
Ministry of Natural Resources and Tourism

Acknowledgements

The Forestry and Beekeeping Division (FBD) directed the Tanzania Forestry Research Institute (TAFORI) to revise the 1992 Forestry Research Master Plan in order to address issues of current and future concern. TAFORI in turn appointed a task force to over see the process. The task force was composed of: Mr. E. Sabas, Chairman (TAFORI/FORST); Mr. I.Y. Mnangwone (FBD, MNRT); Dr. L. Nshubemuki (TAFORI); Dr. J. Saramaki (FORST); Prof. S.A.O. Chamshama (SUA); Dr. C. Mung'ong'o (IRA, UDSM); Mr. T. Kirway (DRD, MAC) and Mr. M. L. Mhando, Secretary (TAFORI). I wish to thank all members of the task force for their dedication, advice and guidance that led to the successful accomplishment of this work.

Resource persons contributed to the various chapters of the National Forestry Research Master Plan (NAFORM). It gives me great pleasure to appreciate contributions from the following: Dr. A.R.S. Kaoneka, Prof. A.G. Mugasha, Mr. E. Sabas, Mr. F.B.S. Makonda, Mr. I.Y. Mnangwone, Dr. K.F.S. Hamza, Dr. L. Nshubemuki, Mr. M. L. Mhando, Prof. R.E.L. Ole-Meiludie, Prof. S.A.O. Chamshama, Mr. S.T. Mwihomeke, Dr. S. S. Madoffe, Dr.Y. M. Ngaga and Prof. Z.S.K. Mvena. I also wish to thank Ms. H. Vanhanen of the Finnish Forestry Research Institute for her various inputs during the preparation of the NAFORM.

The NAFORM document was edited by Prof. S.A.O. Chamshama assisted by Dr. A.R.S. Kaoneka. I wish to thank them for their work and interest that they have devoted to this assignment.

I am grateful to Mr. I. Zilihona and W. C. Hamisy both of TAFORI for a commendable job in questionnaire response analysis and compilation.

I wish to thank all the stakeholders who responded to the questionnaires, the participants to the two workshops and those who reviewed the first draft for their input to the NAFORM.

I owe special thanks to the Government of Finland through the FORST project for the financial assistance that made it possible to accomplish the work of preparing the NAFORM.

Heartfelt thanks also go to the Ministry of Natural Resources and Tourism for not only initiating the idea of revising the NAFORM but also for accepting TAFORI invitations to officiate workshops including chairing a number of sessions.

The Board of Directors of TAFORI views the NAFORM (2000-2009) as the latest milestone in the quest for forestry research development in Tanzania. The Government and other stakeholders are asked to take note of this milestone, support it and make use of it.

Prof. Salome B. Misana
Chairperson, TAFORI Board of Directors

Executive Summary

Background to the NAFORM

The Tanzania Forestry Research Institute (TAFORI) was established in 1980 by Act No. 5 of 1980. Its functions include to carry out and co-ordinate forestry research in Tanzania and to disseminate research results to end-users. A TAFORI Forestry Research Master Plan covering the period (1993 – 2002) was prepared in 1992 (TAFORI 1992). It was then felt that in order to achieve the national forestry development objectives as spelt out in the Tanzania Forestry Action Plan (TFAP 1989), forestry research is a vital component. The National Forest Policy of 1998 directed that forestry research and development priorities be reviewed based on demand-driven research principles. In particular a new National Forestry Research Master Plan (NAFORM) should be developed to address issues, opportunities and challenges emerging from socio-economic, policy and environmental developments.

Objective of NAFORM

The overall goal of the NAFORM is to **develop appropriate knowledge and technology for the sustainable management of forest resources.** The specific objectives of the NAFORM on the basis of the overall goal are to:

- Develop management and conservation systems for natural forests.
- Generate appropriate tree planting/management, agroforestry and rehabilitation technologies for subsistence farmers and other land users.
- Improve productivity of plantations by identifying and improving suitable species and their nursery, establishment, management and protection techniques.
- Generate reliable data and information to guide decisions on forest issues at all levels.
- Develop efficient and environmentally sound harvesting techniques.
- Develop technologies for improved utilisation and marketing of forest products.
- Establish linkages between socio-economics, policy, forestry extension and natural resources as a basis for improving forest policy and forest management decisions.
- Develop research expertise, facilities and appropriate environment to respond to the forestry research needs of Tanzania.
- Develop and maintain cost-effective dissemination mechanisms.

Methodological Aspects

The preparation of the NAFORM was the responsibility of a task force composed of 8 members from TAFORI/FORST, SUA, UDSM, FBD and DRD. In addition, resource persons were nominated to provide input to specific subject areas.

A questionnaire survey was conducted in order to get the input of stakeholders in setting research priorities for the NAFORM. Four main categories of stakeholders were surveyed namely: forestry land management agencies, viz., NGOs, government and government agencies and private entities; Agricultural and Forestry Research and Training Institutions; end users of forest products; and forestry related international donor agencies.

The survey responses were summarised and used in appropriate sections of the NAFORM. The questionnaire responses and other aspects in the NAFORM were discussed during two national workshops involving stakeholder representatives. The final draft of NAFORM was synthesised by a team of two editors.

Strategies

In order to realise the objectives of the NAFORM, the following strategies will be used:

- Demand driven research and involvement of relevant stakeholders in the design and conduct of research so as to achieve better results and more effective implementation.
- Multi-disciplinary research approaches will be used to develop effective solutions to the multi-faceted problems on management and use of forests.
- Research emphasis will be on applied research i.e. research that focuses on problem identification, solution and prevention. Adaptive research i.e. research oriented towards adapting existing research results and technologies to minimise research costs will also be emphasised.
- Networking and linkages between institutions and researchers within the country, at regional and global levels will be emphasised in order to facilitate exchange of information, collaborative research projects and complementarity of research projects. This will minimise duplication of efforts ("reinventing of the wheel") and thus improve efficiency in the use of limited research resources.
- Contract research for clients with specific research issues.
- Develop "user-friendly" means of communicating forestry research results to stakeholders.

Research Programmes

The NAFORM consist of six research programmes namely:

- Management of Natural Forests;
- Community and Farm Forestry;
- Plantation Forestry and Tree Improvement;
- Forest Resource Assessment;
- Forest Operations and Utilisation;
- Socio-economics, Policy and Forestry Extension.

For each research programme information is provided on background and justification, objectives, outputs, research activities and indicative inputs.

Support Programme

Three sub-programmes within the support programme have been identified. These are:

- Human Resources;
- Infrastructure;
- Publications and Dissemination.

For each support programme information is given on background and justification, objectives, outputs, activities and indicative inputs.

Inputs

Indicative cost figures have been given for all research and support programmes. Specific input requirements are identified for each programme. Detailed research or support projects write-ups will come up with more realistic cost estimates.

The NAFORM entails substantial financial cost. Therefore more commitment and support of the government as well as assistance from donor agencies are important. In the longer term, a forestry research fund managed by a Board of Trustees should be established. Sources to the fund may include:

- Contributions by the government, donor agencies, international organisations, foundations, corporate bodies and private individuals.
- A research levy to be paid upon selling forest products.
- Environmental fee either charged separately or embodied in the price of forest products.

Implementation Arrangements

Overall Co-ordination

Act No. 5 of 1980 establishing TAFORI gave the Institute the mandate to co-ordinate research in forestry carried out within Tanzania mainland. The task of co-ordinating NAFORM implementation therefore clearly rests with TAFORI. The TAFORI Board of Directors through the Research and Publications Committee should oversee the implementation of the NAFORM. In order to ensure effective co-ordination of the NAFORM, it is recommended that a co-ordination unit headed by a Co-ordinator be established at TAFORI.

Monitoring and Evaluation

All research projects under the NAFORM shall be monitored and evaluated (*ex-ante*, current, termination and *ex-post*) to ensure that implementation is according to plan and to appraise projects/programmes in terms of relevance, effectiveness, efficiency and impact. Monitoring and evaluation systems shall be user-focussed by involving users in their design to ensure that user needs for information will be addressed.

Half-yearly reports shall be used to monitor and evaluate research projects and copies of the reports must be submitted to the Co-ordination Unit. External evaluations shall be done when required. TAFORI shall organise annual meetings where results of research activities will be presented. The NAFORM shall be revised from time to time as it is deemed necessary. Evaluation and review after five years is mandatory.

Concluding remark

NAFORM has been formulated. Meaningful efforts must be made to ensure its successful implementation. This demands the participation of all stakeholders, technical staff and scientists in appropriate fields. Also sustainable financing and proper co-ordination are vital aspects

Chapter 1 Introduction

1.1 Background to the NAFORM

The Tanzania Forestry Research Institute (TAFORI) was established in 1980 by Act No. 5 of 1980. Its functions include to carry out and co-ordinate forestry research in Tanzania and to disseminate research results to end-users. A TAFORI Forestry Research Master Plan covering the period (1993 – 2002) was prepared in 1992 (TAFORI 1992). It was then felt that in order to achieve the national forestry development objectives as spelt out in the Tanzania Forestry Action Plan (TFAP 1989), forestry research is a vital component. Moreover, global issues such as global agreements and conventions, of which Tanzania is a signatory, demand among others, thorough research. In view of this, the Forestry Research Master Plan was developed in order to concentrate scarce research resources on the most important forestry problems. However, inadequate human resource capacity, low priority in terms of funding and infrastructure development have hindered the implementation of most of the research programmes (MNRT 1998).

In the advent of policy, socio-economic, and environmental changes that have taken place since 1992, the Revised National Forest Policy of 1998 directed that "Forestry research and development priorities will be reviewed based on demand – driven research principles" (MNRT 1998: p.43). Further, it states that: "The Forestry Research Master Plan will be revised in collaboration with stakeholders, and will set out priority areas for forestry research. Research and development will focus on improved forest and tree management especially indigenous species. Collaboration between national research institutions will be promoted while keeping close linkages between the research institutions and users through information exchange, symposia, seminars and joint development of research plans. International and regional co-operation in forestry research will be promoted" (MNRT 1998: p.43).

On the basis of this background, the Forestry Research Master Plan has been revised to have a more national outlook and reflect the current National Forest Policy (MNRT 1998) as well as pertinent global issues. The methodology used in the preparation of the National Forestry Research Master Plan (NAFORM) is described in Chapter 3.

1.2 Forest Sector Review: Trends and Prospects

1.2.1 Resource Endowment

Forest Resource

Tanzania forests cover a total area of 33.5 Mill ha representing about 40% of the total land area (MNRT 1998). Over 96% of the forested land is classified as other wooded lands, 3.4% is closed forest and 0.3% mangroves. About 13 Mill ha have been gazetted as forest reserves. A modest area of 80,000 ha of the gazetted area owned by the government is under plantation forestry and about 1.6 Mill ha are under water catchment management. The main genera planted are *Pinus* and *Cupressus* (see also section 2.3.3). Annual replanting in the government forest plantations is estimated at

10,000 ha. Mangroves forest covers 115,000 ha. There are about 100,000 ha of woodlots/private plantations.

The major threat to the forest resources is accelerated deforestation estimated at 130,000 to 500,000 ha per year (MNRT 1998). The wide range is attributed to lack of regular forest resource assessment. The direct causes of deforestation include: settlement expansion (local inhabitants and refugees) and agriculture, commercial charcoal and fuelwood production, overgrazing, uncontrolled fires, shifting cultivation and illegal logging. The underlying causes of deforestation are rapid (and uncontrolled) population growth, poverty, market and policy failures as well as structural adjustment programmes (SAP). The consequences of deforestation include serious land degradation resulting in decreased land productivity, loss of biodiversity, loss of CO_2 sink and diminishing returns from forest investments. The link between poverty, population and environmental degradation is recognised. Yet specific studies for Tanzania to elucidate the exact links have not been conducted (see also sections 2.3.9 and 4.6).

Forest Industries

Forest-based industries in Tanzania are characterised by the presence of about 130 small industries concentrated in few regions. The skewed distribution has bearing on raw material removals, consumption pattern and domestic price. Based on installed capacity, the total wood processing capacity in 1992 was 900,000 m^3 $year^{-1}$ roundwood compared to 710,000 m^3 $year^{-1}$ roundwood in 1998 (Ngaga *et al.* 1998). Indigenous hardwoods from natural forests account for about 300,000 m^3 $year^{-1}$ roundwood whereas plantations contribute 600,000 m^3 $year^{-1}$ roundwood. In the advent of economic reforms most capacity has been privatised. Currently, the private sector has a significant share in the wood processing mills, especially in sawmilling where it owns about 78% (Ngaga *et al.* 1998). The factors causing low capacity utilisation include: poor technology; poor funding and investment; poor links between forest owners, the industry and market; and lack of business orientation.

The sawmilling industry is the oldest and most widely distributed wood processing industry consuming about 50% of the industrial roundwood. The installed sawn-hardwood capacity is about 90,000 m^3 of log intake per year and for sawn-softwood the installed capacity is about 220,000 m^3 of log intake per year (Ngaga *et al.* 1998). However in recent years some of the sawmills have been closed due to economic and technical reasons. In addition to industrial sawmilling capacity, pitsawing has a substantial share particularly in areas having poor accessibility and accounts for about 40% of national sawnwood production.

Wood-based panel products consumed in Tanzania are veneer and plywood, hardboards, chipboards and a modest amount of blockboards. The plywood mills have a rated capacity of 12,600 m^3 $year^{-1}$ although the present annual production capacity is only 1,700 m^3 $year^{1}$. The estimated hardboard annual production capacity is 9,000 m^3 but production has been about 52% of the annual mill capacity. The chipboards mill has a rated capacity of 7,000 m^3 $year^{-1}$. The actual production declined from 34% capacity utilisation in 1992 to 10% in 1995.

The pulp and paper industry is the second largest consumer of roundwood and accounts for 22% of softwood raw material consumption. The total pulping capacity is 75,000 t $year^{-1}$ of pulp and the paper manufacturing capacity is 78,000 t $year^{-1}$. The overall capacity utilisation is 32% (Table 1).

1.2.2 Socio-economic Assessment

Importance of the Forest Sector

Forests are important in Tanzania due to the myriad of goods and services they offer to the national economy and society to improve human welfare (see also section 2.3.8). Wood-based energy consumption is estimated to account for more than 92% of total energy consumed in Tanzania and per capita consumption is estimated at 1m^3 $year^{-1}$ (FBD 1992, MNRT 1998). Many of the forest products that have recognised market value are traded. The estimated contribution to the Gross Domestic Product (GDP) in 1998 was 3.3% (including hunting) and about 10% of the country's registered exports. The contribution would have been higher had the forest benefits been correctly valued. The sector employs about 3% of paid labour. Also the figure would have been higher if the forest sector was performing efficiently. Moreover, a substantial number of people in the informal sector are engaged in charcoal business that has been booming.

Production, Exports, Imports and Projection Outlook 1998-2018

Production Trends

The projection of production and trade based on study by Ngaga *et al.* (1998) is shown in Table 1. It can be gleaned from Table 1 that hardwood sawnwood declines by 2%. This is logical, as the resource base for hardwoods will decline drastically over the period. Moreover the government has imposed harvesting ban on most hardwood producing forests for a number of reasons including preservation of biodiversity and watershed values as well as allowance for standing trees to reach maturity.

Sawnwood from softwoods and paper and paperboard production are forecast to increase (Table 1) due to envisaged improvement in macro-economic indicators and hence a perceived expansion in both production and consumption.

Charcoal production is forecast to increase (Table 1) partially due to stagnation in technological development and inability of many consumers to switch over to alternative energy sources. The increase is also attributed to fairly rapid population growth and the increasing numbers of low-income urban dwellers.

Trade, Export and Import

According to a recent study by Ngaga *et al.* (1998), the international trade in forest products will be low in the medium and long term planning horizon. The projections suggest a net export in softwood at an average of 34,000 m^3 $year^{-1}$, hardwood sawnwood at 1,000 m^3 $year^{-1}$ and hardboard at 1000 t $year^{-1}$. The forecast further suggests a net import in all paper products ranging between 22,000 and 38,000 t $year^{-1}$. The increase in import is likely to trigger a slowdown in domestic production due to stiff market competition. The most important factors likely to affect production and

competition in trade include high production and transportation costs and low price-cost margin associated with low industrial capacity utilisation.

Table 1. Products and production capacity in 1998 (Ngaga *et al.* 1998)

Products	Capacity available, (000 m^3 or t)	Production (000 m^3 or t)		Change (%)
		1998	2018	
Sawnwood				
♦ Hardwood	105	94	92	-2
♦ Softwood	316	162	224	38[(1)]
Wood-panels	22	13	17	31
Paper and paperboard	94	30	54	81
Charcoal[(2)]	887	585	777	33

[(1)]The rather high positive change may be too optimistic because a lot of cleared plantations are yet to be replanted. Most probably the production of wood-based panels and paper and paperboard will be affected.
[(2)]Recorded and most likely an underestimation

Price Movement

The price trends for the period 1998 through 2018 as depicted in Table 2 indicate that most prices tend to be fairly inelastic due to some economic factors such as declining resource base, poor domestic production and low purchasing power as a result of slow economic growth. Certainly such prediction does paint an unfavourable future picture regarding the development of the forest industry sector.

Table 2: Average domestic price of various forest industry products for the period 1998 through 2018 (Ngaga *et al.* 1998)

Product	Price (000 TAS per m^3 or t)	
	1998	2018
Charcoal	25	30
Plywood	275	300
Sawwood		
♦ Hardwood	95	120
♦ Softwood	25	50
Hardboard	190	200
Chipboard	125	130
Newsprint	250	275
Other writing and printing papers	275	300
Packaging and wrapping papers	230	250

Non-Wood Forest Products

Potentially Tanzania could export a considerable amount of non-wood forest products (NWFP) such as honey, beeswax, herbal medicines, game meat, gums, as well as other

chemical products such as tannins and toxins. Other non-wood benefits of forests include watershed functions, maintenance of soil fertility, conservation of biodiversity, sustaining cultural values, carbon dioxide sequestration, climatic amelioration, creation of seasonal employment and tourism.

Most NWFP are harvested for subsistence consumption and form a significant part of household economies and play a vital part in food security. Thus research on NWFP development and marketing is required in order to widen the scope of utilisation (see also sections 2.3.8 and 4.5.2).

1.2.3 Management and Policy Issues: Retrospect and Impacts

Management Overview

The forest sector has been largely managed by the government through the Forestry and Beekeeping Division (FBD) in the Ministry of Natural Resources and Tourism (MNRT). Centralised management has caused both market and policy failures worth revisiting. Moreover, over the last couple of decades, Tanzania has been implementing SAP aimed at alleviating the economic ills of the country. The reforms have had both direct and indirect impacts on the forest sector. The impacts of these reforms are yet to be quantified and hence the need for more studies (see also sections 2.3.9 and 4.6). The reforms are so important that they will be briefly reviewed in this text.

A Case of Policy Failures

Policy failures are indexed upon the inability of the government to institute management with adequate financial and managerial capacity. The consequence has been inefficient management of the forest resource. This has led to improper tending and harvesting schedules. The financial cost was largely dependent on subsidy from the government, which has been inadequate. The government has been applying a system whereby all accrual revenues are remitted to the Treasury for reallocation. Nevertheless the allocation to forestry sector has been as small as 1% of the total national budget (MNRT 1998).

The second aspect of policy failure relates to the failure of the government to adequately define property rights thereby rendering unreserved forests an open access resource with the consequent risk of overexploitation and general resource degradation. It is often argued that well-defined and transferable property rights provide an incentive for efficient management and utilisation of forest resources (Kaoneka *et al.* 1998).

Thirdly, policy failures are indexed upon the inability of the government to charge a sufficiently high forest rent that reflects the real financial cost of managing forests partly due to absence of valuation studies. The low forest rent created an economic incentive for overexploitation of forests.

Finally, policy failures arise due to the implementation of old forest policy which fails to adequately address all emerging opportunities and constraints imposed by both national aspirations and international agreements and conventions for which Tanzania is a signatory.

A Case of Market Failure

Market failures are consequent upon the inability of market prices, especially under the condition of open access exploitation, externalities, incomplete information and imperfect competition, to reflect accurately the value of marketed and non-marketed or non-tradable environmental goods and services (Wardle and Kaoneka 1999). These failures are aggravated by the inherent market distortions in the Tanzanian economy.

Market failures are also consequent upon the inability of markets to ensure equity resource and income distribution to promote the maximisation of collective welfare of the society (Kaoneka *et al*. 1998, Wardle and Kaoneka 1999). Therefore the correction of both policy and market failures is not only an important issue but also an objective necessity. An explorative study by Kaoneka *et al.* (1998) suggests the adoption of new valuation and pricing approaches.

Impact of Structural Adjustment Programme

Tanzania embarked on economic reforms in the early 1980s under the SAP sponsored by the International Monetary Fund (IMF) and the World Bank. The measures of the SAP package included liberalisation of trade, reducing government spending, floating exchange rate of the domestic currency and decentralisation of management roles largely through privatisation and devolution.

Trade Liberalisation

The idea of trade liberalisation is to remove barriers that have bearing on the free performance of markets. Such trade barriers include tariffs, taxes and subsidies. Liberalised trade introduced market competition on both substituting and complementary forest products. Locally produced forest products, however, could not withstand market competition basically due to inferior quality of final products.

Further, heavily subsidised public wood processing industries could not match competition due to inefficiency. Therefore, the expected improvement in efficiency and international trade competitiveness could not be achieved. Over the longer-term, however, trade liberalisation is likely to have a positive effect provided certain conditions such as the existence of a good system of forest management.

Reducing Government Expenditure

The measure of reducing government expenditure was intended to minimise budget deficit, a chronic characteristic of the Tanzanian economy. In order to achieve the intended goal a number of measures were introduced including:

- reducing or eliminating government subsidies on public enterprises including the forest sector;
- reducing budgetary allocations to some public sectors;
- cuts on government paid manpower; and
- transferring responsibility of some functions to the private sector.

The measure has had dual drastic impact on the development of the forest sector as it reduced the financial capacity of the FBD to manage the forest resources effectively, as it depended entirely on government subsidy to manage its affairs. Furthermore, there

was contraction in the capacity for long-term investment in primary forest production, forest harvesting and wood processing.

Floating Exchange Rates

The floating of exchange rates of the local currency, the Tanzania shilling (TAS), was done in order that the demand and supply of foreign currency be efficiently allocated through market forces rather than being rationed by the government. The immediate impact of the measure was massive devaluation of the shilling against major currencies such as Sterling Pound and United States Dollar (USD).

Ideally, according to economic principles of international trade, devaluation encourages production of export products, as they become price-competitive due to cheapness in the world market. Despite the perceived opportunity, the forest sector could not benefit due to weak and inefficient wood processing capacity.

The National Forest Policy

For nearly three decades the independent Tanzania has been implementing a forest policy of 1953. The policy emphasised among other things the need to protect forest resources and managing them in the most productive way to meet present and future needs. The policy envisaged shared responsibilities. However, there was no legal provision to enforce such responsibilities. Deficiencies of the old policy led to the development of a revised forest policy.

The revised National Forest Policy (MNRT 1998) reflects a long-term effort. The policy represents an improved vision of the forest sector in a wide context. The policy recognises explicitly the role of various stakeholders, viz., government, private owners and local communities. The new national forest policy represents both opportunities and constraints.

Objective of the revised National Forest Policy:

"The overall goal of the National Forest Policy is to enhance the contribution of the forest sector to the sustainable development of Tanzania and the conservation and management of her natural resources for the benefit of present and future generations" (MNRT 1998 p.14).

The objectives of the forest sector on the basis of the overall goal are as follows:

- Ensured sustainable supply of forest products and services by maintaining sufficient forest area under effective management;
- Increased employment and foreign exchange earnings through sustainable forest-based industrial development and trade;
- Ensured ecosystem stability through conservation of forest biodiversity, water catchments and soil fertility;
- Enhanced national capacity to manage and develop the forest sector in collaboration with other stakeholder;

The revised National Forest Policy envisages three types of ownership pattern: private and concession system, joint management agreements and community-based ownership. Successful adoption of the new management paradigms requires some basic knowledge.

1.3 Forestry Research Contribution

Forestry research in Tanzania has contributed to the development of the forest sector. Biological studies such as provenance trials, tree breeding and different silvicultural techniques have contributed to the successful establishment of forest plantations while other studies have contributed to better understanding of forests as ecosystems (see also section 2.3). Such studies have formed the basis for evolving effective management strategies and protection measures.

Socio-economic studies have produced information on production and general utilisation of forest products (see also section 2.3). They have generated information necessary for creating marketing strategies of various forest products. Moreover such studies have produced indicative contributions of the forest sector to GDP and employment. The studies have exposed the inefficiency in most public wood processing facilities.

Extensive research has been constrained by low budgetary allocation from the central government and limited personnel capacity in relevant fields (see also section 2.2). One reason for low budgetary allocation perhaps is that research undertakings take time to produce the required or expected positive outputs. This may influence decision-makers to put low emphasis on forestry research. Also poor economic performance, strict implementation of SAP and servicing of external debt has reduced the financial capacity of the government to fund forestry research.

Past and present research results have indicated knowledge gap on various issues. Further, successful implementation of the National Forest Policy demand, *inter alia*, the availability of reliable knowledge and information. Forestry research should lead to better understanding of the concepts and approaches to sustainable forest management (SFM) and provide more effective tools to render SFM more profitable and acceptable.

Chapter 2 Background: Forestry Research in Tanzania

2.1 Historical Perspectives

Nshubemuki (1998) gives a comprehensive account of Tanzania's forest research history. Historical review of most institutions involved in forestry and forestry related research is also available in DRT (1991) and TAFORI (1992). Three distinct periods are recognised. The German and British periods, and the situation after independence.

The German period is credited for the establishment of a 2.5 ha nursery near Dar es Salaam in 1893. The nursery tested over 270 species for tropical plantations, ornamental and other trees. Another major development during the German period was the establishment of the Biological Agricultural Research Station at Amani in 1902. The station undertook a systematic test of indigenous (Juniper and Podo) and exotic (Cypress, Eucalypts, Teak and Black Wattle) tree species. A number of tree species tested, currently constitute major plantation tree species in Tanzania.

The British period is noted for the consolidation of the pioneering work started by the Germans. These included the renaming (1928) the Amani Station to East African Agricultural Research Station and its subsequent shift from Amani to Muguga in 1948. Large scale planting of exotics was also initiated during that period. The tree species used being *Pinus patula, P. radiata* and *Cupressus Iusitanica*. Furthermore, Mr. D.K.S. Grant first published some studies of local timbers undertaken in this period in 1936 under "Tanganyika Timbers". This was later revised to include more tree species (Bryce 1967).

Following the shifting of the Amani station to Muguga to form the East African Agricultural and Forestry Research Organisation (EAAFRO), in the early 1950's the then Tanganyika Government established Silvicultural and Utilisation Research Stations respectively at Lushoto and Moshi to cater for research problems specific to the country while EAAFRO concentrated on regional research needs.

The period between 1950 to 1961 when Tanganyika won independence, and thereafter up to 1980 is the most important one due to enhanced output of forest research from improved research facilities and networking provided by EAAFRO.

The establishment of the Department of Forestry in 1973 at Morogoro Campus of the University of Dar es Salaam (UDSM), further augmented the national forestry research effort. This is because the training of foresters at technical level had been initiated some 40 years earlier. In 1974, the Department was elevated to a Division. When the Parliament enacted Act No 6 of 1984 establishing Sokoine University of Agriculture (SUA), the Division became the Faculty of Forestry and has since 1998 been renamed Faculty of Forestry and Nature Conservation.

The collapse of the East African Community (EAC) an umbrella organisation embracing EAAFRO activities in 1977, led to the establishment of TAFORI in 1980. The Institute is mandated to carry out and co-ordinate forestry research in Tanzania to fill the forestry research deficiencies resulting from the collapse of the EAC.

TAFORI is semi-autonomous, self-accounting and overseen by the Board of Directors and is currently under the MNRT.

In its first decade (1980-1990), TAFORI experienced considerable funding constraints due to unfavourable economic climate, lack of facilities and incentives to attract experienced scientists. Considerable improvements in the funding of TAFORI were registered in mid 1990's especially under the Finnish Government funded project "Forestry Research Support in Tanzania" (FORST).

2.2 Institutional Framework, Human and Research Resources

2.2.1 Institutional Framework

Relevant Institutions

Forestry Research in Tanzania has always been conducted by various institutions including governmental, non-governmental (NGO) and private. Forestry Research has also been carried out under specific projects and programmes.

The major institutions doing forestry research and related activities are: TAFORI and the National Tree Seed Programme (NTSP) under the MNRT; Faculty of Forestry and Nature Conservation (SUA) and Institute of Resource Assessment (IRA) and Department of Botany (UDSM) under the Ministry of Science, Technology and Higher Education; Division of Research and Development (DRD) under the Ministry of Agriculture and Co-operatives (MAC) and the National Environment Management Council (NEMC) under the Vice-President's Office.

Other Institutions/Faculties which are involved in forestry and forestry related research include:

- Forestry Training Institute, Olmotonyi;
- College of African Wildlife Management, Mweka;
- Forest Industries Training Institute ,Moshi;
- Njiro Beekeeping Research Centre, Arusha;
- Ngorongoro Conservation Area Authority, Ngorongoro;
- Tanzania Wildlife Research Institute, Serengeti;
- Faculty of Agriculture, SUA, Morogoro;
- Faculty of Arts and Social Sciences, UDSM, Dar es Salaam;
- Department of Zoology and Marine Sciences, UDSM, Dar es Salaam;
- Tropical Pesticides Research Institute, Arusha;
- Institute of Traditional Medicine, Muhimbili University College of Health Sciences, UDSM, Dar es Salaam;
- Building Research Unit, Ministry of Lands and Human Settlements, Dar es Salaam;
- MAC Training Institutes (MATIs), in various parts;
- University College of Lands and Architectural Studies, UDSM, Dar es Salaam.

Several non-governmental organisations and private companies are involved in forestry research. These include the Tanganyika Wattle Company, Kilombero Valley Teak Company, Wildlife Fund for Nature (WWF) and Wildlife Conservation Society of Tanzania.

Although different institutions are involved in various aspects related to forestry research, the bulk of the research obligations are vested with TAFORI. The institute has full mandate to conduct, co-ordinate and disseminate forestry research in Tanzania. Co-ordination has generally been weak and measures to ensure effective co-ordination are outlined in section 7.1.

Institutional Linkages

Since all the institutions involved in forestry research were started at different times and with different mandates, it would seem reasonable to elucidate overlaps and avoid duplication while at the same time putting mechanisms in place to share research results and experiences. Exchanging ideas and information while research is in progress, and collaborating with other scientists, can greatly speed up the process of finding solutions to the complex critical problems. However there seem to be lack of active linkages. The lack of linkages and co-ordination and communication among research institutions has adverse impact on forestry research development. These cannot simply be ignored by decision-makers. Weak linkages have also been shown in agriculture as pointed by the National Agricultural Research Master Plan (NALRM) of 1991 that: "a few formal linkages still exist between research and extension and with the universities, but linkages with other agencies, private or governmental, that are interested in agricultural research have all but ceased to exist."(DRT 1991: p 36)

Examples of the few linkages can be cited. These include the joint establishment of medicinal research plants at Lushoto between TAFORI and the Institute of Traditional Medicine, joint research in agroforestry between Agricultural and TAFORI research staff at the Southern African Development Community (SADC)/International Centre for Research in Agroforestry (ICRAF) Agroforestry Project at Tumbi, Tabora and TAFORI/ ICRAF and Hifadhi Ardhi Shinyanga (HASHI) Agroforestry Research Project in Shinyanga. Others are joint TAFORI and Faculty of Forestry and Nature Conservation Project on monitoring of the effects of leucaena psyllid parasitoids and involvement of TAFORI staff in the development of timber quality rules by the Tanzania Bureau of Standards. There is a memorandum of understanding between TAFORI and SUA and between the institutions and other institutions like the Centre for International Forestry Research (CIFOR).

Reasons for poor research linkages between and within institutions are attributed to lack of financial and human resources. Consequently, linkages have mainly been with institutions that can source funds. As a result institutions have more linkages with foreign national and international research institutions than with local ones.

To make effective use of the available human and financial resources, leaders of forestry research institutions and organisations should encourage, facilitate and promote research linkages. Research linkages offer the following opportunities:

- Promotes the sharing of scientific information and expertise;
- Provides opportunities for developing staff skills and exchanging technologies;
- Provides access to knowledge and skills outside of forestry research institutions and organisations;

- Reduce research costs and makes more effective use of scarce research talents and skills;
- Reduce unnecessary duplication of research efforts;
- Co-ordinates research programmes/projects for a more effective problem-solving approach;
- Links researchers and educators and trainers to facilitate the transfer of updated information in the classroom and the field.

2.2.2 Human and Research Resources

Human Resources

Currently there are over 30 institutions doing forestry and forestry related research in Tanzania with quite varied degrees of research capacities. Based on the survey data, most of the forestry research institutions in Tanzania, save for the Universities, are constrained by human resources. Therefore meaningful human resources development is necessary.

The current situation is indicated in Table 3. The overall picture of the forestry related research and training institutions with regard to human resource remains unsatisfactory hence the need for constant review of human resources development plans.

Research Resources

Save for the universities, most of forestry research related institutions in Tanzania have a long history that has implications on their status with regard to research capacity. Under normal circumstances, long-standing institutions are supposed to have quite strong research capacity. However, the situation in Tanzania is quite different. The existing institutions are adversely affected by recurrent problems with respect to funding and physical resources.

Funding

Many of the institutions are grossly under-funded. Budgetary allocation to forestry and forest related issues have been 1% of the total budget. For example, allocation to TAFORI from the government for the past ten years has been an average of about 28% of its annual requirements. The major portion of the allocation from the government covered salaries and overheads with a small part going to actual research. Support from donor agencies has covered human resource development, physical resources and research activities. Donors meet about 70% of total forestry research costs (see also section 6.4)

Physical Resources

The Universities are better endowed with research resources. For the other institutions, there are limited physical resources in terms of office space, office equipment, staff housing, fully equipped laboratories, and field equipment and transport facilities. Most of the available facilities are old, obsolete and not well maintained. Further, some facilities such as laboratory equipment are not entirely

suitable to the local conditions and hence inefficiently utilised. Details on available physical resources may be obtained from DRT (1991) and TAFORI (1992). Overall, the available laboratories have the capacity to mainly meet institutional needs.

Table 3: Human resources situation in forestry research, training and related institutions

	Ph.D	M.Sc.	B.Sc.
SUA-Agriculture	70	34	0
SUA-Forestry	30	8	1
UDSM-IRA	14	5	0
UDSM-Botany	11	2	0
DRD-Central Zone	3	10	7
DRD-Eastern Zone	13	53	32
DRD-Lake Zone	4	20	11
DRD-Northern Zone	12	25	14
DRD-Southern Zone	3	11	4
DRD- S. Highlands	8	31	15
DRD-Western Zone	1	10	3
DRD-ADRI/TTRI	4	12	13
DRD-HQ- Temeke	4	14	13
TAFORI.	1	14	5
NTSP	0	2	5
LITI-Morogoro	0	8	5
MATI-Ilonga	0	4	6
MATI-Ukiriguru	0	4	3
MATI-Uyole	1	11	15
MATI-Kilombero	1	1	3

Source: Survey data (1999) and DRD, MAC

2.3. Past and Current Research Activities

2.3.1 Tree/Shrub Seed and Nursery

Seed research in Tanzania has mainly focused on: timing and collection procedures, storage and germination studies. Species coverage involved a mix of indigenous and exotic species. A comprehensive treatment of pre-sowing methods, germination and rapid viability testing, and methods for growing seedlings from seed for 123 indigenous tree species including indigenous fruit tree species, is provided by Msanga (1998).

Early nursery studies were tailored towards producing large, healthy and robust seedlings. Following expansion of tree planting to drier areas in the 1970s, later studies emphasised on production of drought hardy seedlings. Nursery related studies have generally focussed on potting mixtures, myccorhizae, sowing techniques, drought hardiness inducement, fertiliser types and application levels, phytotoxicity,

diseases and effects of soil reaction on seedling survival and growth. Chamshama and Nshubemuki (1998) give a detailed overview of these studies.

While an impressive quantity of tree/shrub seed and nursery research has been carried out (Somi and Nshubemuki 1980), this has emphasised more on exotics than indigenous species. This has resulted in having insufficient knowledge of suitable nursery techniques for the establishment of indigenous species.

2.3.2 Tree Improvement

The Germans made initial introduction of exotic species in trial plots in 1891 through 1914 (Schabel 1990). More species trials were laid out following the establishment of arboreta at Kigogo, Sao Hill in 1935, and Lushoto (1952). Two genera, *Eucalyptus* and *Pinus* are the most widely planted. Other species that were widely planted include: *Cupressus lusitanica, Cedrela odorata, Gmelina arborea, Azadirachta indica, Senna siamea, Acacia* spp. and *Tectona grandis.* Most of the early trials were laid out in highland areas but were later extended to low potential areas (Forest Division 1984).

Other tree improvement work carried out mainly during the period 1950s and late 1970s emphasised on provenance testing, progeny testing, seed orchards, seed stand establishment, selection of plus trees and establishment of clone banks. The tree improvement activities have been summarised (Madoffe and Chamshama 1989). Selection and breeding has focused on survival, growth and stem form while selection for desired wood has only recently received attention. While most provenance trial results have been published (see for example Nshubemuki 1998), other trials lacked proper follow-up due to absence of qualified tree breeders and funding constraints as the tree improvement activities were entering the second generation requiring more sophisticated quantitative methods.

In an effort to broaden the genetic base and species range, new provenance trials involving *Casuarina* spp., *Grevillea robusta* and *Azadirachta indica* have recently been established.

2.3.3 Plantation Establishment and Management

Results of plantation establishment and management studies have been summarised (Chamshama and Nshubemuki 1998). Site preparation studies show that rigorous site preparation such as mechanical complete cultivation result in improved survival and early growth of planted seedlings. The technique is expensive and thus requires adequate financial outlay.

Results from spacing trials involving *C. lusitanica, P. patula* and *Tectona grandis* showed non significant differences in most variables between the current spacing of 2.4 x 2.4 m and 3.0 x 3.0 m. A spacing of 3.0 x 3.0 m was recommended if sawnwood is the production goal as this would result in a later and merchantable thinning and reduced cost of thinning as there would be fewer thinning schedules. However, the recommendation is yet to be implemented due to lack of funds and indifference in pricing of timber products. It is also worth noting that this spacing regime is also used in Zambia, Zimbabwe and South Africa.

A number of reports have indicated nutrient deficiencies in first rotation stand (Lundgren 1978). Limiting nutrients are: nitrogen, phosphorus and (in the Southern Highlands), boron. The few fertiliser trials carried out have shown that it is possible to increase yield through application of mostly nitrogen and phosphorus.

There are ongoing studies in a number of forest projects on the effects of chemical fertilisers and interplanting with leguminous tree/shrubs on productivity of second rotation crops. The use of nitrogen fixing legumes is especially viable given the financial constraints facing the forestry sector.

Several studies have been carried out on the effects of weeding types/intensities on seedling survival and growth. The results show the superiority of clean weeding over spot, strip and control treatments.

An evaluation of the Taungya system at North Kilimanjaro showed that the practice is beneficial in terms of tree survival, food crop production, financial income to the peasants. Currently, a study in the West Usambaras is evaluating the effect of the taungya farming on soil fertility, soil erosion and productivity as well as socio-economic impact of the system.

There are no pruning trials. Thinning research has been conducted in Tanzania mainly on *P. patula* and *C. lusitanica* and thinning recommendations have been given. The recommended thinning schedules are spacing of 3.0 x 3.0 m, 1111 sph, without thinning and rotation age of 25 years; and a spacing of 3.0 x 3.0 m, 1111 sph and one commercial thinning at the age of 15 years. The problem has been on the lack of adoption of recommendations.

Prior to 1950's there were few studies in forest protection. However, the introduction of exotic tree species in 1950's provided an opportunity for the emergence of new insect pests and diseases that were previously only found in the native habitats. This consequently called for studies of these new developments. Among the first studies were survey of forest diseases and injurious timber insects in the early 1960's (Etheridge 1965).

To date some of the most outstanding research undertaken includes wood preservative studies, survey of biology and ecology of wood-living beetles, conifer aphids and mahogany defoliators. The studies indicate that silvicultural and cultural methods in forest management could limit insect pests and disease incidences. Breeding for resistance was also initiated for *Dothistroma* needle blight and pine woolly aphids. Although these activities were not continued, due to paucity of experts, funds and equipment, it was a good starting-point towards the cultivation of exotic conifers in Tanzania. Biological control using exotic predators (*Tetraphleps raoi*, *Leucopis tapiae*) and parasitoids (*Tamarixia leucenae* and *Psyllaephagus yaseeni*) has also been undertaken against pine woolly aphids and leucaena psyllid respectively. Furthermore, biological control against cypress aphid using parasitoids (*Pauesia* spp) is currently being undertaken.

Research in fire ecology has been lagging behind until in the recent years when studies on the effect of fire on flora and fauna were undertaken. The relationships

between fire occurrence and peoples' occupation and/or forest uses have also been studied.

2.3.4 Management of Natural Forests

Research in natural forests was initiated in Tanzania just and after independence. However, it is noted that the momentum could not be maintained for a long time due to under funding and rapid turn over of forest researchers and management staff (Mugasha 1999). Indeed research in natural forests has lagged behind that of exotic tree species most likely because of the common belief that indigenous tree species are slow growing.

Past research results in natural forests up to 1978 mainly carried out in Kilimanjaro, Meru, Usambara and in the Miombo have been summarised (Somi and Nshubemuki 1978). The major highlights are:

- Complete protection from fire in clear felled miombo resulted in profuse and rapid regeneration. The regeneration was however considered too dense and may entail expensive thinnings. Both annual early burning and alternate annual no burning and late burning were considered better management options than complete protection from fire and annual late burning (control);
- *Olea capensis* (1.8 m long striplings) nest planted and mixed with *Grevillea robusta* as a nurse tree resulted in good growth and fewer branches than line planted *Olea* or when nursed with *P. elliottii, Trema orientalis, G. arborea, Vitex keniensis* and *Acrocarpus fraxinifolius*;
- Clearfelling of mature and overmature *Ocotea usambarensis* resulted in better natural regeneration than girding and frilling with different chemicals;
- Direct sowing of *Beilschmedia kweo, Cephalosphaera usambarensis* and *Newtonia buchananii* was found not a suitable method for regenerating these species. Natural regeneration of these species was found to be profuse and well distributed;
- Gap planting resulted in good survival and growth of *V. keniensis* and *A. fraxinifolius* but poor survival of *Maesopsis eminii, Khaya anthotheca, Cedrella ordorata, Terminalia superba and T. ivorensis*;
- Artificial regeneration and underplanting resulted in poor survival and growth of *Podocarpus usambarensis.* Natural regeneration of *P. usambarensis, Baikiaea eminii* and *Heywoodia* spp responds well to canopy opening;
- Artificial planting of *C. usambarensis, T. ivorensis, M. eminii* and *C.ordorata* resulted in high survival and growth;
- Root suckers provide the most promising means of regenerating *Millicia excelsa* compared to coppicing and direct seeding. Stump planting (1.9 cm diameter and 27 cm root length) gives good survival and growth;
- Thinning (medium and heavy) results in increased diameter growth of second growth *O. usambarensis.*

The wetlands, lowland forests along the coastal belt and mangroves have not received much research attention. Research at ecosystem level is also lacking. Also, the available growth data is for few species and is incomplete to enable making sound decisions. In this decade, a permanent sample plot (PSP) programme has been initiated in a closed undisturbed montane forest at Mazumbai, dry miombo forests at

Kitulang'alo Forest Reserve and moist miombo in Iringa. Baseline data has been collected and preliminary results obtained.

In the last two decades hydrological studies have been undertaken in Mbeya, Sao Hill forest plantations, Iringa catchment areas, Mazumbai and Morogoro. Gauging stations also exist in many major rivers. Average evapotranspiration for evergreen forest in Mbeya was found to be 1400 mm per year. At Sao Hill, water use by *Eucalyptus saligna, Pinus patula* and grassland were 830, 665 and 613 mm yr^{-1} (Mhando 1991). Dynamics of soil water potential showed that soil under forest cover is drier than that under grassland. Soils under eucalypts were drier than those under pines. It is noted that little research has been undertaken on the hydrological processes and the influence of forests and human activities on water quantity and quality under different climatic and soil conditions. To allow generalizations there is need to assess the hydrological role of forests in different climatic, soil and land use environments.

Some phenological studies were initiated in 1976 with about 700 tree species but could not be continued due to poor funding. Several botanical surveys for purposes of species identification, herbarium material and/or ethnobotany have been undertaken in the Usambara, Uluguru, Nguru, Nguu, Rubeho and Udzungwa (Pocs *et al.*1990, Lovett and Pocs 1993, Mmari and Mabula 1996). Systematic biodiversity surveys were initiated in six forest reserves in East Usambara in 1995 aimed at developing biodiversity database (EUCFP 1995). The phenological observations and floristic inventories have been limited to a few species and forests. The need for more systematic biodiversity inventories in different ecosystems cannot be overemphasized.

Information on phenotypic and genetic variability of indigenous trees species is necessary for their conservation and management. Current research on spatial and genetic variation of the African Ebony (*Dalbegia melanoxylon*), traditionally protected forests (mainly sacred forests) and the African violet (*Saint paulia*) will aid in the management and conservation of the two species and natural forests. Effects of different forest interventions on regeneration, growth and quality of trees in different ecosystems is also limited. Stand manipulation studies initiated in Tabora dry miombo woodlands are a step in the right direction. Such studies need to be stepped up to cover other species and areas and ecosystems.

Few forest protection studies have been undertaken in natural forests. These include survey of forest diseases and injurious timber insects, survey of insects for reference collection, biology and ecology of wood living insects, psyllid galls control in *Khaya anthotheca* and *M. excelsa* rearing of parasites for the control of *Gonometa podocarpi* and heart rot studies in *O. usambarensis*. Studies on stem cracks in *N. buchananii* are ongoing. About 1000 species for reference are available. The introduction of exotic species has increased the chances of eruption of new pests and diseases. Therefore there is a need to undertake short and long-term research activities to mitigate the impact.

Only scanty and mainly explorative studies have been conducted on the values of forests on environmental services such as climate change and CO_2 sequestration. However, pursuant to the Kyoto Protocol of 1997, it is likely that more efforts will be

directed towards researching issues related to climate change and other environmental issues. Further, of late there has markets for environmental goods and services are emerging hence an economic incentive for investing in research on environmental issues.

2.3.5 Community and Farm Forestry

According to Tanzania's revised National Forest Policy, community and farm forestry (CFF) apply to agroforestry practices of planting, managing and utilising trees/shrubs for various functions on crop lands, grazing lands, and home compounds. It also applies to the involvement of farmers and other members of the community in afforestation of degraded communal lands and protection of surrounding natural forests.

Agroforestry (AF) is simply defined as the science and art of cultivating trees in the farmland. It can greatly influence the alleviation of land shortage in densely populated zones through enabling the same piece of land to provide for crop, wood and animal based goods and services, maintain and even promote the productivity of farming systems through soil erosion control and soil fertility enhancement. AF is a traditional land use practice in many parts of Tanzania. It is most practised and developed in the densely populated parts of the country.

Early CFF research focused on two areas namely woodlot establishment and AF. Establishment of woodlots in Tanzania was intensified in the late 1960's with establishment of the Village Forestry Section by the FBD. The goals for establishment of woodlots were to supply wood for various purposes, control of soil erosion and improvement of soil fertility. In the absence of formal research on the establishment and management of woodlots, practices used in industrial plantations were adopted for use in woodlots. There has been modest success. Due to land shortage, farmers find it difficult to exclusively allocate arable land for woodlots. Furthermore, the time of planting and tending woodlots coincides with the time for planting and tending of agricultural crops and hence the competition for labour. In order to enable farmers to introduce trees/shrubs on their farms, AF research was initiated in Tanzania in mid 1970's.

The first formal AF experiment was established by SUA (the then Faculty of Agriculture, Forestry and Veterinary Science of the UDSM) at the University Farm, Mafiga in 1976 (Lulandala 1978) and significant expansion took place in the subsequent years. In 1989 AF research was extended to Gairo, a semi-arid area. Some other institutions in Tanzania have also been involved in agroforestry research. These institutions include TAFORI and some Agricultural Research Institutes. The research carried out up to mid 1990's has evaluated effects of intercropping and alley cropping on the performance of tree and food crops. The commonly used species was *Leucaena leucocephala.* Some other species such as *Eucalyptus tereticornis, E. camaldulensis, Faidherbia albida* and *Prosopis juliflora* have been used for intercropping mainly with maize, sorghum and beans. In general intercropping of food crops with trees was found to increase yield of food crops, an effect partly attributed to improved nutrient relations. However, intercropping of food crops with trees works well in humid areas where there is no restriction in soil moisture availability. It does not work well in semi-arid areas because food crop yields from inter-cropping and alley cropping systems tend to decline with time due to an increase in below ground competition for moisture and nutrients between food crops and trees (Chamshama *et al.* 1998). Soil moisture availability is one of the important factors limiting food crop

productivity in semi-arid areas. Against this background, alternative AF technologies (i.e. rotational woodlots, improved-fallows, relay-cropping systems) for semi-arid areas of Tanzania have been tested in Morogoro, Shinyanga and Tabora.

The rotational woodlot is a low input and cost effective technology which can provide tree products, maintain soil fertility and provide fodder for livestock while conserving the environment (Otysina *et al*. 1996). The system involves a tree establishment phase where fast growing multipurpose trees are intercropped with crops, a tree fallow phase when trees are allowed to grow and develop, and post fallow phase when trees are harvested and the cropping cycle started again. Since farmers do not have to leave a portion of their land for woodlots only, rotational woodlots offer an opportunity for introducing trees on farmland. Rotational woodlots can also alleviate utilisation pressure exerted on natural forests/woodlands.

Rotational woodlot technology has been evaluated in Shinyanga and Tabora. In Shinyanga, rotational woodlots using *Acacia polyacantha* and *L. leucocephala* produced 11 and 13 t ha^{-1} $year^{-1}$ of fuelwood respectively. In Tabora, the wood produced from 2.5 and 5 year old *Acacia crassicarpa* woodlots was respectively 112 and 187 t ha^{-1} (Anon. 1998). This suggests that adoption of rotational woodlots using indigenous and Australian acacias may significantly check deforestation of woodlands and forests and consequently reduce environmental degradation. In Tabora and Shinyanga rotational woodlot research is now focusing on soil fertility improvement and maintenance, and increasing production of cotton and food focusing on rice and maize. Rotational woodlot research has also been initiated in Morogoro.

Improved fallow is targeted use of planted species in order to achieve one or more of the aims of natural fallow within a short time or on a smaller area. Traditional fallow take several years to restore fertility because natural vegetation is slow in reaching maximum biological productivity. In contrast, systems in which fast growing trees are selected, planted and managed in fallow, can grow and mature within a short time thereby enhancing soil fertility by bringing up nutrients from lower soil layers, litter fall and atmospheric nitrogen fixation (Sanchez *et al*. 1985). At the end of the fallow period trees/shrubs are cut down and materials not used as fuelwood are returned to the soil. In Tanzania, *Cajanus cajan, Gliricidia sepium, Sesbania macrantha* and S. *sesban* and *Tephrosia vogelii* have been evaluated for improved fallows. Increased nitrogen (up to 448%) and phosphorus (up to 192%) uptake and maize yields (up to 135%) after a two year fallow of *G. sepium* have been reported from Morogoro (Chingonikaya 1999). For sub-humid and semi-arid areas of Morogoro, *G. sepium, S. macrantha* and S. *sesban* and *T. vogelii* appear to be suitable species for improved fallows. Maize grain yield increases of up to 172% over natural fallow have been recorded after 2 year *S. sesban* fallows in Tabora and Ukiriguru (Anon.1998). Cotton grown after *S. sesban fallows* at Ukiruguru has shown an increase of over 50% over natural fallows. Highest seed cotton yields were observed in the two years fallow as compared to one year fallow (Anon. 1998).

Improved fallows can also increase wood supply. For example, the wood biomass yield from 2 year fallows of *G. sepium* and *S. sesban* at Gairo was 43.6 and 25.6 t ha^{-1} respectively (Chingonikaya 1999). Corresponding yields from SUA farm were 43.6 and 25.5 t ha^{-1} (Chamshama and Mugasha 1999 unpublished data).

In places where land holdings are limited, the alternative to rotational woodlots and improved fallows is the practice of relay cropping in which land is not left fallow but annual crops are interplanted with fast growing nitrogen fixing shrubs/trees. Following harvesting of food crops, shrubs/trees are allowed to grow during the dry season. Just before the next planting season all shrubs/trees are also cut and non-woody materials incorporated into the soil for next planting season. This process is repeated from year to year. This AF technology has been tested on a smaller scale in Morogoro. However, *T. vogelii* planted at high density seems to have some potential in semi-arid areas.

2.3.6 Forest Resource Assessment

Data collection on forest resources has been and remains to be one of the oldest and key functions of the FBD. This is achieved through forest surveys and inventories. The FBD established zonal survey and inventory offices to facilitate data collection. Until 1970s, forest survey concentrated on demarcation of natural forests for reservation and determination of planted areas in plantations. For these purposes survey benchmarks, beacons as well as PSP were established. The PSP were mainly for monitoring forest yield and changes. Other survey and inventory activities like the Canadian Government funded inventory of indigenous forests between 1971 and 1973 were for exploitation purposes and were treated as recurrent forest activities and their methodologies very static.

The growing participation of non-public sectors in forestry activities and the global concern on natural resources is resulting into growing demand for forest resources data. Likewise, the increasing pressure on forest resources and establishment of forest plantations whose management demand information on raw material availability stimulates new demands on forest resources data. Until very recently, forest data collection and the forest management was mainly a responsibility left to FBD. It is realised that individuals and the private sector have made considerable efforts to plant trees and woodlots outside forests. The extent and potential of these trees to supplement forest values are virtually unknown. More attention dominated in forest utilisation and, for that purpose only availability of mature trees for exploitation was the main concern.

The increasing pressure and public concern on the conditions and use of the natural resources drew the attention of other institutions. Amongst these are the UDSM, which established the IRA to gauge and monitor natural resources. The IRA is a centre of excellence for the natural sciences and has already made significant progress in the collection of natural resources information, materials and equipment. Likewise, the establishment of the NEMC as an overall watchdog on environment also opened more avenues for accessing more data on trees, forests and the environment as a whole.

The latest institutional development is the establishment of Tanzania Natural Resources Information Centre (TANRIC) under the umbrella of IRA. The establishment of TANRIC originates from the TFAP whose review in 1988 and 1989 recommended, *inter alia*, that information on natural resource use be collected and permanently monitored and institutions in charge of natural resources strengthened.

The other collectors and users of forest resources data include the Faculty of Forestry and Nature Conservation of SUA and TAFORI. Through these institutions and support from other development partners some useful information has been generated. These include: volume and yield tables for some tree species, deforestation rates of selected localities, inventory data for some forests, the Tanzania vegetation cover types maps (1984) and Land Use and Cover Maps (1996). There are ongoing studies on growth and yield and deforestation rates and causes.

Despite these deliberate efforts to collect data on forest and related resources most of this information has not been properly utilised. One reason is lack of co-ordination between data collection and the end uses. The other reason is that the data collected has not been processed into easily accessible form.

2.3.7 Forest Operations and Techniques

Forest Operations and Techniques embrace all activities pertaining to the procurement of timber to the forest industries and markets. It involves an understanding of the relationships between labour, technology, the forest resource, forest industries/market, people and the environment.

Timber harvesting in the country's natural and plantation forests has been based on tree length, shortwood/log length and semi-processed systems (Abeli and Dykstra 1981, Ole-Meiludie and Dykstra 1982, Migunga and Dykstra 1983). A wide range of machines and methods has been used for small-medium-large scale operations, for tree cutting, extraction and log hauling operations. The options adopted have mainly been based either on traditional or available and easily adaptable technology, without considering the scale and economy of the operation.

Several work studies, on cutting operations in miombo and plantation forests, have reported production rates and costs using two-person crosscut saws, axes and powersaws (Abeli and Dykstra 1981, Micski and Stridsberg 1981, Migunga and Dykstra 1983). Improper cutting techniques and use of poorly maintained tools have been reported as some of the reasons for damages and timber losses experienced in this activity. Limited information is available for montane and mangrove forests.

Research work undertaken for extraction operations in miombo and plantation forests has indicated that the methods and equipment commonly applied included: log rolling, manual sulky, ox-skidding, farm tractor with chain or rear-mounted winch, articulated skidders, tractor-trailer and forwarder (Abeli 1979, Ole-Meiludie and Omnes 1979, Migunga 1996). These extraction systems have mainly been applied in flat to gentle slopes. Cableways, the most suitable technology in steep and difficult terrain conditions, have not been practised and researched. Where terrain allows and logs are scattered, "terrain truck" has also been used for hauling logs from the stump to processing mills.

A number of studies have reported productivity and unit costs for shortwood trucks, combination rig trucks and tractor-trailer in log hauling operation (Abeli 1979, Abeli and Dykstra 1981, Fue and Ole-Meiludie 1989, Nyama 1992, Fue *et al.* 1998). Lack of well planned and low quality roads have been noted as the factors contributing to small load sizes, low hauling speed and consequently low hauling production rates.

While some forest operations have been assessed through work and productivity studies, limited information is available on ergonomic principles and their application (Abeli and Ndossi 1985, Saarilahti and Abeli 1985, Saarilahti and Ole-Meiludie 1987). The few forest engineering researches reveal that access into the forests is difficult, some of the existing logging methods and equipment are inappropriate and the productivity of both labour and machine is low (Abeli 1992).

Current research activities in forest operations and techniques include: the use of oxen for skidding logs in forest plantations; effect of logging tractors on natural and artificial regeneration; and environmentally sound harvesting in miombo woodlands.

2.3.8 Forest Utilisation

Substantial research activities have been conducted under the theme of forest utilisation. Initial research efforts have been directed towards wood-based products especially timber (mainly wood properties of trees in natural forests and plantations). Over time, however, the research activities have been widened to include all aspects of forest benefits, viz., wood products, techniques of utilisation, NWFP and environmental services. Also research efforts have adopted a multidisciplinary approach to analyse issues related to the interface between forestry and agriculture. A brief review of these research efforts is presented in this text.

Several research activities have been conducted on wood energy (see for instance Ishengoma 1982, Temu *et al*. 1984, Ishengoma *et al*. 1992). Findings from these studies indicate that:

- The Tanzanian society has had a long tradition of using wood as a source of energy for various purposes including cooking, lighting and heating. Today the use of wood energy has not declined and stands at over 91% of total energy source;
- Traditional three stone firewood cooking “stove” has as low efficiency as 7% and produced a lot of smoke which is socially inconvenient and a health hazard;
- Improvements could be made by constructing charcoal stoves with local materials so that the efficiency increases to 15% and with potential to reduce consumption of firewood by as high as 50%;
- Experience from Asia shows that charcoal stoves made of clay have an efficiency of 30%. The same has been adopted and some regions of Tanzania especially urban centres are making extensive use of clay charcoal stoves.

Some research activities have been conducted and are continuing on the utilisation of lesser-known tree species (see for instance Ishengoma *et al.* 1992, Ishengoma and Chihongo1995, Ishengoma *et al*. 1997, 1998a,b,c, Hamza and Makonda 1998). Results indicate that lesser known tree species have technical attributes that are comparable to other widely used tree species. And hence the potential for wide use and marketing.

NWFP have recently gained wide recognition as being very important both socially and economically. Some studies have been conducted on this aspect (see for instance Ishengoma *et al.* 1992, TAFORI 1992, Makonda 1997, Hamza and Makonda 1998). Findings from these studies indicate that:

- NWFP are widely used for subsistence consumption and form a significant part of household economies;
- Commercial marketing of NWFP is limited due to absence of competitive markets and low scale production;
- Expanded harvesting and utilisation can greatly increase the value of NWFP to the rural household economies as well as the national economy.

Presently there is a study on socio-economic and technical aspects of NWFP

2.3.9 Socio-economics and Policy

Socio-economic issues are thought to be associated with almost all activities connected with forestry as well as rural development. Thus the scientific community opinion has become increasingly aware of the need to understand socio-economic issues and impact of policies for decision making. This need has been exacerbated by the shift in priorities, growing economic competition and the drive to involve local communities in the management of forest resources.

Most socio-economic studies so far carried out have focused mainly on plantation forestry, agroforestry, afforestation and some aspects of land uses. Some of the socio-economic studies on specific issues include Monela *et al.* (1993), Mlambiti *et al.* (1993), Kaoneka (1993), Monela (1995), Bhatia and Ringia (1996) and Sannoh (1998). Generally policy studies are scanty and a few of those available include an analysis of the forest industry sector and international trade by Ngaga (1998) and a review of the national forest policy by Kaoneka *et al.* (1999). Most of these studies are done to understand certain aspects of socio-economic issues and to provide some baseline data. Nevertheless, many important gaps remain in our understanding of the influence of socio-economic factors and the available policy options and their impact on the forest sector. Hence the need for more detailed studies.

On going studies include: contribution of the forest sector to GDP; modelling degradation process of open forests; sustainable land use practises; socio-economic aspects of management of miombo woodlands; sustainable land use practices; and socio-economic and gender analysis of community based forest management initiatives.

2.3.10 Forestry Extension

Forestry extension in Tanzania is a relatively new subject compared to other basic training aspects of forestry. The lagging behind of forestry extension is due to the fact that forestry has remained alien professionally to people who are the direct users of forestry technologies. This is largely a product of the history of forestry itself (Mvena 1998).

With the dawn of social forestry and the need to actively involve people in utilising and sustaining forest resources and involving people in afforestation programmes, forestry extension is increasingly becoming an integral part of forestry akin to its sister discipline of agricultural extension in agriculture. Foresters have realised that lack of proper extension resources has led to the accumulation of research results (TAFORI 1992). Too often, the same report reiterates, researchers spend their energies only on research and development process and forget the dissemination of results. Historically,

there has been a weak link between foresters and the ultimate users e.g. farmers and there have been no efforts to review and refine this vital link.
In order to promote forestry technologies to ordinary users other than industries, the Government has, in recent years, actively trained foresters in forestry extension. The ultimate goal is to provide an effective linkage between forestry researchers and the users of forestry research results.

Chapter 3 The NAFORM: Objectives, Priority Setting and Strategies

3.1 Objectives

The role of the forests sector to the economy and the contribution of forest research have been reviewed in Chapter 1. The overall goal of the national forestry policy (MNRT 1998) outlined in chapter 1 can best be realised if proper backstopping is provided by forestry research. The overall objective of the NAFORM is thus to **develop appropriate knowledge and technologies for the sustainable management of forest resources[1].**

The specific objectives of the NAFORM on the basis of the overall objective are to:

- Develop management and conservation systems for natural forests;
- Generate appropriate tree planting/management, agroforestry and rehabilitation technologies for subsistence farmers and other land users;
- Improve productivity of plantations by identifying and improving suitable species and their nursery, establishment, management and protection techniques;
- Generate reliable data and information to guide decisions on forest issues at all levels;
- Develop efficient and environmentally sound harvesting techniques;
- Develop technologies for improved utilisation and marketing of forest products;
- Establish linkages between socio-economics, policy, forestry extension and natural resources as a basis for improving forest policy and forest management decisions;
- Develop research expertise, facilities and appropriate environment to respond to the forestry research needs of Tanzania;
- Develop and maintain cost-effective dissemination mechanisms.

3.2 Setting priorities

The preparation of the NAFORM was the responsibility of a task force composed of eight members from TAFORI/FORST, SUA, UDSM, FBD and DRD. In addition, resource persons were nominated to provide input to specific subject areas.

To get the input of stakeholders in setting research priorities for the NAFORM, questionnaires were administered to four main categories of stakeholders:

- Forestry land management agencies: NGOs, Government and Government agencies and Private entities (Cf Table 4);
- Agricultural and Forestry Research and Training Institutions.
- End users of forest products;
- Forestry related International/Donor agencies.

[1]Sustainable management of forest resources means conservation, management, development and utilisation of forest resources.

Questions for the different categories of stakeholders covered the following aspects:

- Forestry land management agencies and end users of forest products:
  - main activities undertaken
  - main problems and problems requiring research
  - prioritising the research programmes
  - collaborators
  - information (source, usefulness, type required)
  - dissemination (means, ways to improve).

- Agricultural and Forestry Research and Training Institutions:
  - main activities undertaken
  - human resources (qualifications, numbers and areas of specialisation)
  - physical facilities (laboratories, transport and field equipment)
  - financial resources (Government, Donor and other sources)
  - main problems
  - collaborators
  - prioritising forestry research programmes and indicating areas requiring research
  - information (source, usefulness, type required)
  - dissemination (means, ways to improve).

- Forestry related International and Donor Agencies:
  - areas of emphasis of development aid
  - ways of sustaining forestry research funding
  - prioritising the forestry research programmes.

Table 4 shows number of stakeholders contacted by categories and percent response while Table 5 shows prioritisation of research programmes by the stakeholders. Appendices 1 and 2 respectively show stakeholder indication of forestry related problems requiring research and researchable areas.

The survey responses were summarised and used in appropriate sections of the NAFORM. The questionnaire responses and other aspects in the NAFORM were discussed during two national workshops involving stakeholder representatives.

The following criteria adapted from the Kenya Forestry Research Institute (KEFRI 1999) was used to prioritise research activities:

- Is the problem identified a lack of knowledge or a lack of application of existing knowledge?
- Is the problem easy to deal with and likely to bring results in a reasonable time?
- If successful, will the results be disseminable?
- Will the results impact on a large number of people?
- Will the results impact on a large area?
- Will the results have a significant, positive economic impact?
- Will the results have significant, positive environmental impact?

Is the problem consistent with national priorities?

Table 4. NAFORM stakeholders – Number contacted and responses

Stakeholder-Category	Number Contacted	Response		Proportion %
		Number	%	
Forestry Land Development Agencies				
• NGOs	56	49	86	12.3
• Government and Government Agencies	220	183	83	46.1
• Private entities	8	6	75	1.5
Agriculture and Forestry Research and Training Institutions				
• Research Institutions	24	21	87	5.3
• Training Institutions	26	23	88	5.8
End users of forest products				
• Large scale	40	34	85	8.6
• Small scale	70	63	90	15.9
International/ Donor Agencies	22	18	82	4.5
Total	466	397	89	100

Table 5. NAFORM - Stakeholders indication of Research Priority Areas

	Research Programmes					
Stakeholder Category	CFF[1]	MNF	PFT	FOU	SPE	FRA
Forestry Land Development Agencies						
-NGOs	2.4[2]	2.5	3.4	4.2	3.6	4.2
-Governmental Organisations	2.4	2.3	3.7	4.5	3.7	3.8
-Private entities	2.8	2.5	3.5	5.0	3.7	3.8
Sub – mean	**2.5**	**2.4**	**3.5**	**4.6**	**3.7**	**3.9**
Agriculture and Forestry Research and training Institutions						
-Research Institutions	2.8	1.9	3.1	4.1	4.4	3.7
-Training Institutions	2.3	2.1	3.4	4.6	4.4	3.7
Sub – mean	**2.6**	**2.0**	**3.3**	**4.4**	**4.4**	**3.7**
Wood and non-wood end users						
-Large scale	3.1	3.5	2.2	3.3	4.4	4.0
-Small scale	2.9	3.2	3.5	3.0	4.4	3.9
Sub – mean	**3.0**	**3.4**	**2.9**	**3.2**	**4.4**	**4.0**
International and Donor Agencies	2.0	2.3	4.9	4.6	4.9	4.9
Total	20.7	20.3	27.7	33.3	33.5	32
Mean	**2.58**	**2.53**	**3.46**	**4.16**	**4.18**	**4.0**

[1] ***See list of abbreviations and acronyms.***

[2] Priority: 1= First priority, 2= 2nd Priority,….. 6= 6th Priority.

3.3 Strategies

In order to realise the objectives of the NAFORM outlined in 3.1, Institutions/individuals involved in research implementation under the NAFORM will use the following strategies:

- Demand – driven research and involvement of relevant stakeholders in the design and conduct of research so as to achieve better results and more effective implementation;
- Multi-disciplinary research approaches will be used to develop effective solutions to the multi-faceted problems on management and use of forests;
- Research emphasis will be on applied research, i.e., research that focuses on problem identification, solution and prevention. Adaptive research i.e. research oriented towards adapting existing research results and technologies to minimise research costs will also be emphasised;
- Networking and linkages between institutions and researchers within the country, at regional and global levels will be emphasised in order to facilitate exchange of information, collaborative research projects and complementarity of research projects. This will minimise duplication of efforts ("reinventing of the wheel") and thus improve efficiency in use of limited research resources.
- Contract research for clients with specific research issues;
- Develop "user-friendly" means of communicating forest research results to stakeholders.

Chapter 4 Research Programmes

4.1 Management of Natural Forests

Background and Justification

Forest degradation, deforestation and global climate change are considered to be major challenges in the new millennium. The United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992 through its three major policy documents, the Rio Declaration, Agenda 21 and Forest Principles and the Conventions on Biological Diversity and Climate Change recommend regulation on the use and management of natural resources particularly forests to enhance their diversity and sustainability. The 1998 Tanzania national forest policy addresses this issue by giving specific policy statements on strengthening of biodiversity, watershed management and soil conservation research and information dissemination.

Tanzania natural forests and woodlands are unique ecosystems for their forest products, genetic, species and habitat diversity, and catchment and aesthetic values. They vary in type, vegetation composition, structure and function. Increasing human and animals pressure and uncontrolled fires on these ecosystems are causing excessive utilisation of forest products, forestland degradation and loss of biodiversity. In some cases the functions of the systems are threatened. For successful and sustainable forest management and conservation it is a prerequisite to have accurate and adequate research information on silvicultural systems. These include appropriate methods of harvesting, regeneration and tending. The traditional exotic plantation tree species techniques may not necessarily be applicable to indigenous tree species.

Unfortunately available research information on different aspects of ecology, silviculture, biological and hydrological processes, growth and yields and biodiversity is not adequate for sound management and conservation of these resources. It is therefore necessary to undertake research in this field in order to devise management interventions that can improve and sustain the functions of these ecosystems.

Environmental services are important as far as human welfare is concerned. These include conservation of biodiversity and gene pool. Some species of wild coffee such as *Coffea mongensis* available in Eastern Arc Mountains are known to be useful in breeding for disease resistant varieties. Also forests are important in providing watershed functions such as water catchment, reduction of soil erosion, soil conservation and minimisation of down-stream sedimentation and flooding, habitat for wildlife and sink through CO_2 sequestration thereby reducing global warming. Forests play a vital role in maintaining air quality and reduce environmental pollution. One big challenge facing management of forest resources is that there is a trade-off between producing wood products and environmental service. Thus decision-makers need reliable data and information to design efficient management alternatives. Limited research currently undertaken has failed to address all issues

related to the role of forest in producing environmental service. Hence the need for expanded research.

Objectives

Goal

Develop sustainable management and conservation systems for Tanzania natural forests.

Specific objectives

- Generate biodiversity data necessary for planning and management purposes.
- Better understand the biological, ecological and hydrological processes in natural forests.
- Develop appropriate silvicultural and management techniques for the different forest types and restoration of degraded lands.
- Characterise catchment forests into production, protection and biodiversity zones.
- Minimise losses caused by different forest agents.
- Determine the impact of deforestation on CO_2 sequestration.
- Examine the potential of various tree species in CO_2 sequestration.

Output

- Biodiversity databases established and maintained.
- A vegetation map and a vegetation book of Tanzania produced.
- Areas with high endemic species and fragile or threatened ecosystems demarcated for conservation.
- Management guidelines for natural forests in place.
- Biological, ecological and hydrological processes better understood and indicators for characterisation of catchments established.
- Co_2 storage quantified.

Research Activities

- Conduct biodiversity surveys and monitor biodiversity and ecological processes in different natural forest types.
- Identify endemic and or threatened species and areas which need conservation.
- Monitor regeneration and factors influencing it and evaluate different propagation techniques.
- Undertake phenological observations of selected indigenous tree species in various ecosystems and localities.
- Monitor the effect of fire, grazing, logging and wildlife to seedling recruitment, species diversity and soil physical and chemical properties.
- Monitor hydrological processes and the impact of human activities on the hydrological cycle.
- Survey and identify natural enemies.
- Monitor changes by observation in established PSP.

- Conduct studies on Co_2 sequestration potential for different tree species and stands.
- Conduct studies on the effect of deforestation on climate change through the release of Co_2 to the atmosphere.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	M.Sc	Ph.D.	M.Sc
Ecology	1	2	-	-
Biosystematics	-	-	1	1
Hydrology	-	-	1	1
Botany	1	-	-	1
Entomology	1	1	-	-
Pathology	1	-	-	1
Statistician	-	-	-	1
Fire	-	-	1	1
Total	4	3	3	6

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Activities	1500.0
Training	490.0[1]
Total	1990.0

[1]1M.sc costs 25 Mill TAS
1PhD costs 70 Mill TAS

4.2 Community and Farm Forestry

Background and Justification

There is serious land degradation in Tanzania due to high human and livestock populations (see for instance Kaoneka 1993). This has resulted in reduced food crop production, quality of rangelands and fuelwood supply. In order to check environmental degradation, tree/shrub planting interventions on farm land are considered to be essential. The planting of trees/shrubs in village communities has mainly been woodlots or boundary planting for the supply of fuelwood and poles. However, the introduction of trees/shrubs in village communities has always been difficult due to arable land shortage. Thus one major advantage of rotational woodlots, improved fallows and relay cropping is that they offer cost-effective ways and means of introducing trees/shrubs on farmlands. Adoption of these low external input and sustainable landuse systems helps in improving agricultural productivity and reducing environmental degradation.

Although a lot of work has been and is still being done on improved fallows and rotational woodlots in the humid tropics (see Adejuwon and Adesina 1990) little work has been done in sub-humid and semi-arid areas of Tanzania (Fasuluku 1998, Chingonikaya 1999). The little work already done on improved fallows and rotational woodlots in semi-arid areas reveals that these AF technologies have some potential for improving soil fertility, increasing crop and fuelwood yields. However, their success largely depends on proper selection of woody species and their subsequent management. *Sesbania sesban, S. macrantha, G. sepium, T. volgelii, C. calothyrsus, C. cajan* and several indigenous and exotic *Acacia* species are the most promising multipurpose species for humid and sub-humid and dry land AF.

Some of these species have been successfully used in alley and relay cropping, improved fallows, and rotational woodlots. However, like most multipurpose tree/shrub species there has been no selection of the best provenances for potential sites in Tanzania except at SUA farm, Gairo and selected sites in Shinyanga and Tabora. There is therefore a need to test additional tree/shrub species and provenances. The success of rotational woodlots, improved fallows and relay cropping depend also on the length of the fallow, cropping phases, food crops species, establishment methods and spacing. Site specific answers pertaining to these questions have yet to be provided.

Although one of the goals of the CFF is to enhance soil fertility regeneration, the soil processes under improved fallows, rotational woodlots and relay cropping are not well understood. Unravelling the processes occurring within the soil will help in explaining the long and/or short term effects of rotational woodlots, improved fallows and relay cropping and will help in developing suitable soil fertility management techniques so that maximum benefits can be derived from them.

Dairy and oxen production is an important feature of agropastoralist systems in Tanzania. However, the intrinsic capacity of the local cow for milk production is low. The poor quality fodder and low supply further influence this especially during the dry season since agropastoralists especially in semi-arid areas do not reserve fodder for dry season grazing. This makes fodder the most important livestock-fodder related constraint in these areas. Attempts have been made for dry *Leucaena* leaf meal supplementation to cattle grazing natural forages in both the wet and dry season. Compared to other protein sources such as cotton seed cake and cotton seed hulls, *Leucaena* and other browse legume leaf meals may be relatively cheaper sources since they can be easily grown in semi-arid areas. Supplementation studies carried out elsewhere indicate that even small amounts of fast growing legume browse such as *Leucaena leucocephala* leaves could improve the condition of animals on the low quality natural forage. Leguminous plants such as Leucaenas, Acacias, *Gliricidia* and *Stenocarpa* have consistently maintained high fodder yield (4 - 8 t ha^{-1}) in semi-arid areas. It has been observed that meal based on 2-3 kg dried *Leucaena* leaf meal per cow/day have sustained milk yield of 10 litres/cow/day compared with only 6-8 litres/cow/day obtained with the use of grass and maize bran alone. This clearly shows that fast growing fodder species have some potential for alleviating feed fodder shortages and can provide a cheap way of supplementing animals especially during the dry season and hence increase animal weight and milk production. Thus there is an urgent need of introducing the fodder bank technology

to livestock farmers in some other parts of Tanzania for evaluation. This will also require evaluation of other potential species.

Objectives

Goal

Generate appropriate tree planting and AF technologies for resource poor farmers and other land users.

Specific objectives

- Screen indigenous and exotic tree/shrub species and provenances for provision of wood, fruits, medicine, fodder, soil fertility maintenance/improvement, and for other services of AF technologies.
- Develop and adapt appropriate AF technologies for soil conservation and soil fertility maintenance/improvement; and increased and sustainable production of various wood and non-wood products.
- Develop appropriate forestry technologies for rehabilitation of degraded communal lands.
- Establish and maintain a national database on CFF related information.

Outputs

- Range of suitable indigenous and exotic tree/shrub species for use in woodlots or various AF technologies increased.
- Appropriate AF technologies and tree management techniques for soil conservation, soil fertility maintenance/enhancement and for other services developed and adopted.
- CFF national database established and managed.

Research Activities

- Conduct species and provenance trials of various trees/shrubs for woodlots/AF in various ecological zones and farming systems and end uses.
- Biological and socio – economic evaluation of various AF technologies for various end uses in sets of ecological zones and farming systems.
- Establish and maintain a national database of all CFF research work done in Tanzania.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	M.Sc.	Ph.D.	M.Sc
Silviculture	5	1	-	-
Agroforestry	1	1	-	4
Forest soil	2	-	-	1
Total	**8**	**2**	**0**	**5**

Infrastructure

Laboratory for soil and plant analysis (see section 5.2 for costs).

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Activities	846.0
Training	100.0
Total	946.0

Plantation Forestry and Tree Improvement

Background and Justification

Early research in seed and nursery aspects, species and provenance selection, establishment and management of exotics account for the successful large scale planting of the various tree species in Tanzania (see also sections 2.3.1 – 2.3.3). As a result, wood requirements are increasingly being met from the plantations (see also section 1.2). The importance of plantation forestry is their provision of other direct and indirect benefits. Direct socio-economic benefits include provision of NWFP, job creation, and food security through taungya, export promotion and revenue through taxation and forest rent. Indirect benefits include service functions such as water catchment and as CO_2 sink. Further, plantation forests have the potential of reducing pressure of exploiting natural forests.

Plantation yields during first rotation in Tanzania varied from 25 to 35 m^3 ha^{-1} yr^{-1} for pines and cypress, 30 m^3 ha^{-1} yr^{-1} for eucalypts and 10 m^3 ha^{-1} yr^{-1} for teak (Ahlback 1988). These yields though modest were acceptable under low intensity silviculture. Some species are now being attacked by various diseases and (vertebrate and invertebrate) pests resulting in yield declines. As a consequence, some hitherto productive species are now being abandoned because of these attacks.

While in some instances new areas are being opened up for plantations such as Kilombero for teak planting, in most situations, future wood needs will have to be obtained from existing planting sites i.e. second and subsequent rotations. The productivity of the second and subsequent rotations will have to be maintained or increased to meet the increasing domestic and international demand for wood and wood products since environmental concerns, social pressures and the rapidly diminishing resource constrain the harvest of timber from natural forests.

Maintaining or increasing plantation productivity can be achieved by adopting strategies that will increase yield per unit area e.g. by using improved and adapted seed and appropriate soil and site management practices as well as limiting or minimising attacks by diseases, pests and fires. Understanding the processes, which influence stand productivity, will assist in developing management options for optimal plantation productivity. Further screening of indigenous and exotic species as well as trials of species mixture should be carried out as a way of broadening the

genetic base and increasing species diversity. This would serve as an insurance against pests, diseases and climate fluctuations.

Objectives

Goal

Generate technologies to secure sustained production of major plantation indigenous and exotic tree species for given end uses.

Specific objectives

- Develop genetically improved planting stock for forest plantations and other uses.
- Develop suitable nursery, establishment and tending techniques for increasing the productivity of forest plantations.
- Develop large-scale propagation methods for indigenous tree species.
- Minimise the negative impacts of biotic and or abiotic agents on forest plantations.

Outputs

- Genetically improved planting material is made available.
- Suitable, improved nursery, establishment, and tending techniques of forest plantations secured.
- Propagation guidelines for indigenous tree species obtained.
- Management guidelines for the protection of forests against pests, diseases and fire hazards, available.

Research Activities

- Screen genetically improved material available locally, and from neighbouring countries.
- Test nursery and evaluate the impact of silvicultural practices, on the productivity of successive rotations.
- Test different propagation methods for indigenous tree species.
- Monitor and evaluate forest health with respect to insect pests and
- pathogens.
- Determine the effect of fire on forest plantations.

Human Resources

Discipline[1]	Existing strength and Level		Additional Requirements	
	PhD	MSc	PhD	MSc
Tree species selection	1	-	-	-
Soil Science				
- Agriculture	11	2	-	-
- Forestry	2	-	-	-
Forest Ecology	2	2	-	-
Plant physiology	1	1	-	-
Tree Breeding	-	1	2	-
Plant Breeding	5	4	-	-
Plantation management	2	2	-	-
Silviculture	2	1	-	-
Total	26	13	2	0

[1] For other relevant disciplines, refer Human Resources under 4.2

Inputs

Infrastructure

A laboratory for tree improvement, forest entomology and pathology research (see section 5.2).

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Activities	1319.0
Training	140.0
Total	1459.0

4.4 Forest Resource Assessment

Background and Justification

Sustainable forest management demands accurate and reliable data and information. Informed decisions have to be made to enable forest management achieve its overall goals. On the other hand, for the forestry sector to sustain its long-term goals its capacity to forecast the trends of forest ecosystems and their consequences is necessary. In broad terms forestry information is needed for three main uses:

- National policy development and planning;
- Investment appraisal and decision making;
- International policy development and negotiation.

It is only through hard facts that foresters can convince decision-makers to give forestry more and appropriate consideration in resource allocation *vis a vis* other sectors.
For these reasons we need to collect reliable information on:

- Forest resources regarding information and statistics on the area, stocking, growth, condition and type of forest resources in the country; wood/fibre production, vegetation and biodiversity potential of the forest ecosystems and trees outside forests and their potential to supplement values that accrue from the forests;
- Forest products that include information and statistics on production such as capacities, consumption and trade capacities.

Currently the forestry data situation is highly disorganised due to the following reasons:

- Actual data needs are not well known;
- Available data and information is scattered over different users;
- Data collection is irregular and its capacity limited;
- Data processing capacity is limited;
- There is poor co-ordination between the various stakeholders.

There is therefore need to revamp the whole system and put in place a system which can ensure sustainable flow of the needed information and statistics on forest resources.

Objectives

Goal

Enhance national capacity to collect, compile and disseminate reliable and accurate information and statistics on tree and forest resources for both local and international needs.

Specific Objectives

- Standardise forestry terminology and its usage.
- Identify and update trees and forest resources data needs.
- Institute reliable means of collecting, processing and disseminating the data.
- Prepare and update forestry outlook reports.

Outputs

- Harmonised forestry data standards and classification systems.
- Local guidelines on forest resources assessment available.
- Forest resources database maintained.
- Forestry outlook reports regularly produced.

Research Activities

- Develop standards and classifications, definitions and structure of trees and forest resources data and information.
- Develop affordable technology for collecting, processing and validating trees and forest resources data.
- Develop, monitor and evaluate changes in trees and forest resources.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	MSc	Ph.D	MSc
Growth & Yield	1	1	-	-
Satellite Imagery	1	-	-	1
Computer Programmer	-	-	-	1
Statistician	-	-	-	1
Total	2	1	0	3

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Equipment	100.0
Activities	900.0
Training	75.0
Total	1075.0

4.5 Forest Operations and Utilisation

4.5.1 Forest Operations

Activities involved in Forest Operations and Techniques, also generally referred to as timber harvesting, are necessary for gaining benefits from a forest enterprise. Timber harvesting activity is the first sequence of events to convert a forest from a community of trees into consumer products. Traditionally, timber harvesting was considered solely an economic venture, mainly production of commercial timber. However, recent concerns for the environment, biological diversity and the aspirations of local community have brought in other strong factors. Effects of timber harvesting on soils, potential tree crops and other vegetation, water regimes, wildlife and aquatic resources, among others, will have to be considered along with the economic implications.

Generally, in undertaking timber harvesting activities one must consider several factors. These include objectives of the enterprise; control of quantity and quality of production; cost efficiency; capital requirements; information needs for terrain and timber; available harvesting technologies and transportation systems, costs and effects. Others are environmental effects to soil and water; infrastructure and maintenance demands for harvesting systems; workforce requirements and

utilisation, safety and health implications, and post-harvest operations for reforestation or other purposes, such as slash disposal to reduce fire hazard.

Timber harvesting activities therefore require balancing of many factors. Harvesting should be considered as a production process with refined objectives while accounting for the physical limitations, economic expectations and environmental concerns. There is need to understand, through research, how these factors influence productivity and costs in forest operations and techniques.

Timber harvesting methods in natural forests for commercial timber have often been characterised by poor utilisation of the resources and high selectivity resulting to over-exploitation of some high grade species. Damage on remaining trees and soil disturbance affecting natural regeneration is also characteristic of harvesting natural forests. Furthermore, use of inappropriate harvesting equipment has often led to high operational costs and greater damage to the environment. There is need also to stipulate "appropriate" harvesting methods for high montane, miombo woodlands and mangrove forests. Special techniques should also be designed, through research, for harvesting village and private woodlots.

During the plantation forest establishment, timber harvesting did not have local research-based information. A number of studies have contributed to development of labour-intensive logging methods and tools, performance levels of different harvesting systems, and improved design and construction of harvesting systems.

Since the inception of commercial forest harvesting, the systems applied have mainly been geared to suit available techniques rather than seeking technologies, which meet appropriate criteria. Limited research has addressed ergonomic principles and their application to the workforce, pertaining to workload, skill, payment and safety.

Objectives

Goal

Promote harvesting practices that will improve standards of utilisation and reduce adverse environmental impacts.

Specific Objectives

- Develop environmentally sound harvesting systems in natural and plantation forests so as to guarantee sustainable supply of timber products to forest industries and local communities.
- Increase productivity and efficiency of forest operations at reduced operational costs and environmental impacts.
- Improve the working and living conditions of workforce in forest operations.

Outputs

- Improved planning, co-ordination and control of harvesting operations for sustainable utilisation of forest products.

- Optimised productivity at minimised costs and environmental impacts of harvesting activities.
- Reduced timber and economic losses.
- Increased workers efficiency, health, safety and motivation.

Research Activities

- Undertake comprehensive plans to optimise productivity for various terrain, timber characteristics and harvesting system specifications and minimise costs, subject to constraints imposed by silvicultural, environmental and social considerations.
- Revise the current road design guidelines to determine optimal road grade (Optimal grade is the one which minimises road construction costs, truck hauling costs and both road and vehicle maintenance costs), spacing and landing spacing to minimise total transport costs.
- Make comparisons of alternative cutting and extraction systems with the aim of adopting the appropriate technologies.
- Undertake harvesting impact assessment to reduce timber and economic losses as well as environmental degradation resulting from improper harvesting practices.
- Apply ergonomic principles to determine and evaluate the situational, workplace and other factors and propose improvements to attain higher productivity at reduced costs and increased job satisfaction.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	MSc	Ph.D	MSc
Forest Engineers	6	5	1	3

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Equipment	120.0
Activities	240.0
Training	140.0
Total	500.0

4.5.2 Forest Utilisation

Background and Justification

Forests are a natural resource capable of producing many diverse benefits both wood and NWFP and environmental service. Wood products include sawnwood, wood-panels, paper and paperboard, poles and fuelwood (see also Section 1.2). Many of the wood products are market or tradable goods and have recognised market values. Over 95% of the total population of Tanzania depend on wood as their only source of

domestic energy (Hamza and Makonda 1998). Per capita consumption is estimated at 1 m^3. Globally the use of wood for fuel is the single largest utilisation of wood. It is estimated that 50% of the wood consumed in the world is used for domestic energy and in Tanzania it accounts for about 97% of total wood removals.

Utilisation and marketing of wood forest products has been curtailed by several economic and technical problems (see also section 1.2). Research is needed to improve the processing and utilisation of wood products. Moreover research is needed on lesser-known wood species for the purpose of minimising skewed demand on limited and scarce tree species.

Most NWFP consist largely of non-market or non-tradable goods without an established market value. It has been realised; however, that NWFP and services have high social and environmental values whether measured by scarcity or social preference. In fact, NWFP play important roles in developing countries in terms of supporting economic activity of local people as well as the well being of people (FAO 1995). Therefore, there is a dire need to quantify NWFP. Further, there is a growing interest in designing efficient ways of harvesting, processing and utilising NWFP. Technical matters related to this issue demands research.

Objectives

Goal

Develop technologies for improved utilisation of trees and forest resources.

Specific Objectives

- Determine the wood properties of tree species grown in forestry and farming systems in order to improve utilisation of these resources.
- Improve productivity and efficiency of wood processing industries.
- Develop appropriate facilities and techniques for processing, drying, storage, packaging and marketing of NWFP
- Establish criteria to identify more important NWFP for selection and development.

Outputs

- Expanded and increased supply of timber tree species enhanced.
- Diversified and increased supply of forest products realised.
- Guidelines on processing, drying, storage, packaging and marketing NWFP available.
- More efficient wood energy utilisation realised
- Food security in rural areas improved.
- New products available in the market.
- Large number of useful tree species domesticated.

Research Activities

- Determine anatomical, physical, mechanical and strength properties of lesser-utilised tree species and natural durability.
- Carry out studies on marketing potential of lesser-known tree species
- Conduct studies on wood industries' processing techniques
- Conduct studies on identification and development of processing, drying, storage, packaging and marketing of NWFP
- Carrying out studies on charcoal quality from different tree species.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	MSc	Ph.D	MSc
Wood Scientists	3	3	3	2

Infrastructure

A forest utilisation laboratory (see section 5.2)

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Activities	500.0
Training	140.0
Total	640.0

4.6 Socio-economics, Policy and Forestry Extension

Background and Justification

A critical feature of forestry activities that distinguishes them from most other primary activities, including agriculture, is the prevalence of externalities. The existence of these externalities implies that the free interplay of market forces will not bring about socially desired outcomes. The world is becoming increasingly aware of these market failures. Contemporary effort is to internalise the externalities and make them part of the general accounting equation. It is apparent that the primary challenge facing the forest sector today is to prevent the excessive rate of deforestation by expanding efforts towards sustainable management of the remaining forests and wooded land. Socio-economic factors must be understood to be able to address these challenges effectively.

Policy issues have significant influence on decisions which the society take toward forests either collectively or individually and the National Forestry Policy has emphasised the need for policy analysis (MNRT 1998). Most of the reforms taking place in Tanzania and elsewhere as a result of policy changes have a bearing on the development and sustainable management of the forest sector. However, the impact

of these macro and sectoral policies on the conservation and management of forest resources is not fully known.

There has been very little attention on social-economic and extension issues despite their significant influence on the establishment, conservation, management and utilisation of forest resources. Many social forestry programmes in Tanzania have performed dismally due to the reluctance of the communities to constructively participate in such programmes. Reasons behind this reluctance are not fully understood as not much research has been done in this direction.

Therefore, the success in forest development and management particularly taking into account the challenges ahead will very much depend on our accurate understanding of the complex factors related to socio-economic, policy, and forestry extension.

Objectives

Goal

Improve forest policy and decision-making for establishment, management and conservation of forest resources for social and economic development of Tanzania.

Specific Objectives

- Examine policy matters in relation to property rights, land tenure, gender issues and forest resources.
- Examine the effect of both macro and sectoral policies on sustainable management of forest resource.
- Assess alternative options for sustainable management of forest resources at different levels.
- Develop appropriate criteria and indicators for sustainable forest management
- Identify information gaps in information flow.
- Document existing forestry technologies.
- Document indigenous technical knowledge of farmers as related to forestry.
- Assess various extension methods employed in forestry extension.

Outputs

Policy

- Potential opportunities and constraints of alternative management options and utilisation methods of forest resources identified.
- Information on the effects of macro and sectoral policies on forest conservation, management and utilisation documented.
- The effect of different policy options for sustainable management of forest resources documented.

Socio-economics

- Baseline data for socio-economic aspects of communities in the country documented.
- Socio-economic impact of conservation of natural resources and biodiversity established.
- Contribution of the forest sector to food security, GDP, local economies and environmental benefits established.

Forestry Extension

- Refined and efficient forestry extension organisation and administration in place.
- Tailor-made and thus acceptable forestry technologies disseminated.
- Data bank of existing appropriate forestry technologies and indigenous technical knowledge related to forestry established.
- Prioritised teaching methods for use in forestry extension work in place.
- Social, economic and political constraints related to social forestry documented.

Research Activities

Policy Research

- Undertake studies on the effect of various policies such as forest policy, taxation, subsidies, trade policies, interest rate and exchange rate policies, and privatisation; and international conventions and agreements on the management and utilisation of forest resources.
- Conduct empirical work on policy options for developing markets for NWFP.
- Assess the effect of different policy options for addressing issues such as the effect of conventional policy instruments such as taxes, subsidies, tariffs and regulations; and international transfers to governments to protect forests.
- Conduct studies to identify and assess critical variables in end-user sectors that are significant in estimating consumption of forest products, and the supply responses of different types of production systems.

Socio-economic Research

- Undertake socio-economic impact of human activities on forest resources and the interaction of forests, including off-farm trees, and the surrounding communities.
- Investigate factors contributing to failure to meet fuelwood, poles and construction timber demand, continuous land degradation, and mismanagement of soil and water resources.
- Investigate modes of land and tree tenure, and the effect of alternative property right regimes on incentives for collaborative forest management.
- Assess the contribution of the forest sector to food security, GDP, local economy and employment in Tanzania.
- Determine the magnitude of environmental benefits**.**

Forestry Extension Research

- Conduct a study on the institutional and organisational set up of forestry extension.

- Undertake studies on inventory and adoption and diffusion of the existing forestry technologies
- Carry out a survey of existing indigenous technical knowledge under different land-use systems.
- Evaluate the various forestry extension approaches.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	MSc	Ph.D	MSc
Socio-economics & Policy	4	-	3	3
Forestry Extension	1	-	2	4
Total	5	0	5	7

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Socio- Economics & Policy			
Activities	300.0		
Training	285.0		
Forestry Extension			
Activities	250.0		
Training	240.0		
		Total	1075.0

Chapter 5 Support Programme

5.1 Human Resources

Background and Justification

One of the largest investments in forestry research institutions and organisations is the investment on human resources. Researchers and technical staff recruited to work in forestry research organisations will strongly influence that organisation's capacity and capability to do effective research. Thus recruitment must be planned well in advance and closely linked to long-term strategic research program plans. Forestry research often demands recruitment of people with a particular blend of knowledge, skills and experience. Often people with such attributes are scarce and on high demand. Thus purposeful development of human resource with such talents is a prerequisite to forestry research.

Human resource is a very important component for successful forestry research. The successful design, conduct and implementation of research strategies demand adequate and well-trained human resources. Nevertheless, with the exception of higher learning institutions, forestry research institutions appear to have insufficient human resources. Also there are some areas of specialisation that have either very few or no human resources at all. In order for the forestry research institutions to play meaning full role in research it is important to solve problems related to human resources.

Objectives

Goal
Develop national human resource capacity to conduct forestry research to meet national and international obligations**.**

Specific Objective

To recruit, train, develop and retain very well qualified researchers as well as other categories of staff to strengthen the research capacities of relevant institutions.

Output

- Strengthened forestry institutional research capacity in terms of human resources.

Activities

- Develop incentive packages to attract and retain staff
- Develop and sustain human resources development programmes
- Recruit, based on competence, researchers and other necessary categories of staff to fill in the existing gaps
- Draw up comprehensive training programmes.
- Identify and ensure diversity of relevant and competent training institutions, both local and international

- Develop institutional linkages and collaboration at both local and international levels.

Inputs

The inputs are indicated under the respective research programmes.

5.2 Infrastructure

Background and Justification

Infrastructure, like other supporting services, is very important in forestry research. Good and efficient infrastructure ensures that forestry research is conducted in a conducive environment. Invariably this leads to the production of reliable research results and findings. On the contrary, however, many institutions conducting forestry research either lack research infrastructure or those available need major repairs. This situation has greatly contributed to low research productivity and hence demand due attention.

Objectives

Goal

Strengthen the capacity of forestry research institutions through the establishment of adequate infrastructure to enhance forestry research capacity so as to meet national and international research obligations.

Specific Objective

Provide forestry research institutions with adequate infrastructure for carrying out research to meet local and international research obligations**.**

Output

Strengthened infrastructure capable of supporting carrying out of forestry research to meet national and international commitments.

Activities

- Develop a sustainable routine repair, maintenance and/or replacement of infrastructure.
- Develop mechanisms of assessing and replacing obsolete facilities

Inputs

	TAS Mill
Laboratories for TAFORI[1]	252.0
Soil and plant analysis	
Tree improvement, entomology and pathology	
Forest utilisation	
Office for TAFORI	84.0
Rehabilitation of office	320.0
Total	**656.0**

[1]Three laboratories @ 200m^2
Construction cost TAS 300,000.0 per m^2
Furniture: 15% of construction cost
Equipment: 25% of construction cost

5.3 Publications and Dissemination

Background and Justification

As pointed out under section 2.2, forestry research and the related activities are currently done by many public and private institutions. Presently, there is so far no well-established structure responsible for accessing literature. This is inspite of the fact that the Act establishing TAFORI stipulates that it is required to be a depository of all forestry research findings in Tanzania (TAFORI 1992). This given TAFORI the status of a national forestry library. SUA is a national agricultural library.

The lack of proper extension resources, has led to the accumulation of research results in TAFORI. It is indeed difficult for one to identify a streamlined reporting and disseminating mechanism when it comes to forestry. Under the present set up, it is difficult to locate information on research activities and publications in the country. There is also little co-ordination amongst these many different institutions in terms of dissemination of research findings (MNRT 1998).

In order to enhance collection and dissemination of forestry research results there should be a unit with a clear mandate for keeping custody of literature. Dissemination of research results should be tailored to the whole spectrum of end-users such as scientists, industrialists and farmers.

Objectives

Goal

Improve information flow among researchers, extensionists, and end - users.

Specific Objectives

- Make forestry-related literature easily accessible to researchers.
- Strengthen the research-extension-end-user linkages for cost-effective dissemination process.

Outputs

- Information centre in place and equipped with resources for collecting and filing relevant material and servicing those needing the information.
- Research-extension-end users linkages strengthened.
- Networking mechanism of forestry researchers and extensionists in place.

Activities

- Identify key players in forestry-related research, extension and end-users.
- Establish a national forestry library in TAFORI.
- Collect forestry related literature from institutions and individuals involved in forestry research.
- Disseminate research findings through cost-effective extension methods and reporting protocols.
- Improve research and dissemination linkages between agriculture, forestry and extension.

Inputs

Human Resources

Discipline	Existing Strength and Level		Additional Requirements	
	Ph.D.	MSc	Ph.D	MSc
Information Officer	-	-	-	2
Forestry Extension	1	-	-	1
Total	1	0	0	3

Financial Resources

Costs: TAS, (Mill): Year 2000 –2009

Activities	120.0
Training	75.0
Total	195.0

Chapter 6 Inputs

6.1 Introduction

This chapter presents the financial implications of the research programmes presented in Chapter 4 and the input requirements for the support programme as shown under chapter 5. While higher degree training needs are indicated for all the programmes, it is likely that some requirements may be met by recruitment. All costs are indicative. Detailed research or support projects write-ups will come up with more realistic cost estimates. In the short and medium terms, the bulk of research funds will come from the government and bilateral agreements. In the longer term, the forestry fund proposed in the draft forestry act and the research fund proposed in section 6.4 should meet most of the NAFORM costs.

6.2 Input Requirements for the Research Programmes

Table 6 shows the costs for research activities, equipment and training. The total estimated cost for the research activities is estimated at TAS 5955 Mill. Equipment and training costs are summarised in section 6.3.

Table 6: Budget (TAS, Mill) For the Research Programmes

Programme/Activities	Period		Total
	2000-2004	2005-2009	
Natural Forests			
Activities	750.0	750.0	1500.0
Training	250.0	240.0	490.0
Sub-total			1990.0
Community & Farm Forestry			
Activities	464.0	382.0	846.0
Training	50.0	50.0	100.0
Sub-total			946.0
Plantation Forestry & Tree Improvement			
Activities	659.5	659.5	1319.0
Training	70.0	70.0	140.0
Sub-total			1459.0
Forest Resource Assessment			
Activities	500.0	400.0	900.0
Training	40.0	35.0	75.0
Equipment	50.0	50.0	100.0
Sub-total			1075.0

Table 6 (Continued):

Programme/Activities	Period		Total
	2000-2004	2005-2009	
Forest Operations			
Activities	120.0	120.0	240.0
Training	70.0	70.0	140.0
Equipment	70.0	50.0	120.0
Sub-total			500.0
Forest Utilisation			
Activities	250.0	250.0	500.0
Training	70.0	70.0	140.0
Sub-total			640.0
Socio-economic, Policy & Extension			
Activities	350.0	300.0	650.0
Training	285.0	240.0	525.0
Sub-total			1075.0
Grand total			**7785.0**[1]

[1] Total costs
Equipment TAS Mill 220.0
Activities ,, 5955.0
Training ,, 1610.0

6.3 Input Requirements for the Support Programme

Table 7 shows the input requirements for the support programme. The estimated cost is 2461.0 Mill TAS.

Table 7: Budget (Mill TAS) for the Support Programme (2000-2009)

Sub-programme/Activities	Period		Total
	2000-2004	2005-2009	
Human Resources	835.0	775.0	1610.0
Infrastructure			
Office for TAFORI	84.0	-	84.0
Rehabilitation	320.0	-	320.0
Laboratories	252.0	-	252.0
Publications and Dissemination			
Activities	60.0	60.0	120.0
Training	40.0	35.0	75.0
Grand total			**2461.0**

6.4 Financing Strategies

In Tanzania the main source of financing forestry research is joint funding between the Government of Tanzania and international donors. Public funding has also been cited as a major source of financing forestry research in Finland and Norway (Hellstrom *et al*. 1998). The indicated aspects that favour public funding in forestry research include:

- Missing/limited markets for forestry research results;
- Imperfect juridical infrastructure;
- Positive external effects in the form of innovations;
- Positive distributive effect in favour of rural areas;
- Stabilisation of an economy in recession;
- Sustainability of Research and Development (R & D) funding.

Further, investment in forestry research is long-term in nature and benefits accrue in the distant future and hence a disincentive for private funding, which have tendency for short-term discount. Also investments in forestry research embody high premium of risk and uncertainty.

As pointed out in section 2.2, donors fund most of the forestry research activities in Tanzania. This scenario is attributed to the poor performance of the Tanzanian economy during the past two to three decades which led to poor funding of all research and social services. The implementation of SAP which among others require debt servicing led to further reduction in government expenditure on various services including forestry research. This trend is unlikely to be reversed in the short to medium terms.

Funding from foreign sources has provided significant benefits in strengthening forestry research capacity in Tanzania. However, such funding is unlikely to be indefinitely sustained. To ensure sustainability, all efforts have to be directed towards creating local sources of financing research. Adequate and reliable funding is very crucial for successful development of forestry research. The overall goal is to create sustainable means of funding forestry research and development. In the short-term, however, funding of forestry research is likely to come from the government, donor agencies and possibly other public agencies (see also Section 2.2.2). In the longer term, a forestry research fund managed by a Board of Trustees should be established. Sources to the fund may include:

- Contributions from the government, donor agencies, international organisations, foundations, corporate bodies and private individuals;
- A research levy to be paid upon selling forest products;
- Environmental fee either charged separately or embodied in the price of forest products.

Some prerequisites to successful soliciting of funds for forestry research include:

- Setting very clear priorities of research areas that tie up strongly with the national forestry policies and programmes;
- Building strong research capacity to guarantee research output, hence creating credibility.
- Conduct demand driven research.

Chapter 7 Implementation Arrangements

7.1 Overall Co-ordination

Act No. 5 of 1980 establishing TAFORI gave the Institute the mandate to co-ordinate research in forestry carried out within the United Republic of Tanzania. The task to co-ordinate NAFORM implementation therefore clearly rests with TAFORI. However, for various reasons, TAFORI has in the past not been able to effectively co-ordinate forestry research in Tanzania. Therefore a number of measures have to be taken to facilitate effective co-ordination of the NAFORM implementation.

The TAFORI Board of Directors through the Research and Publications Committee should oversee the implementation of the NAFORM. Specifically, it should:

- Receive, consider and approve NAFORM projects for funding.
- Receive, consider and approve annual reports, work-plans and budgets.
- Set a mechanism for collecting forestry research related information and developing a depository of the same.

A co-ordination unit headed by a Co-ordinator should be established within TAFORI. The Co-ordinator should report to the Director General (DG) of TAFORI and should be responsible for the NAFORM implementation and management. The Co-ordinator should be appointed among senior scientists of TAFORI.

The main responsibilities of the Co-ordinator shall include:

- Overall co-ordination of all NAFORM activities.
- Receive applications for research grants and present them to the Research and Publications Committee.
- Receive technical and financial progress reports of research projects.
- Solicit various sources of funding for the NAFORM.
- Organise annual review workshops where results of research activities will be presented.
- Establish forestry and related scientists' membership list.
- Establish formal and informal linkages with relevant institutions and networks at national, regional and global levels.
- Facilitate with the assistance of the information officer, publication of results and identify various sources of information and disseminate to relevant scientists, extension agents and other stakeholders.
- Perform any other functions as required by the DG of TAFORI.

7.2 Monitoring and Evaluation

All research projects under the NAFORM shall be monitored and evaluated (*ex-ante*, current, termination and *ex-post*) to ensure that implementation is according to plan and to appraise projects/programmes in terms of relevance, effectiveness, efficiency and impact. Monitoring and evaluation systems shall be user-focussed by involving users in their design to ensure that user needs for information will be addressed.

Half-yearly reports shall be used to monitor and evaluate projects under the NAFORM. Copies of the reports must be submitted to the Co-ordination Unit not later than one month after the reporting period. For each project, an annual report shall be prepared to reflect the immediate objectives of the project, what has been achieved, problems encountered and solutions devised, and any list of publications. Project leaders shall present the information in the NAFORM annual review workshop involving Directors, Project leaders and some stakeholders. External evaluations shall be done when required.

The NAFORM shall be revised from time to time as it is deemed necessary.
Evaluation and review after five years is mandatory.

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Appendix1: Stakeholder indication of forestry related problems requiring research

Stakeholder category	Forestry Related Problem
FORESTRY LAND DEVPT AGENCIES	
a) Non Gvt Organizations	• Land degradation • Forest fires • Forest diseases and pests • Absence of joint forest management • Erratic weather (establishment problems?)
b) Gvt Organizations	• Land degradation • Forest diseases and pests • Forest fires • Limited species choice • Poor weather (establishment problems?) • Absence of forest valuation • Silvic of indigenous spp not known • Nursery techniques • Limited appropriate agroforestry systems • Inadequate Bio-diversity conservation • Limited energy alternatives
c) Private companies	• Forest fires • Teak seed, establishment and management problems
END USERS OF WOOD/NON-WOOD PRODUCTS	• Forest pests • Forest fires • Land degradation

	• Nursery techniques

Appendix 2: Stakeholder indication of researchable areas

Research Programme	Researchable Areas
COMMUNITY AND FARM FORESTRY	• Indigenous tree spp in Agroforestry • Indigenous conservation practises e,g, Ngitiri • Evaluation of fodder spp • Medicinal plants-chemical composition and propagation • Tree-crop interactions • Aquaculture • Domestication of indigenous fruit/food trees • Species screening for agroforestry • Soil conservation methods
MANAGEMENT OF NATURAL FORESTS	• Fire and grazing impacts on natural forests • Vegetation surveys • Natural regeneration and enrichment planting • Domestication of endangered and other valuable spp • Biodiversity monitoring • Catchment/watershed management • Forest health studies • Sacred forests • C&I of sustainable forest management • Village/joint forest management • Carbon sequestration • Climate change • Rehabilitation of degraded areas
PLANTATION FORESTRY & TREE IMPROVEMENT	• Seed, nursery and establishment studies • Species screening • Forest health studies • Species for urban forestry • Site index studies
FOREST OPERATIONS AND UTILIZATION	• Bio-energy research • Wood preservation and natural durability • Strength properties and utilization of Lesser known trees • Non-wood forest products-devpt/marketing • Alternative uses of forest products/wastes

	• Environmentally sound harvesting techniques

Appendix 2 Continued

SOCIO-ECONOMICS, POLICY AND FORESTRY EXTENSION	• Forestry and food security • Joint forest mgt incl. Indigenous knowledge • Forest sector contribution to GNP • Tree and land tenure issues • Land degradation causes • Forestry products contribution to livelihood
FOREST RESOURCE ASSESSMENT	• Inventory of natural forests