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Report to the Ministry
of Science and Technology
of the Federal Republic of Nigeria

ISNAR R37

REVIEW OF THE NIGERIAN INSTITUTE FOR OIL PALM RESEARCH (NIFOR)

isnar
International Service for National Agricultural Research

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands, on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing, and operations.

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The NIFOR Review Mission acknowledges the kind reception and attention we received from Director Ataga and the NIFOR staff. These plus the draft 10-year development programme and other documents which the NIFOR staff prepared in advance facilitated the work of the Mission immensely.

Thanks are due also to the numerous individuals listed in our itinerary who provided information, comments, and insights which the Mission found extremely useful in making our assessments and formulating recommendations.

In particular we wish to cite our enlightening discussions with the Honorable Federal Minister of Science and Technology, Professor E. Emovon; the Director of the Federal Department of Agriculture, Mr. I. Eleje; the Director of the Department of Agricultural Sciences of FSMT, Dr. S. Adetunji; Mr. Mike Ejemba and his staff of the FDA/MEU in Benin; and Mr. T. Husain and Mr. M. Alikhan of the World Bank mission at Lagos.

And lastly to Ms. Joyce Ogiste of the ISNAR secretarial staff who patiently typed the mission report.

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EXECUTIVE SUMMARY

INTRODUCTION

At the request of and on behalf of the Nigerian Government, the International Service for National Agricultural Research (ISNAR) undertook a study of the research and development activities and of the management of the Nigerian Institute for Oil Palm Research (NIFOR), with the primary objective of defining the Institute's role in the development of the oil palm industry, assessing the Institute's capacity to fulfill such role, and to recommend ways and means of achieving the purposes for which the Institute was organized.

The field study was conducted during the period 5-26 February 1988. The members of the review mission were:

K. Berger	U.K.	End-use
J. Ekpere	Nigeria	Extension/Training
J. Ferwerda	Netherlands	Crop Production
M. Kayode	Nigeria	Finance and Management
J. Meunier	France	Crop Improvement
E. Javier	ISNAR	Head of Mission/ Research Management

Following are the salient points in the Mission's report and recommendations.

CAPACITY OF NIFOR TO MEET THE NEEDS OF THE OIL PALM INDUSTRY FOR OIL PALM SEED

NIFOR's breeding programme is based on a modified reciprocal recurrent selection procedure initiated in 1959. The improved seeds which are elite tenera hybrids of selected dura and pisifera parents are distributed as Extension Work Seeds (EWS) in the form of sprouted seeds, primarily through the government extension service and directly to the palm estates. NIFOR has some capacity for seedling production in its main nursery at Benin and in its substation at Abak.

The Mission reaffirms the validity of the breeding procedure and notes the genetic progress that has been achieved by NIFOR in the first recurrent cycle materials. The Mission has important specific recommendations in the handling of the first-cycle materials and in the conduct of the second recurrent cycle, which is under way.

NIFOR has the potential to produce 7-million hybrid seeds per year, which is enough to establish about 25,000 hectares. Some re-planting of the first-cycle parents was done in 1987 to replace those which were already too tall to harvest. The second-recurrent-cycle progenies are not expected to come on stream until the mid 1990s.

However, in order to realize the 7-million-seed potential, NIFOR needs additional transport, supplies, and proper facilities to process, store, and germinate seeds. The Mission therefore recommends additional support for seed production operations at NIFOR, rehabilitation of the present seed unit, and installation of new cold storage and seed germination equipment.

The cloning of superior hybrids through tissue culture could supplement the propagation of EWS by conventional seed production. Nigeria can purchase the technology outright or develop the capacity indigenously through NIFOR and one or two Nigerian universities. Since the availability of improved seeds is not as yet a major constraint to oil palm development in the country, the Mission recommends that Nigeria take the second option. The two young Ph.D.s at NIFOR with training abroad in tissue culture can form the nucleus of the initiative.

The Mission recommends the establishment of a tissue culture facility at NIFOR which initially will have the capacity to produce 12,000 - 15,000 experimental clonal materials. The decision to construct a commercial tissue-culture clonal-propagation facility can be taken at a later stage.

ADEQUACY OF AGRONOMIC PACKAGES FOR OIL PALM PRODUCTION

The Mission considers the current technology and practices in nursery management, field establishment, and palm grove maintenance and management adequate for the purposes of the industry for the time being. However, the Mission expects this aspect of NIFOR's activities to pick up rapidly as new major production areas are opened and as the industry demands more location-specific recommendations, particularly on fertilizers, to replace the broad recommendations NIFOR has issued so far.

The place of the oil palm in complex farming systems will be a major immediate research challenge to NIFOR; more so as increasingly the semi-wild groves in smallholder plots are replaced by high-yielding tenera hybrids and as pressure for food production builds up in the more densely populated areas in the southern states. This implies a strengthening of farming systems research and the broadening of agricultural economics to socioeconomics at NIFOR.

The Mission has specific comments and recommendations on NIFOR's research in agronomy, soils, physiology, crop protection, farming systems, and ecology.

LIAISON WITH EXTENSION AND OTHER AGENCIES

The major link of NIFOR with extension and development agencies and with the private sector had been primarily through the provision of improved seeds and seedlings. Extension, training, and other communications support activities at NIFOR were limited. This relative isolation was imposed on NIFOR not so much by lack of competent manpower and willingness as by lack of mobility and operating resources.

The Mission has specific recommendations on the following points:

- conduct of on-farm adaptive research and demonstrations with FDA and the tree-crop units in the state ministries of agriculture to bring researchers, extension subject-matter specialists, extension agents, and farmers together;
- training needs of the state tree-crop units;
- communications support to small-holder programmes;
- advisory and consultancy services;
- linkages and joint research with processors and end-use institutions;
- linkages with universities and other research institutions in Nigeria and abroad.

These initiatives suggest a substantial increase of extension-related functions. Internally, NIFOR needs to resolve the issue of subject-matter specialists and their working relationships with the discipline divisions and the commodity research programmes.

SMALL-SCALE PROCESSING EQUIPMENT

The Mission compliments NIFOR for the progress it has achieved in the design of the NIFOR minimill. Although the Mission expects further modifications and improvements of the basic model, the technology is sufficiently mature and should be shared with local processors and fabricators.

The NIFOR palm wine bottling technology is very practical and is ready for popularization.

NIFOR could make another breakthrough in the design of small-scale equipment which will separate, clean, dry, and sort palm kernels. A lot of palm kernels appear to be wasted at present.

Design and prototyping are appropriate functions of a public entity like NIFOR. However, NIFOR needs to articulate a strategy for popularizing and commercializing its inventions. Moreover, the Governing Board of NIFOR must rule on the extent to which NIFOR should be involved in commercial fabrication.

END-USE RESEARCH

This is a new area of research for NIFOR. On the basis of very limited contacts with the private sector, the Mission identified six possible end-use applications of immediate research interest.

The following needs to be done:

1. increased coordination between NIFOR staff and private end-users to verify and validate immediate industry needs and interests;

2. retraining abroad for NIFOR researchers for the areas identified (short-term training);

3. recruitment of an experienced expatriate oils and fats chemist/food scientist for short, recurrent visits to assist in initial programme formulation and implementation.

HUMAN RESOURCES AND FACILITIES DEVELOPMENT

Except for a few narrow specializations, the scientific staff at NIFOR are adequately trained. However, they are grossly underutilized for lack of facilities and operating expenses. Most of NIFOR's facilities are obsolete and run-down and would need substantial re-equipping. Additional provisions for supplies and materials are badly needed. Unfortunately, Government subventions to the Institute have been declining since 1981.

The Mission recommends the infusion of about six million U.S. dollars worth of equipment, new facilities, renovation, construction, and training during the next five years.

The equipment, facilities, and training requirements are broken down as follows:

	Amount U.S. Dollars
Laboratories	1,015,260
Seed production/Tissue Culture	472,450
Other Units (workshops, library, computers, etc.)	604,960
Vehicles	768,000
Utilities	1,350,000
New Administration/Central Lab	450,000
Improvement of general facilities (main station)	520,000
Improvement of general facilities (Abak substation)	330,000
Training	300,000
U.S.$	5,810,670

ORGANIZATION AND MANAGEMENT ISSUES

NIFOR as a research institution derives much of its institutional strength from four major factors:

- a highly trained scientific staff;

- a well-established experiment station infrastructure with functional, albeit aging, facilities;

- a tradition of scholarship and relevant research;

- operating management processes in place.

However, NIFOR is unable to fully capitalize upon these institutional strengths. The Mission traces this inability of the Institute to realize its full potential to two weaknesses, both of which have basic policy implications:

- first, the gross mismatch between available resources and institutional objectives;

- second, the proliferation of non-research activities which drain resources and management attention away from the core functions.

A Question of Mandate. NIFOR has the mandate for oil, coconut, raphia, and date palm. NIFOR does not have the resources nor can all the four commodities justify a comprehensive research programme, considering their present and potential importance to the country.

The Governing Board and the FMST must decide to what extent NIFOR is expected to commit staff and resources to coconut, raphia, and date (conversely, at the expense of priority research on oil palm).

Overcommitment to Non-Research Activities. Moreover, only 31% of the Institute staff are directly engaged in research, the rest being assigned to administration, research support, production, and community services. In comparison, at PORIM in Malaysia, the research institution closest to NIFOR in terms of mandate, 60% of staff are directly engaged in research.

The Mission understands the background to these extra commitments and fully appreciates their humanitarian and political implications. However, the fact remains that NIFOR is far too large for its core functions of research, extension, and training. The Governing Board and FMST must resolve which activities to keep at NIFOR and which to divest and/or pare down significantly in the interest of the long-term health of the Institute.

In the near term, these non-research activities can be made more efficient and the redundant staff reassigned to other units, preferably to the core functions. Similarly, the income-generating units can be made to yield more revenues to support NIFOR.

Revenue Generation. Along this line, the Mission recommends the appointment of a second deputy director for plantations, production, and services, whose charge will be to further trim down staffing and enhance revenue potential without impairing their supportive functions to research and extension. The revenue-generating units should be fully costed, treated as business activities, and should pay their way.

The spin-off of the NIFOR oil mill company should be completed as soon as possible. The NIFOR staff seconded to the oil mill should be encouraged to transfer or, if they cannot be accommodated in the oil mill, they should be granted generous separation benefits or reabsorbed by NIFOR. The NIFOR oil mill should have its own board with whom NIFOR's Governing Board can negotiate strictly on business terms. NIFOR should expect to receive interest from its advances to the oil mill company and payment of annual dividends (which NIFOR has yet to receive after a few years of operation).

Making the Programme-Discipline Matrix Operational. The Mission supports the previous decision to establish commodity programmes over the old discipline divisions for better integration and coordination. However, the Mission would discourage the management from totally emasculating the discipline divisions.

The Mission recommends that a client-contractor relationship be established between the commodity programmes and the discipline divisions. The programmes contract research which the discipline divisions implement. The programmes will essentially have staff functions but will have substantial control over funds. The divisions, on the other hand, will have line functions and will have administrative supervision of staff and facilities in the divisions. The recruitment and promotion of scientific staff, however, will be a joint responsibility of the appropriate programme leaders and division heads.

Top Management. The Institute Director at present is heavily weighted down by day-to-day decisions. The Mission recommends that he be assisted by a deputy for research, extension, and training; a second deputy for research support, revenue generation, and community services; and an assistant director for administration and finance.

Recurrent Expenditures. Even as we highlight the need for better management at NIFOR to make more efficient and effective use of resources, it is quite obvious that much of the management problems in the Institute have their roots in the 55% decline of federal subventions during the last six years (1981-87) as a result of the drastic drop of petroleum revenues to the Federal Government.

Pending actual receipts, the approved budget for 1988 is now back to the 10 million naira level, although most of the recent increases were adjustments for salaries.

Based on our recommended work programme, the Mission believes that, within the next two years, NIFOR would require 16-18-million naira per annum to operate effectively. This does not include any further salary increases planned by Government and the requirements of the other palms in NIFOR's mandate. NIFOR may be able to generate half of the increment, but the rest has to come from Government.

PROPOSAL FOR A QUICK-DISBURSING FACILITY

In anticipation of the forthcoming Second Tree Crops Project and while waiting for the major rehabilitation effort at NIFOR, the Mission proposes that a modest emergency fund in the amount of $523,000 be taken out of the overall requirements and be made available at the earliest possible time. The amount is needed to restore utilities, repair vehicles to provide mobility to researchers, provide bridging support for seed production, to get started with the new end use programme, and to advance preparation of training and extension materials.

CHAPTER I - INTRODUCTION

1.0 Introduction

Nigeria used to be the world's leading producer and exporter of palm produce. By the mid 1970s exports had stopped altogether, and by 1985 Nigeria was importing around 150,000 metric tons of palm oil. During 1970-84, palm oil production is estimated to have grown at 2.3% per annum, but consumption increased at 3.7% per annum during the same period. If the trend continues, Nigeria's palm oil deficit could go as high as 610,000 metric tons in 1995.

However, Nigeria has the potential to produce far more than it is producing now. Three-quarters of oil palm fruit bunches are processed in the villages, with an extraction efficiency of as low as 40-50%. If more upscale mills are established, extraction efficiency can be improved to 70-92%. Moreover, it has been demonstrated that the construction of an oil mill encourages the harvesting of the semi-wild palms, from which 80% of present production comes.

Nigeria has only 150,000 hectares planted to high-yielding tenera hybrids. In comparison, Malaysia, the world's current top producer has 1.4 million hectares under hybrids. Nigeria has several million hectares of land suitable for cultivated oil palm production. She should be able to at least satisfy her rapidly increasing domestic palm oil demand, if not regain part of her previous world market share.

The Nigerian Government is fully aware of these circumstances and is renewing its efforts to reinvigorate the oil palm industry. The industry has been accorded high priority at the federal level and by practically all the states within the oil palm belt. Negotiations are under way for a second phase to a World Bank-assisted Tree Crops Project and for support from the European Economic Community.

The Nigerian Institute for Oil Palm Research (NIFOR) is the principal Government agency responsible for conducting research on the improvement, cultivation, and processing of the oil palm. It is the only source of adapted and high-yielding palm hybrids in the country. Thus NIFOR is expected to play a pivotal role in the future development of the oil palm sector.

This report, which was prepared by the International Service for National Agricultural Research on behalf of the Federal Ministry of Science and Technology (FMST), and the Federal Ministry of Agriculture, Water Resources and Rural Development (FMAWRRD), is part of a broader look into the strategy for rehabilitating and further expanding Nigeria's oil palm industry. The report reviews the role of NIFOR in oil palm development, assesses its current capacity and potential, and recommends ways and means to enable the Institute to meet present needs and to anticipate future demands of the industry.

1.1 Terms of Reference

The Review Mission was given the following specific terms of reference:

1. examine the capacity of NIFOR to meet the projected needs for improved seeds and seedlings in the expansion programme of the oil palm industry for the next ten years; they should identify weaknesses, if any, in the production of such improved seeds and seedlings and make recommendations for strengthening this activity; this will include the development and possible use of tissue culture techniques for accelerating production of better planting;

2. review the recommended agronomic packages for oil palm production with a view to identifying areas requiring further research and development;

3. review the liaison between Research and Extension for the industry, with a view to identifying areas requiring strengthening; this will include the examination of the link between NIFOR and the Federal Ministry of Agriculture, on the one hand, and the relevant State Ministries of Agriculture and the producers on the other, especially with respect to the identification and articulation of areas of need;

4. review the achievements in the development of improved small-scale processing equipment and determine areas for improvement and support;

5. review the newly organized End-use Research Programme and determine requirements for establishing it on a proper footing;

6. examine the physical infrastructure, plant and equipment, and other requirements and determine their suitability and adequacy for at least the next ten years to enable the satisfactory performance of the required research and development work;

7. examine the cost of these activities and the financing arrangements in terms of their adequacy and sources of funding, including possible private-sector contributions;

8. consider any other factors relevant to the above which could impede the establishment of satisfactory research and its orderly conduct, and make appropriate recommendations to resolve them.

1.2 The Review Team

The review team was composed of the following:

Kurt G. Berger	-	End-use (UK)
Johnson A. Ekpere	-	Extension (Nigeria)
Jan Dirk Ferwerda	-	Crop Production (Netherlands)
M. O. Kayode	-	Finance and Management (Nigeria)
Jacques Meunier	-	Crop Improvement (France)
Emil Q. Javier	-	Research Management and Head of Mission, ISNAR (Philippines)

The brief curricula vitae of the review team members are shown in the Annex.

1.3 Itinerary

The field review was conducted during the period 7-27 February 1988. Most of the time was spent at NIFOR's main campus at Benin city in Bendel State. The team split into two at one stage to visit small-holder plots, palm estates, and village and commercial oil mills in several states. Also included in the schedule were visits to oil processors and palm oil product users around Lagos.

The details of the itinerary are in the Annex.

CHAPTER II - BACKGROUND

2.0 Geography

Nigeria is a federal republic comprising twenty-one states and a federal capital territory. It is the most populous country in Africa. The latest estimates place its population at 100 million and growing at the rate of 3.3%. Eighty-three % of the population live in rural areas. Annual per capita income was US$760 in 1985. It has a total land area of 923,770 square kilometers.

The country is entirely within the tropical zone. There are two seasons: a wet season which lasts from April to November when the prevailing monsoon winds blow from the southwest, and a dry season which lasts from December to March, when the harmattan winds come down from the northeast.

Mangroves and rain forest are the principal vegetation in the humid south and occupy about 20% of the land. The forests are succeeded by four belts of savannah running roughly east to west, with the height of grass and density of wood diminishing progressively as one goes farther north.

The soils over a large part of the north and southwest are derived from old crystalline basement complex rocks. They are highly mineralized and give rise to soils of high nutrient status, although they are variable from place to place. On the sedimentary rocks in the southeast, northeast, and northwest, and coastal parts of the southwest, the soils are sandy and less variable but are deficient in plant nutrients and very prone to erosion.

Nigeria has generally a low relief compared with the east, central, and southern parts of the continent. The most conspicuous feature of the landscape is the confluence of two great rivers - the Niger and the Benue - which is proudly reflected in the seal of the republic.

2.1 The Economy

Nigeria's economy has been dominated by the oil sector during the last two decades. The oil sector accounts for practically all foreign receipts, four-fifths of Government revenue, and one-fourth of gross domestic product.

Nigeria's GDP expanded at a healthy rate of 6-7% during 1975-80. However, with the collapse of oil prices in 1981, the economy ground to a halt and declined by 12.1% during 1981-83. With improved oil prices and better weather, the economy turned around to a moderate 2.4% GDP growth in 1985. Oil prices slumped and GDP deflated once more in 1986.

The present Government has been taking resolute steps to put the economy on the right track again. The devaluation of the naira, curtailment of consumer imports, increased reliance on local sources of raw materials, renewed priority for food and agricultural development, privatization of parastatals, reduction of the federal budget, and streamlining of the bureaucracy should help correct the misdirected efforts of the past.

2.2 Agriculture

Agriculture used to be the largest sector in Nigeria's economy. In 1962 agriculture, including livestock, fishery, and forestry, contributed 61% of the GDP. With the discovery and development of oil, agriculture's contribution declined to about 21% by 1980. Oil revenue has since declined drastically, and now agriculture is back to about 27% of GDP.

The principal agricultural commodities in the commercial sector used to be cocoa, groundnuts and groundnut oil, palm oil and palm kernel, rubber, cotton and cotton seed, and timber. But now cocoa is the only agricultural export of any significance.

Subsistence food crops like maize, sorghum, taro, yams, cassava, rice, and millet are widely grown. They are usually intercropped and/or interplanted with export or cash crops.

Smallholders comprise the majority of Nigeria's agricultural production base. Many parastatal estates have been established for major export crops, but the existing land tenure does not lend itself to large-scale operations. Most of the agricultural lands are communally owned, and in any case the previous British colonial administrations discouraged ownership of large tracts of land by non-indigenous entities.

The economic and administrative reforms during the last few years have tended to redress the policy bias against agriculture. The devaluation of the currency and the regulation of food imports have made the production of export crops like cocoa, rubber, palm oil, and other food crops very attractive once more. The present Government's priority for and commitment to agriculture and rural development is stressed by the establishment recently of a Directorate for Food, Roads and Rural Infrastructure, directly under the Office of the President.

2.3 The Science and Technology Sector

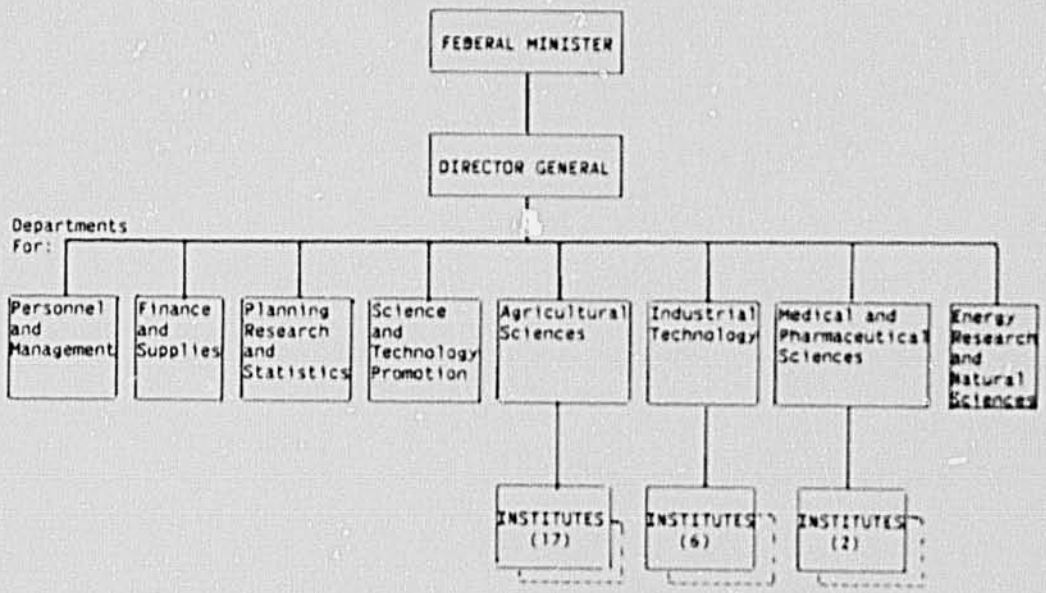
Scientific and industrial research is a responsibility of the Federal Government. The earlier constitutions placed scientific and industrial research on the "concurrent" or joint responsibility list with the states, but since the mid 1970s, research had been essentially under federal hands. The responsibility for national science policies and priorities, for planning, coordinating, and integrating research and for mobilizing and harnessing science and technology for national development needs, is vested in the Federal Ministry of Science and Technology (FMST). Some scientific research is conducted in the universities, but the bulk of research resources are in the 25 research institutes under the supervision of FMST listed in Table 1.

The Federal Ministry of Science and Technology is organized into eight departments, each headed by a Director (Figure 1). The research institutes used to report directly to the Federal Minister of Science and Technology, but following the reorganization implemented shortly after the Mission left the country, the research institutes now report to the appropriate Department Directors.

Table 1: Research Institutes of the Federal Ministry of Science and Technology

	Headquarters Location
AGRICULTURAL SCIENCES	
1. National Cereals Research Institute	Badeggi
2. National Veterinary Research Institute	Vom
3. National Root Crops Research Institute	Umudike
4. Nigerian Institute for Oil Palm Research	Benin
5. Institute for Agricultural Research	Samaru
6. National Animal Production Research Institute	Shika
7. Nigerian Stored Products Research Institute	Ilorin
8. National Institute for Horticultural Research	Ibadan
9. Lake Chad Research Institute	Maiduguri
10. Nigerian Institute for Oceanography and Marine Research	Lagos
11. Cocoa Research Institute of Nigeria	Ibadan
12. Institute for Agricultural Research and Training	Ibadan
13. Rubber Research Institute of Nigeria	Benin
14. Nigerian Institute for Fresh Water Fish Research	New Bussa
15. Forestry Research Institute of Nigeria	Ibadan
16. Agricultural Extension Research Liaison Service	Samaru
17. National Institute for Trypanosomiasis Research	Kaduna
INDUSTRY	
18. National Office of Industrial Property	Lagos
19. Nigerian Building and Road Research Institute	Otta
20. Federal Institute of Industrial Research, Oshodi	Lagos
21. Nigerian Research Institute for Chemical Technology	Zaria
22. Product Development Agency	Enugu
23. Raw Material Research Council	Lagos
MEDICAL SCIENCES	
24. Nigerian Institute of Medical Research	Lagos
25. Nigerian Pharmaceutical Research Development Institute	Abuja

Figure 1: Federal Ministry of Science and Technology



The Federal Minister of Science and Technology is assisted by a Director General (formerly Permanent Secretary) who is responsible for day-to-day overall administration and coordination.

Most of the research institutes are organized as parastatals with semi-autonomous governing boards. The parastatal status allows the institutes certain flexibilities denied to regular agencies in the bureaucracy, such as the authority to reorganize within the institute, the authority to set priorities within their respective mandates, to retain and spend their incomes, and to set personnel policies subject to broad federal civil service guidelines.

The governing boards are responsible for the setting of programme priorities and strategies, determination of organization and structure, approval of programme and budget, and appointment of staff (except the Director). The members of the governing boards who are appointed by the President upon recommendation of the Federal Minister of Science and Technology are drawn from the sectoral ministries, from academe, from the private sector and the public at large. This broad sectoral representation in the boards is intended to ensure that research conducted by the institutes is relevant to the needs of the end-user ministries, the private sector, and the public as a whole. The chairpersons of the boards used to be directly responsible to the Federal Minister. With the recent reorganization it is implied that they will now report directly to the appropriate Department Director.

Their semi-autonomous status notwithstanding, the research institutes nevertheless are guided by-and-large by federal rules and regulations on financial and personnel matters. Since most of the institutes hardly generate incomes, they are heavily dependent on Federal Government subventions for support.

Similarly, as the Federal Ministry is ultimately accountable to Government for the performance of the research institutions, FMST retains substantial authority over the institutes. This is exercised mainly through the budget process. Major research thrusts and initiatives which normally require substantial capital outlays and significant increments in recurrent expenditure must be vetted by the Federal Minister before they can be funded and implemented.

2.4 The Oil Palm Industry

Environment. The oil palm grows abundantly in the southern states of Nigeria. It is found on rainforest land used for the production of food crops in a shifting-cultivation system. The most suitable areas are in the southernmost areas in the delta, where rainfall is high and relatively well distributed. However, as one goes farther inland to the north and west, water gradually becomes a limiting factor to oil palm adaptation and production.

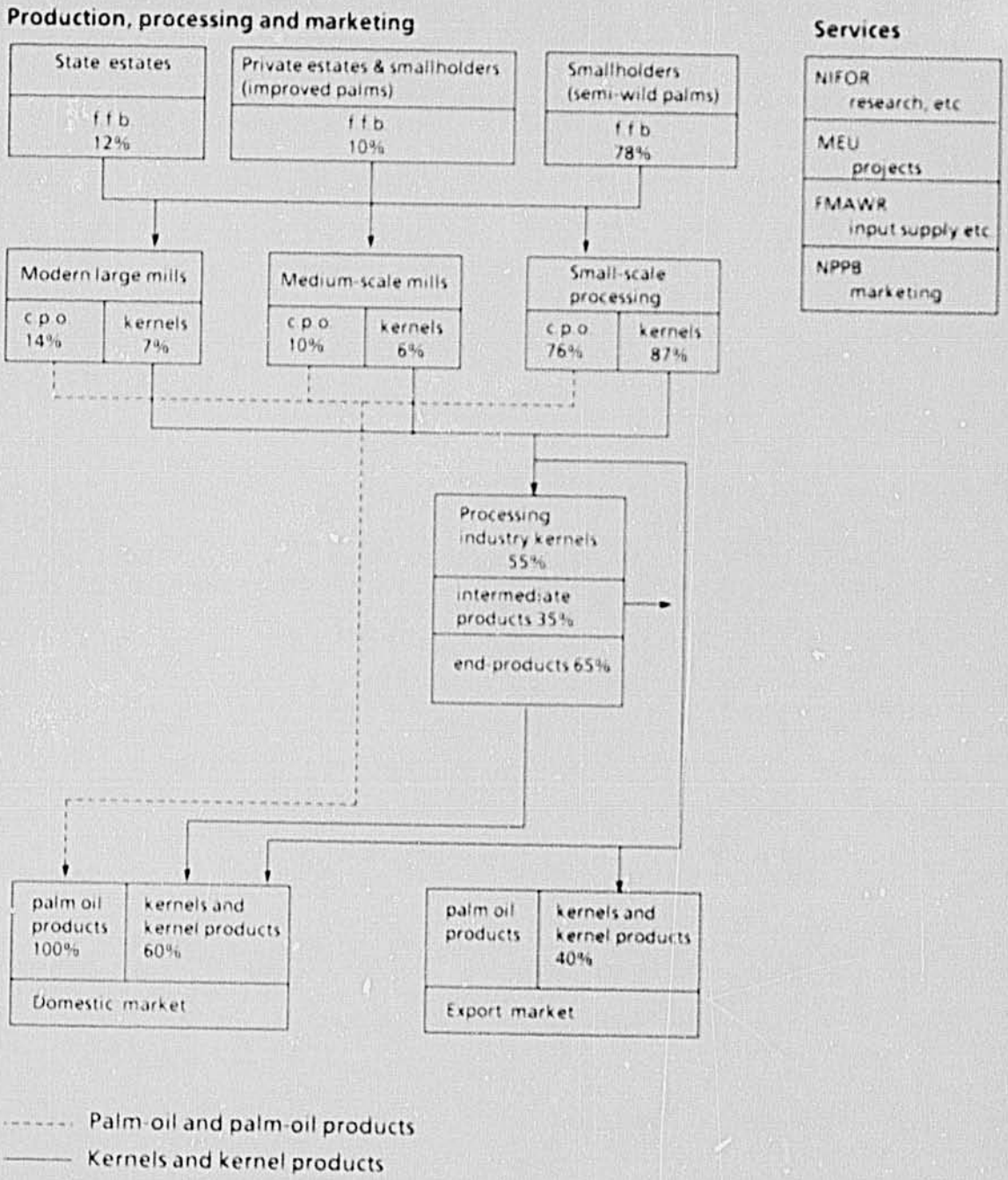
Soil structure in the oil palm growing areas is usually adequate, but nutrient and organic content are usually low. Inherent soil infertility, water deficits associated with the monsoonal climate, and low light intensities in most of the oil palm growing areas result in lower average yields compared with those obtained in Malaysia.

Structure of the Industry. The industry is graphically described in Figure 2. Palm oil in Nigeria comes from three sources: the semi-wild groves from which the bulk of production originates; the hybrid tenera plantings in smallholder plots and a few small private estates; and from the parastatal estates.

On the processing side, the fresh fruit bunches go to small-scale processing units in the villages, to small- to medium-scale mills, and to modern large mills. The main products are palm oil and palm kernel products. Much of the palm oil is consumed as crude palm oil. There is a small manufacturing industry producing soap, edible fat or oil, and margarine.

On the services side, the major institutions are NIFOR for research, training, and source of hybrid seeds; the Monitoring and Evaluation Unit of the Federal Department of Agriculture (MEU/FDA) for project preparation, evaluation, and monitoring; the FMAWRRD for input supplies; and the Tree Crop Units (TCUs) of the State Ministry of Agriculture for extension, seedling supply, and training. The defunct Nigerian Palm Produce Board (a parastatal) used to be responsible for marketing for export, while domestic trading for oil palm products is open to the private sector.

Figure 2: The oilpalm sector in Nigeria. From Moll, H.A.J. 1987. The Economics of the Oil-Palm. Pudoc Wageningen. (page 219)



Semi-Wild Groves. The density of the palms in the wild varies from less than ten to over 150 mature trees per hectare. The trees are not given any care at all other than pruning of the subtending leaf petioles during harvesting. The ripe bunches are brought down by climbers and crushed at home for kitchen use or sold to village processors, or estate mills if they are accessible.

NIFOR estimates that about 28 million hectares of land in southern Nigeria are suitable for oil palm cultivation. The present actual area in the wild is estimated to be equivalent to 2.4 million hectares of regularly spaced palms (most often quoted figure).

Since the only direct costs to production are labor for harvesting and the cost of transport, the exploitation of the semi-wild groves is influenced significantly by transport costs and the price of fresh fruit bunches offered to gatherers.

Most of the land on which the oil palm grows belongs communally to families, villages, and tribes. However, certain individuals and families may have cultivation rights to certain parcels of land. Land rights, however, are not necessarily synonymous with tree rights. Thus, in addition to prices and costs, the exploitation of semi-wild palm groves is determined by a complex system of rules and practices which could vary from village to village.

Smallholder Plantings. Nevertheless, individuals do acquire rights to certain parcels of land by outright purchase, inheritance, and/or by assignment by village elders. About 100,000 hectares of such lands have been planted by individual smallholders with improved seedlings in Government-sponsored oil palm replanting schemes during the last 25 years.

The condition of the smallholder plantings is largely unknown. Those planted 20 years ago must be ready for replanting. Most of the smallholder plantings the Mission visited appear not to be well-tended and would need rehabilitation.

Estates. The British colonial government land policy and post-independence practice in Nigeria did not allow companies, local and foreign, and single individuals to acquire vast tracts of land. Thus, unlike in Malaysia, where private estates form the core of the industry, all the large palm estates that have been established in Nigeria are state and/or federally owned.

Production. Palm oil production statistics range from a low of 340,000 metric tons to a high of 760,000 MT, depending upon the source of information (see Annex - End-use Programme for explanation). The FAO estimate, which is on the high side, is based on land area and expected yields and probably assumes 100% exploitation of the semi-wild palm groves. The estimate of 535,000 MT for 1986 by the Monitoring and Evaluation Unit of the Federal Department of Agriculture, on the other hand, assumes only 70% exploitation.

Export and import figures are probably a little more reliable. Exports of crude palm oil have been minimal since the 1970s, reaching a peak of 31,000 MT in 1975. There have been no exports since 1977.

Imports, on the other hand, commenced in 1976. Imports increased steadily each year, and by 1984 Nigeria was importing 135,000 MT of palm oil.

Estimates of palm oil shortfalls range from 150,000 to 350,000 MT for 1985.

While Nigeria has effectively ceased as an exporter of palm oil, it has managed to retain some share of exports of palm kernels and palm kernel products. In 1985 Nigeria exported the following:

palm kernels	-	32,448 MT
palm kernel oil	-	6,624 MT
palm kernel cake	-	13,534 MT

However, this is a far cry from the 380,000 MT of palm kernels the country exported in 1950.

Processing - The fruit bunches are processed in several ways:

village process	-	boiling, hand pounding, and skimming of the oil from the pulped mass
mini-mills	-	with the use of hand-operated curb or hydraulic presses
Power-operated oil mills	-	commercial mills.

For the village process, the oil extraction efficiency is in the order of 40-50%, with an average free fatty acid content of 7-12% (indicator of oil quality). In the mini-mills, such as the one designed by NIFOR, with the use of hand-operated hydraulic presses, extraction efficiency is raised to 60-75% and with a free fatty acid content of 3-4%. The modern commercial mills extract 90-92% of the oil with a low free fatty acid content of 2-3%.

Quite obviously, if all the present fresh fruit bunches (FFB) were brought to modern mills for processing, palm oil production in Nigeria would immediately double. However, the present total milling capacity is only 210 tons FFB/hr. A very recent survey concluded that Nigeria could use an additional 390 tons FFB/hr capacity to process potentially available fresh fruit bunches.

The need for more and more widely dispersed processing capacity has been identified as top priority in the government's oil palm development scheme.

Moreover, a lot of palm kernels are observed to be wasted, although there is a lot of unused modern kernel-cracking capacity. The problem technically appears to be in the separation of the kernel from the fibers.

CHAPTER III - NIFOR

3.0 History

NIFOR was established in 1939 by the British Colonial authorities as the Oil Palm Research Station (OPRS) under the then Nigerian Department of Agriculture. In 1951 the Station was transferred to the West African Research Organization (WARO) as the West African Institute for Oil Palm Research Organization (WAIFOR) by virtue of Ordinance (Nigeria) No. 20 of 1951 "for the purposes of undertaking research into and investigations of problems and matters relating to oil palm and its products, and the provision of information and advice relating to the oil palm". Its activities spanned the British West African territories of Cameroon, Nigeria, Gold Coast, and Sierra Leone.

With the independence of member countries and the dissolution of the West African Research Organization, WAIFOR was changed by the Nigerian Institutes Act No. 33 of 1964 to Nigerian Institute for Oil Palm Research (NIFOR), and its scope of work became confined to Nigeria. The new legislation, however, broadened its responsibilities to include other economic palms like coconut, raphia, and date, and all other palms the Government may from time to time determine.

For more effective coordination of Agricultural Research in the country, NIFOR came under the aegis of the defunct Agricultural Research Council of Nigeria (ARCN) by the Agricultural Research Institutes Decree No. 35 of 1973.

In 1977, the Agricultural Research Institutes Decree was repealed, and NIFOR came under the National Science and Technology Development Agency (NSTDA) by Decree No. 5 of 1977. With the return to civilian rule, the National Science and Technology Development Agency was elevated to cabinet level as the Federal Ministry of Science and Technology by the National Science and Technology Act No. 1 of 1980. The FMST was briefly merged with the Federal Ministry of Education in 1984 but has since then operated as a separate ministry.

3.1 Mandate

The current formal mandate of NIFOR, as spelled out in the Research Institute's Decree of 1973, is to conduct research into the production and products of oil palm and other palms of economic importance and shall, in particular, undertake research into:

a. the improvement of the genetic potentials of the specified crops;

b. the improvement of agronomic and husbandry practices relating to specified crops;

c. the mechanization and improvement of the methods of cultivation, harvesting, processing, and storage of the specified crops;

d. the improvement of the utilization of byproducts;

e. the ecology of pests and diseases of the specified crops and improved methods of their control;

f. the integration of the cultivation of the specified crops into farming systems in different ecological zones and its socioeconomic effects on the rural population;

g. any other matters related to the specified crops.

3.2 Governance

The basis for the status and governance of NIFOR is spelled out in the "Guidelines for the Management of Research Institutes in the Federal Ministry of Science and Technology (1980)", namely,

1. the institutes are semi-autonomous corporate bodies;

2. they are publicly owned and financed, and their staff are public officers; and

3. the Federal Ministry of Science and Technology, as the coordinating and supervising ministry, is responsible to Government and answerable for the activities of these institutes.

The Institute is under the management and direct supervision of a governing board composed of individuals appointed by the President of the Republic upon recommendation by the Federal Minister of Science and Technology. The governing board has broad responsibility for policy formulation, for setting down research priorities and directions, for organizing units within the institute, approving budgets, appointing staff, and for providing overall financial oversight to the institution.

However, as a publicly owned and financed institution NIFOR nevertheless is subject to federal rules and regulations on financial matters and the civil service. Moreover, the governing board is responsible to the Federal Minister of Science and Technology, who is accountable to the Government and the public for the activities of the Institute.

The governing boards of all the research institutes, including NIFOR, were dissolved in 1983. A new NIFOR board has been reconstituted and assumed office shortly after the Mission left the country.

It is anticipated that the new governing board will establish, as suggested by the FMST guidelines, the following essential committees:

1) Staff and General Purposes Committee, for
   - staff appointments, promotions, secondments, confirmation of appointments and discipline
   - staff welfare and related matters
   - staff development and training

2) Finance and Development Committee, for
   - long-term and annual budgets
   - physical development proposals

3) Research Programme Committee
   - long- and short-term research programme
   - application of research results to development

The Director is the chief executive of the institute. He is responsible to the governing board, of which he is a member, for the day-to-day management of the institution.

At NIFOR the Director is assisted by a management committee which is composed of the one Assistant Director, the heads of the research programmes and the support departments, and the administrative secretary[1/]. Also assisting the Director are various standing committees, namely:

1) Department Selection Boards
   - Two separate selection boards for junior and senior staff; recommend eligible staff to the Director and the governing board (as the case may be) for promotion.

2) Training Committee
   - Screens and recommends staff applying for in-service training relevant to the requirements of the Institute.

3) Staff Housing Allocation Committees
   - Two separate bodies set up to help assign quarters to junior and senior staff

4) Sports Committee
   - Coordinates sporting and recreational activities.

5) Publications Committee
   - An editorial body which screens papers for publication in the NIFOR journal.

6) Land Acquisitions Committee
   - Conducting individual negotiations for land required by the Institute.

7) Seed Production Committee
   - Planning and coordinating seed production activities.

8) Isiuwa Welfare Assembly
   - A body set up with the encouragement of management to look after the welfare of the junior staff and their dependents living in the Isiuwa residential area; has twenty-five officers elected by residents.

9) Research Committee
   - For review and approval of research projects.

1/ The Mission was made to understand that four assistant director positions have been established and will be filled soon. It was not clear what the four new management positions are for. The Mission presumed that the new assistant directors will be selected from among the six research programme leaders.

3.3 Structure and Organization

The current organization of NIFOR, as indicated in the briefing notes provided to the Mission, is shown in Figure 3.

At the apex is the Governing Board, the members of which are appointed by the President of the Federal Republic of Nigeria. The board is accountable directly to the Federal Minister of Science and Technology. However, being a parastatal, the reporting relationship of the board to the FMST is not the standard supervision and control solid line reflected in the chart.

The Institute Director, as chief executive, reports to the Governing Board. However, he had in fact a dual reporting role: he was also directly accountable to the Federal Minister of Science and Technology[1/].

NIFOR is organized into seven major research programmes and four support departments as follows:

Research Programmes
- Oil Palm
- Date
- Raphia
- Coconut
- Farming Systems
- End-use
- Extension and Training

Departments
- Policy and Management
- Services
- Plantations
- Production

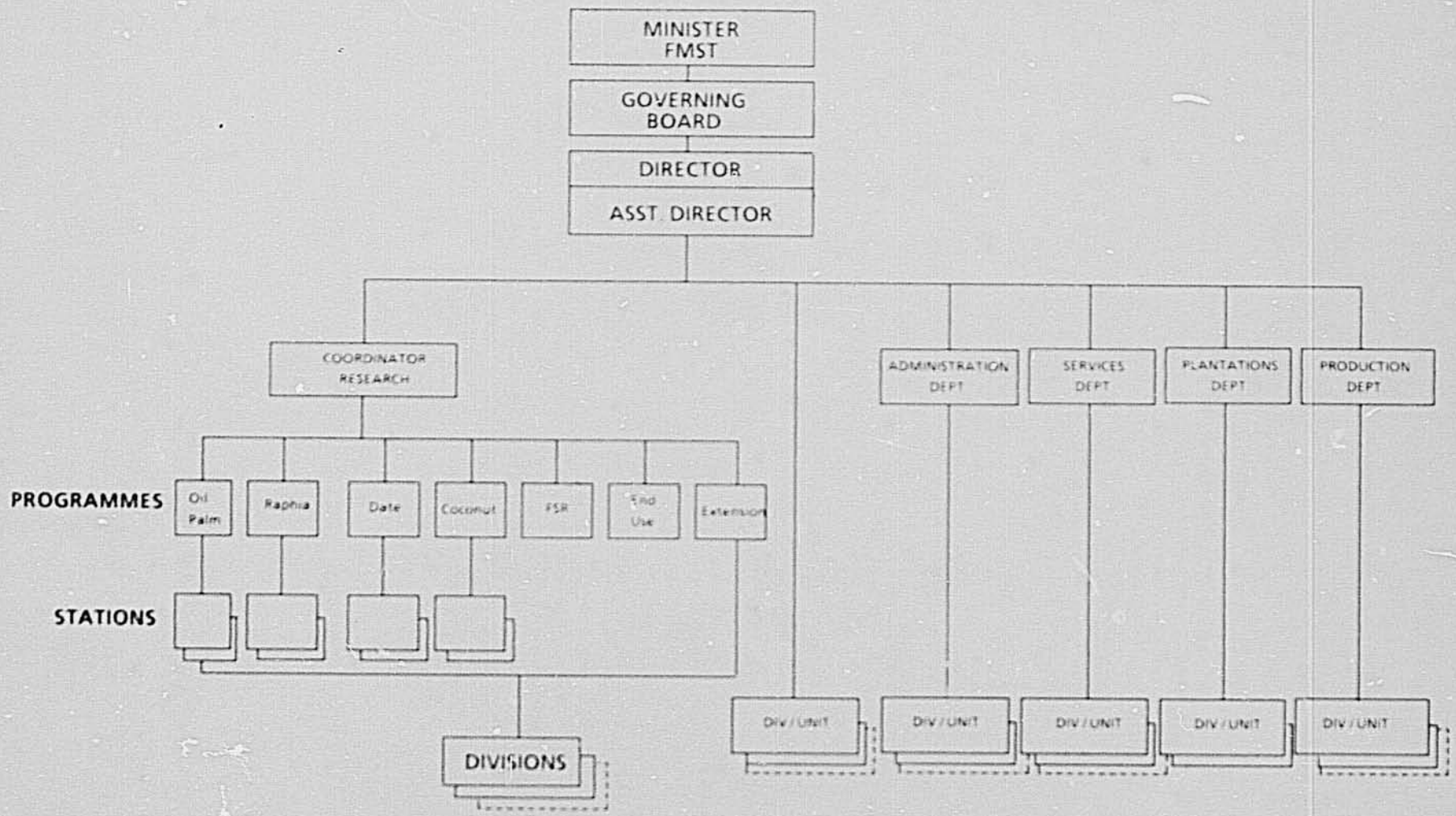
In addition to the main station at Benin, NIFOR operates four substations and 13 outstations strategically located in the main growing areas of its mandated crops. The substations and outstations report directly to the relevant programme leaders.

The present organization was the product of the last reorganization of the previous board in 1983. The reorganization was designed to:

(a) ensure a rational distribution of available trained research staff among programmes in order that research should not be concentrated on any single crop to the detriment of the other crops within the Institute's research mandate;

1/ Shortly after the Mission left, there was a reorganization in the bureaucracy which redefined the position of the permanent secretary. In addition, within FMST, direct line responsibility was given to the Department Directors over the research institutes. This would mean that NIFOR will now report to the FMST Director of Agricultural Sciences, not to the Federal Minister. This raises a complication, as the Director of Agricultural Sciences is himself a member of the board.

Figure 3: Current NIFOR organizational chart



(b) enable research funds to be distributed equitably among the various palms;

(c) ensure that the capital development programmes approved in any plan period are implemented and that each research substation receives adequate attention to ensure early take-off.

The research programmes draw their research and supporting staff from specialist divisions. Each programme is headed by an Assistant Director or a Chief Research Officer, who is designated Programme Leader or Acting Programme Leader, as the case may be.

The chart indicates an overall coordinator for all research programmes. The Mission is unaware if an appointment has been made.

As described in NIFOR briefing documents, the primary function of the Programme Leader is to see to it that research is conducted according to the programme of work approved by the Research Committee. Matters concerning the recruitment of the programme staff (in liaison with the personnel division), making available basic tools needed for research in the field and in the laboratories, periodic reporting on research activities, and staff appraisal and discipline, including annual evaluation and reporting on research staff, all come within the schedule of duties of the programme leader.

The task of building the infrastructure in the relevant substations is also that of the programme leader who, in consultation with the Director, is responsible for disbursing funds to the programme. This arrangement is without prejudice to the guidelines issued by the Federal Ministry of Science and Technology or any directives from the Governing Board.

The smallest administration unit is the Division, which in the research programmes is organized along subject-matter discipline lines. The present discipline divisions are:

Plant Breeding
Agronomy
Chemistry
Biochemistry
Plant Pathology
Entomology
Plant Physiology
Agricultural Economics
Agricultural Engineering
Statistics

The Head of Division coordinates the activities within the division. He is responsible for ensuring that laboratories are well staffed and equipped to meet the needs of the scientists in the discipline belonging to the various programmes.

The supporting staff, i.e., laboratory technologists, technicians, and assistants are supposed to be pooled. The discipline and control of all laboratory staff and all non-research staff in the Division come

under the Head of Division. The Head of Division, being the most experienced staff person, is expected to offer professional advice to his less-experienced colleagues in the execution of their duties.

However, it should be noted that the placement of the scientific divisions in the existing organization chart does not reflect the above description.

There are 22 divisions/units in the support departments. The Policy and Management Department[1/] includes the staff of the Office of the Director, the Administrative Department (general administration and personnel divisions), accounts, stores, the library, the medical division, internal audit, and security.

The Services Department includes transport, maintenance engineering, utilities, central laboratory, computer, instrumentation, fire services, and the special palm oil distribution unit.

The Plantations Department handles harvesting and maintenance of the plantation at the main station.

The Production Department supervises most of the revenue-generating units, such as seed production, nursery, palm wine bottling unit, small-scale processing equipment fabrication unit, and the consultancy for Obotme and Erei estates.

3.4 Physical Facilities and Resources

The main station of NIFOR, which is 30 km from Benin City in Bendel State, occupies an area of 1735 hectares. One thousand two hundred hectares are planted to oil palm and 535 hectares set aside for offices, laboratories, workshops, residences, and other uses.

The station is a community in itself and maintains its own network of roads, generates its own electricity, pumps its own water and provides housing, medical facilities and primary schooling, and maintains a golf course and other amenities to the staff and their dependents.

NIFOR also has on its campus an oil mill with a capacity of 6 tons FFB/hr, which it owns and operates as a subsidiary.

Most of the buildings and residences in the main campus were constructed during the last thirty years, and are in bad need of repair and rehabilitation. The offices and laboratories are overcrowded and would practically require a new set of equipment to replace worn out and/or obsolete ones. Only a few of the 97 transport vehicles are in running condition.

1/ There is some ambiguity in the nomenclature and coverage of this department. The Policy and Administrative Department, as such, does not appear as a unit in the organizational chart, but the Administrative Department appears as a separate box.

Apart from the main campus at Benin, NIFOR maintains four substations for oil palm, date, coconut, and Raphia, at Abak, Dutse, Badagri, and Degeman respectively. Abak, which is the most developed of the substations, has 170 hectares planted to oil palm, a fairly well established road network, and modest office and workshop facilities and housing for the staff.

In addition, NIFOR has 13 outstations at which it conducts field experiments. The outstations are simply test sites and have hardly any facilities at all. The outstations and their locations are as follows:

Outstations	Location State
Acharu	Kwara
Aden	Bendel
Agbarho	Bendel
Anyangba	Kwara
Bida	Niger
Idah	Benue
Ikom	Cross River
Kabba	Kwara
Koko	Bendel
Ilutitun	Ondo
Onishere	Ondo
Umuabi	Anambra
Oredo	Bendel

3.5 Human Resources

Staffing levels. As of 1987-1988, NIFOR has a total regular staff of 1843, among whom 291 and 1552 are classified as senior and junior staff,[1/] respectively. In addition, the Institute employs additional personnel numbering around 500 who are paid on a daily basis.

The staff distribution into departments, programmes, and divisions/units is shown in Table 2 and is summarized as follows:

	% of Regular Staff
Policy and Management	13
Services	19
Plantations	21
Production	16
Research Programmes	31
TOTAL	100%

1/ The Nigerian civil service has 16 grade levels (GL). All employees with the rank of GL07 and higher belong to the senior category. The entry grade for a research officer with a good basic honours degree is GL08. Some technicians, secretaries, and clerks who have been in the service for a long time reach the senior ranks.

Table 2: Regular Staff Distribution into Divisions, Departments, and Programmes

	Staff Numbers		
	Senior Staff	Junior Staff	Total
Policy and Management Department			
Director's Office	3	4	7
Administration	21	39	60
Accounts	10	12	22
Audit	1	4	5
Library	3	5	8
Stores	1	28	29
Catering	2	15	17
Medical	21	23	44
Security	2	45	47
Subtotal	64	175	239
Services Department			
Computer	6	13	19
Instrumentation	2	8	10
M.E. Division	8	96	104
Utilities	10	75	85
Central Lab.	20	56	76
Transport	4	45	49
Subtotal	50	293	343
Plantations Department			
Plantations	9	219	228
Harvesting	3	164	167
Subtotal	12	383	395
Production Department			
Seed Production	6	99	105
Nursery	3	43	46
Palm Wine Unit	2	13	15
NOMC (Oil Mill)	5	60	65
SSPU	1	6	7
Obotme Estate	1	51	52
Erei Estate	2	8	10
Subtotal	20	280	300
Research Programmes			
Oil Palm	48	267	315
Date	21	35	56
Raphia	15	31	46
Coconut	22	29	51
Farming Systems	17	23	40
Extension and Training	12	13	25
End-use	10	23	33
Subtotal	145	421	566
TOTAL	291	1552	1843

Thirty-one percent of the regular staff are directly assigned to the research programmes; the rest perform administrative, other research support functions, social services, and revenue-generating activities.

Researchers. Among the 291 senior staff, 145 or 50% are assigned to the research programmes. And out of the 145, 69 or 48% are researchers; i.e., with at least bachelor of science degrees. The balance of the research senior staff are agricultural superintendents (technicians) who are holders of diplomas in agriculture.

In terms of academic degrees, 96% of the researchers have graduate degrees. Many of the more senior scientists obtained their degrees abroad, but more and more the younger staff get their advanced studies from Nigerian universities:

Research Officers By Academic Degrees

Ph.D.	26
M.Sc.	40
B.Sc.	3
Total	69

In terms of programme assignments, only 15 are assigned to the oil palm programme proper. However, if one includes the farming systems, extension/training, and end-use programme personnel, the actual research staff devoted to oil palm increases to 38 or 55% of the total:

Research Officers by Programme Assignments

Oil Palm	15
Date	10
Raphia	10
Coconut	11
Farming Systems	9
Extension/Training	5
End-use	9
Total	69

The NIFOR researchers are fairly well distributed among several of the major agricultural sciences, as follows:

Research Officers by Division Appointments

Plant Breeding	9
Chemistry	7
Biochemistry	8
Entomology	9
Plant Physiology	5
Plant Pathology	7
Agronomy	10
Agricultural Economics	4
Agricultural Engineering	4
Statistics	2
Extension	4
Total	69

Staff Appointment and Promotion

The Research Institutes Act No. 33 of 1964 empowers the governing boards to define the conditions of service of the staff of the institutes. However, in practice the Federal Government Civil Service Rules (last revised in 1974) and the Federal Government Financial Regulations (of 1976) fully apply to research institute staff.

Many points relative to personnel management are clarified in the FMST Guidelines for the Management of Research Institutes (1980).

By and large, the applicable rules and regulations are reasonable and appropriate and appear to be widely accepted by the staff. For staff recruitment, selection, and placement, minimum requirements are set for different grade levels. However, the Institute has the option to raise the requirements as it deems necessary and appropriate. Thus in recent years, the requirement for recruitment to the research officers rank was elevated from possession of a good first degree to a master of science degree in the relevant discipline.

In the appointment and promotion of senior staff, a Departmental Selection Board goes over the qualifications and conducts an interview of the candidates, if necessary. The Department Selection Board endorses its recommendation to the Governing Board, where it is passed on to the Board Appointments and Promotion Committee. From the committee, the recommendation is considered and approved by the full board. In the absence of a governing board, such staff appointments go directly to the FMST.

The suggested criteria for appointments and promotion in the senior scientific ranks are as follows:

Qualifications	10%
Professional Experience	10%
Non-Quantifiable Elements of Productivity	10%
Quantifiable Elements of Productivity, such as - research with relevant publications - development of technology and innovations relevant to the objectives of the institution - training and extension factors - direct production functions - management and administration effectiveness - any other functions, such as representing the institute in important bodies	50%
Performance at Interview	20%

The indicated weights are relative, and the institutes are free to modify them, depending upon the duties and responsibilities of the post.

The appointment of junior staff is a delegated authority to the institute director. There is a separate Departmental Selection Board for junior staff.

An appeal process is in place. Appeals from the decision of the institute director are referred to the Governing Board. Appeals from the decision of the Governing Board may be elevated to the FMST.

In order to cast a wider net in getting the most qualified individuals in the higher ranks, vacancies in the grade of Chief Research Officer are required to be advertised among all the agencies in FMST. For the Director and Assistant Director positions, applications are solicited within and outside Nigeria. Some staff would wish, though, that the field be narrowed to candidates within the institute itself, but this is considered a minor objection.

Compensation and Benefits. Until recently, the compensation scheme at NIFOR and the FMST institutes was subject to the Unified Grading and Salary Structure (UGSS) of the Federal Civil Service. In addition to the basic salary, the staff enjoyed other fringe benefits, such as transport allowance, leave grant, medical services, and rent subsidy identical to those in the federal civil service.

One previous source of complaint was the disparity between the conditions of service of scientists in the research institutes and of the faculty in the universities, who have very similar qualifications and work demands. Upon strong representations by the FMST, the salary structure of the research institutes was harmonized with those of the universities, effective January 1988.

Staff Training. Staff training policies in the Institute are clearly defined in the FMST Guidelines. For inexperienced research officers with a first degree, they are encouraged to undertake postgraduate training at the earliest opportunity. Consistent with this policy, new research officer recruits at NIFOR are given research officer-in-training appointments.

Staff at the GL12 and higher ranks are encouraged to undertake basic and advanced management courses.

Attendance at conferences, seminars, and workshops are considered part of training and is similarly encouraged. However, attendance as of late has been limited by lack of funds, particularly for those involving travel abroad.

The following categories of training for staff development are available:

- postgraduate training
- technological/technical training
- sub-technical training
- short-term and ad hoc training
  - (a) general management courses
  - (b) induction courses
  - (c) sabbatical leave
  - (d) fellowships
  - (e) study leave

The training programme is administered by the Director of the Institute through a Training Committee which determines training priority, calls for nominations, screens and selects trainees, and recommends for approval by the Director.

In the last five years, seven senior staff (scientists) have benefitted from fellowships abroad, and ten have had general management and personnel management training at the Administrative Staff College of Nigeria (ASCON). Since 1985, nine scientists have completed postgraduate training at the master's and Ph.D. level; twenty have been trained at middle level in technical agriculture (Ordinary and Higher National Diploma), two in library sciences and two in nursing and public administration. Currently, eleven research scientists are at different levels of training at the postgraduate level, and seven are undergoing training in technical agriculture at the sub-degree level.

During the last seven years, NIFOR conducted four in-house training courses for its support personnel -- one for accounts, one for stores, and two for security.

3.6 Revenues and Expenditures

Revenues. NIFOR derives its financial resources from annual Federal Government grants or subventions as well as from its own internally generated incomes. Between 1981 and 1987, the Institute received a total of Naira 54 million of Government subventions (Table 3). Government support reached a peak of Naira 11 million in 1981 but has been declining ever since.

Table 3: NIFOR Government Subventions (1981-87)

YEAR	Recurrent	Capital (1000 Naira)	TOTAL
1981	7,138	4,200	11,338
1982	7,138	2,200	9,388
1983	6,208	2,628	8,836
1984	7,045	533	7,578
1985	5,642	141	5,783
1986	5,872	914	6,786
1987	4,099	964	5,063
TOTAL	43,142	11,580	54,723

On the other hand, NIFOR's operating income comes from sales of oil palm fruit bunches, sprouted seeds and seedlings, and palm wine, and from rents, interests, utility charges, disposal of other assets, and sundry other income (Table 4). Figures for previous years were not available, but revenues have been increasing. Revenue in 1984 was Naira 982,000. In 1985, total revenue was Naira 1,843,000. This almost doubled to Naira 3,344,000 in 1986. Income for the first half of 1987 was Naira 1,776,000.

Forty-one percent of the total revenues in 1986 were from sales of improved seedlings and sprouted seeds. A third came from oil palm fruit bunches.

Table 4: Operating Income (1986)

Source	Amount (1000 Naira)	Percent
Palm produce/bunches	1095	33
Nursery seedlings	1055	32
Sprouted seeds	309	9
Palm wine sales	379	11
Utilities	139	4
Interest	104	3
Miscellaneous	262	8
TOTAL	3344	100

Expenditures. The institute expenditures for the period 1981-86 are summarized in Table 5. Average annual expenditure for the period was Naira 10 million, of which about 10% was spent on capital outlays.

Revenues versus Expenditures. The annual grants and corresponding expenditures are brought together in Table 6 for comparative purposes. Recurrent expenditures regularly exceeded the annual recurrent subventions. Capital outlays were partially diverted to operations each year except in 1982. The total shortfall during 1981 to 1986 was Naira 12,152,000. They were presumably made up for by operating income and extraordinary subventions.

Table 5: NIFOR Expenditures (1981-1986)

Category	YEAR 1981	1982	1983	1984	1985	1986
			(1000 Naira)			
Regular Personnel	4,310	4,230	5,164	5,143	4,207	4,436
Overhead (Operations)	7,789	3,199	4,306	4,119	4,433	4,134
Total Recurrent	12,099	7,429	9,470	9,262	8,640	8,570
Capital	653	3,715	1,091	109	124	647
TOTAL for the Year	12,753	11,145	10,501	9,371	8,764	9,217

Total Recurrent	55,470
Total Capital	6,339
GRAND TOTAL	61,809

Table 6: Subventions Versus Expenditures at NIFOR (1981-86)

		Subventions	Expenditure	Expenditures/ Subventions (%)
1981	Recurrent	7,138	12,099	170
	Capital	4,200	653	
	TOTAL	11,338	12,753	
1982	Recurrent	7,138	7,429	104
	Capital	2,200	3,715	
	TOTAL	9,338	11,145	
1983	Recurrent	6,208	9,470	152
	Capital	2,628	1,091	
	TOTAL	8,836	10,561	
1984	Recurrent	7,045	9,262	131
	Capital	533	109	
	TOTAL	7,578	9,371	
1985	Recurrent	5,642	8,640	153
	Capital	141	124	
	TOTAL	5,783	8,764	
1986	Recurrent	5,872	8,570	146
	Capital	914	647	
	TOTAL	6,786	9,217	
1987	Recurrent	4,099		
	Capital	964		
	TOTAL	5,063		

Distribution of Recurrent Expenditures. The breakdown in percent of expenditures over the 1981-86 period is summarized in Table 7. On the average, half of NIFOR's expenses went to salaries of the regular staff. Not included in this class of expenditure, however, were other personnel-related expenses like wages of daily-paid workers and staff benefits (i.e., monthly travel allowances, housing, medical and pension fund contributions). If these items were included, actual personnel costs increase to 76% in 1986.

Table 7: Distribution of NIFOR Recurrent Expenditures (1983-86) in Percent

CLASS	1981	1982	1983	1984	1985	1986	Average
			p e r c e n t				
Personnel	36	57	54	54	49	52	50
Administrative Expenses	8	20	15	13	14	19	15
Research Expenses	5	5	3	4	4	5	4
Plantation Expenditure	20	-	11	12	16	8	11
Internal Services	6	5	3	3	4	4	4
Miscellaneous	11	4	2	2	2	1	4
Substations	14	10	12	10	11	10	11

Actual Expenditures for Research. The actual expenditures for research are difficult to trace in the budget heads used at NIFOR. Table 8 demonstrates an attempt to reconstruct the actual expenditures for research. All the expenditures in the plantations and substations (operating costs plus wages for daily labor) are assumed attributable to research. Research's share of running-vehicle costs, computer, and other shared facilities is reflected in "others". The total reflected here does not include the salaries of the regular staff in the research units.

The greater bulk of the expenses (78%) is for the plantations and substations, which are essentially physical maintenance expenditures and are almost "fixed" costs. The "variable" research expenses are in "Research Expenses, as shown", which is half for daily labor wages and half for purchase of supplies for direct use of the research divisions.

Thus, during 1983-84-85, the amount of money for supplies at the disposal of the research divisions was only about 150,000 Naira per annum.

Table 8: Estimates of Actual Research Expenditures (excluding salaries of regular staff)

ITEMS	1983	1984	1985
		x 1000 Naira	
Research Expenses, as shown	306	366	333
Plantations	853	988	1,385
Substations	1,102	952	922
Others	261	254	260
TOTAL	2,522	2,560	2,900
TOTAL RECURRENT	9,471	9,262	8,640

Budgetary Prospects for 1988. Pending actual receipts, budgetary prospects for 1988 appear to be promising. The Federal Ministry of Science and Technology got a 100% increase in recurrent expenditures from 1987 to 1988. The approved budget for NIFOR for 1988 is Naira 7,534,305 for personal services and Naira 3,013,722 for overhead. This will bring the current year total to Naira 10,548,027, which is double that of the previous year.

The FMST likewise received a five-fold increase in its capital budget for 1988, albeit from a relatively low base. NIFOR will probably get its fair share of the increase.

3.7 Research Planning, Programming, and Review

Annual Research Planning and Programming. In broad form, there is a comprehensive annual research planning process in place. The Federal Planning Ministry puts together the national social and economic development plans in close consultation with the other federal ministries, the state governments, the local government authorities, and the private sector. The broad national development goals are clearly stated in the national five-year development plans. Major aspects of the five-year plan are stressed by the President in the annual budget messages.

Based on the approved national five-year development plan, the FMST and FMAWRRD and the other major branches of Government send directives to their respective agencies on their ministries' plans for their sectors.

NIFOR takes into account the national science and technology plan as well as that of the agricultural sector dealing with tree crops, and within these frameworks develops an annual plan consistent with its institutional mandate. In addition, NIFOR sits as a member of a National Tree Crops Committee chaired by the Federal Department of Agriculture, where research, extension, the states, and private-sector representatives come together to plan and coordinate their respective activities.

Within NIFOR itself, planning is basically a bottom-up approach. Individual scientists, division heads, and programme leaders relying on their scientific preparation, interests, and experience prepare project proposals which are considered for inclusion in the institute's seven major research programmes. Since the oil palm and other palms in NIFOR's mandate are perennials, most lines of research last for a number of years. Thus very few major changes occur from year to year. The seven research programmes are aggregated into the Institute's annual research plan.

After careful deliberation within the institute, the draft programme goes to the NIFOR Governing Board for comment and approval. In the absence of the Governing Board, the draft programme goes directly to the Office of the Federal Minister for Science and Technology for final approval. Inputs from the Office of the Director of Agricultural Sciences of FMST are incorporated at this stage.

The FMST approval of the NIFOR research programme is based on aggregate thrusts and directions and not on individual projects and experiments. However, since actual subventions to NIFOR averaged only 50% of budget proposals during the last 6 years, another exercise is required to fit projects and experiments with available resources.

The FMST very rightfully leaves the adjustment decision to the implementing institution. However, this vital final step in the research planning and programming continuum is quite obscure.

Strategic and Long-term Planning. In preparation for the review and in time for its 50th anniversary in 1989, the management and senior staff prepared a ten-year development programme for the Institute. The plan included an overview of development in the oil palm industry in Nigeria, a projection of industry needs, and research support requirements during the next decade.

Included were schedules for staff development, infrastructure development, acquisition of equipment, and financial requirements.

A fairly detailed treatment was devoted to the technological needs of the oil palm. For lack of information, the treatment for the other palms in NIFOR's mandate was very limited.

The ten-year plan which NIFOR generously shared with the Mission is yet to be presented to its Governing Board and to the FMST. The Mission therefore takes this document as a first effort, subject to further revision and refinement as NIFOR obtains inputs from its Governing Board, the FMST, and its clients.

Research Reviews. The initial review of project proposals and project results is the shared responsibility of the division heads and programme leaders. The mission was not able to obtain a feel for how well the review process operates. The mission realizes that since there are very few senior researchers in each of the discipline divisions, review by peers within the same discipline may not always be feasible.

In any case there appears to be a certain degree of ambiguity in roles between the programme leaders and division heads. This issue in fact was raised by the staff themselves in individual dialogues with the Mission members.

However NIFOR does conduct a formal internal programme review every other year in which the Institute invites colleagues from the universities, from the Federal Department of Agriculture, and from FMST and from the private sector to assess progress that has been achieved in the previous years and to comment on ongoing and proposed research activities.

Moreover, NIFOR, together with the other Nigerian agricultural research institutes, has been the subject of several external reviews since the 1970s. However, the reviews were comprehensive assessments of the national agricultural research system and did not evaluate in depth the research programmes of the individual research institutes.

Monitoring and Evaluation. The Mission did not find evidence of a formal research monitoring and evaluation process within NIFOR. With the small sizes of working groups and close working relationships, the outcomes must be obvious, and therefore the staff do not deem such formal processes necessary. However, the capsule project summaries in the annual compilations that were shared with the Mission in fact indicated progress (or lack of) in the reports submitted by the staff themselves.

3.8 Information, Communications, Documentation, and Data Processing

Scientific Information. The Institute is served by a small library which the Mission finds very ill-equipped to serve the needs of the research staff. Very few scientific journals and books have been acquired since 1982. Several specific comments by the Mission on research experiments (in the succeeding section) would have been unnecessary if the staff had sufficient access to the literature.

Agricultural Communications. Communications in the context of extension messages and materials for oil palm producers is treated at length in the extension-research liaison services programme. It should suffice to point out at this stage that the quantity and quality of extension materials outputs appear to have been seriously constrained by lack of facilities and resources for such purposes. Staff expertise seems to be not a serious constraint at this stage.

Management Information. The Mission was impressed with the management information on personnel provided by NIFOR which was cranked out of the Institute computer. It is amazing how the Institute has kept its old IBM System 3 working. Obviously the system needs to be replaced soon. Management information on budgets apart from the conventional accounting entries, however, were not available. Information on valuation of equipment and facilities, of receivables and other financial matters in the audit reports, however, were very detailed.

Data Processing. The oil palm breeding data are still largely processed manually. The handling of these scientific data and of the proposed experiments on crop modelling and simulation would require installation of more powerful information handling capacity in the Institute.

3.9 Institutional Linkages

Applied research, by definition, is not an end by itself but a means to an end. The impact of research is realized only after the research outcomes, be they information, technology, improved varieties or breeds of livestock, are translated into policy by decision-makers on one hand and into actual practice by producers or processors, as the case may be.

In the case of NIFOR, its need for institutional linkages as an applied research organization is further accentuated by its separation from the line agencies responsible for extension and development.

Moreover, inherent in the definition of applied research is reliance on other sources for information of a more basic or strategic nature or even those of applied nature developed elsewhere. Since hardly anybody else works on oil palm research in the country, NIFOR must seek its scientific lifelines abroad.

Linkages with Policymakers. NIFOR's current links to higher level authorities are through the Federal Ministry of Science and Technology and to the National Tree Crops Committee convened by the Federal Department of Agriculture. Since the Federal Minister of Science and Technology meets the Institute directors periodically, this direct access is more or less assured and regular.

The mission had no impression of the real influence of the National Tree Crops Committee on policies relating to oil palm industry development. However, the new FDA director indicated he intends to call the National Tree Crops Committee more often to advise FDA, the Federal Ministry of Agriculture, and Government on how best to accelerate development of the industry.

Linkages with the Federal Ministry of Agriculture, Water Resources, and Rural Development. The participation of NIFOR in the National Tree Crops Committee was referred to in the previous section. Equally significant is NIFOR's liaison with the Monitoring and Evaluation Unit (MEU) of FDA based at Benin city. The linkage has been a long-standing one and appears very cordial and fraternal. NIFOR is the main supplier of improved seed to the World Bank-assisted oil palm projects monitored by MEU. Many of the state extension staff in those projects have been sent to NIFOR for training.

In the other direction, MEU participates actively in the biennial external programme review which NIFOR conducts to assess its own programmes.

The Mission's attention was subsequently called to the National Agricultural Development Committee mechanism. However, the Mission did not come across any reference to this committee during the visits to the Ministry of Agriculture.

Linkages with State Ministries of Agriculture. Two linkages have been mentioned in the previous sections - as supplier of improved seeds and as trainer for state oil palm extension staff. NIFOR likewise is the source of extension messages of the tree crop units in the state ministries of agriculture.

Linkages with Smallholders. NIFOR's link with smallholders generally is an indirect one through the state extension tree crop units. Another potentially important link is through the on-farm research of the NIFOR farming systems programme.

Linkages with Estates and Processors. In addition to serving as supplier of improved seeds, NIFOR staff serve as consultants to some estates which seek NIFOR's advice on suitability of planting sites, control of pests and diseases, fertilizer requirements, and other agronomic practices.

The connections with palm oil processors, on the other hand, are tenuous at best.

Linkages with Nigerian Universities and other Institutions. NIFOR invites Nigerian professors to join in its biennial external programme review. However, the linkages are usually through the NIFOR staff who study for advanced degrees in the universities. Tie-up with institutions other than the universities is practically nil.

Linkages with the Outside World. With the paucity of scientific journals and other publications in the NIFOR library, NIFOR's contact with the outside world is extremely limited. Participation in conferences abroad is likewise extremely limited. The most recent connections are those of the few senior staff who have just recently returned from graduate studies abroad and the participation of a few key staff in the international oil palm conference held in Malaysia last year. However, NIFOR maintains some contact through its membership in the African palm oil development association.

CHAPTER IV - RESEARCH AND EXTENSION PROGRAMMES: ASSESSMENT AND RECOMMENDATIONS

4.0 Introduction

Research and extension activities at NIFOR are organized into seven major programmes: oil palm, coconut, raphia, date, farming systems, end-use, and extension. The four commodity programmes and end-use draw their staff from the disciplinary divisions. The farming systems and extension and training programmes collaborate with the discipline divisions, but they have their own regular staff.

The farming systems, end-use, and extension programmes at the present are hardly concerned with the other palms. Therefore, in practical terms there are only two major groups: the oil palm programme and the other palms programme. For this reason and in view of the terms of reference of the Mission, the report will consider the oil palm part in its entirety from agronomy to socioeconomics and end-use. There will only be a brief section on the other mandated crops.

4.1 Oil Palm Breeding, Selection, Tissue Culture, and Seed Production

Systematic oil palm breeding started in NIFOR in 1949. The initial programme led to the identification of good tenera palms which became the basis of the present main breeding programme established in 1959.

Like all other oil palm improvement programmes elsewhere, the NIFOR programme is based on the production of outstanding tenera hybrids from among selected dura and pisifera parents identified through progeny tests. The current main breeding programme employs the modified reciprocal recurrent selection method as described by Spaarnij, Mendez, and Blaak in 1963.

The NIFOR breeding programme was thoroughly reviewed by a United Kingdom expert team (J. Ross and H.J. West) during 1971-75. Forty-seven progenies were selected for seed production among 230 hybrids in progeny trials. In addition, the U.K. team endorsed the continuation of the breeding scheme and based on their recommendations 13 teneras and 13 duras were selected to comprise the foundations for the second recurrent selection cycle.

The NIFOR hybrids under Nigerian conditions have the potential of producing eight tons of fresh fruit bunches per hectare per year in marginal areas (with about 300 mm water deficit) and up to 20 tons in the better areas. Selected dura will produce about 10 tons FFB/ha/year under average conditions, but their oil extraction rate is only 9-10% compared with the 22% of the teneras. In comparison, the better Malaysian plantations produce 25-30 tons FFB, but their rainfall distribution is more even and their soils have better water-holding capacity. Practically all the tenera hybrid plantings in Nigeria come from NIFOR.

The current breeding programme has nine projects. The major breeding objectives include precocity, high yield (tons fresh fruit bunch/per/year and oil-to-bunch extraction ratio), slow vertical growth, oil unsaturation, resistance to fusarium wilt, and tolerance to drought.

Six of the projects are directly under the plant breeding division, namely;

Project	1	Oil Palm Main Breeding and Selection
	2	Gene Pool Collection
	3	Breeding of Short-stemmed Oil Palm
	4	Mutation Breeding
	5	Pisifera Investigations
	6	Tissue Culture

Three others are being implemented in collaboration with other divisions, namely:

Project	7	Breeding for Drought Tolerance
	9	Screening for Oil Unsaturation Among NIFOR Oil Palm Populations
	11	Investigations into the Occurrence, Epidemiology, and Control of Vascular Wilt Disease of the Oil Palm

Main Breeding Programme. The Mission does not contemplate any change in the basic selection scheme adopted by NIFOR. The main breeding programme is appropriately designed and, overall, properly implemented. Nevertheless, the Mission sees an opportunity for NIFOR to achieve greater progress through the incorporation of advanced lines developed by other oil palm breeding organizations into its own. Nigeria has been very generous with other countries in sharing her oil palm genetic resources. She should benefit from these exchanges as well. NIFOR should exploit these advanced lines from other countries to introduce more diversity into its own programme.

Plant breeding data are still processed through the old IBM card system. A new data processing system should be installed to facilitate recording, storage, retrieval, and analyses of information. Moreover, the Mission noted that plant breeding data handling and analyses are done almost exclusively by the statistics division. The plant breeders should be more actively involved in the processing and analyses of their data.

Priorities Among Projects. Mutation breeding is unlikely to produce practical results in the near future. The probability of useful mutations is low and one has to grow extremely large populations to capture them. This project should therefore have a low priority and eventually be phased out.

Except for certain favorable areas, oil palms in Nigeria are often subject to drought stress. Tolerance to drought would therefore be a logical breeding objective. However, experience elsewhere indicates that drought tolerance is an extremely complex character. It might very well be that more rapid progress could be achieved with appropriate cultural practices like mulching, control of density, disbudding, irrigation, and planting in the better rainfall areas than through breeding and selection alone.

Moreover, the work being proposed at NIFOR seems to ignore recent results, particularly from Pobe station in the Republic of Benin, which demonstrated that physiological indicators of drought tolerance in seedlings are not necessarily correlated with drought tolerance in the field.

The physiology of drought tolerance is an extremely interesting field of research. This area of scientific investigation can tie down a lot of resources. The Mission would caution NIFOR from committing more of its scarce resources in breeding for drought tolerance at this stage until NIFOR has seen its way clearly through the problem.

Breeding for Fusarium Wilt Resistance. Fusarium wilt is a serious but still manageable problem in Nigeria. However, the disease is expected to get worse as the older plantations are replanted. Using the method developed by Prendergast in the late 1940s, some 46% of 768 progenies tested in NIFOR were considered to possess some degree of tolerance. However, the reaction at the seedling stage has not been properly correlated with field performance. A new method developed at Manchester is being tested.

This problem must now receive the full attention it deserves. Screening for tolerance in the nursery should be followed up by large-scale screening of selected progenies in wilt-infested fields. Nursery screening for wilt tolerance is now being conducted at the Ajagbodudu station. The Mission recommends very strongly that the facilities at Ajagbodudu be improved to allow for a small laboratory, a large screening nursery, and extensive field-trial plantings.

E. oleifera Hybridization Programme. Hybrids with E. oleifera are known to exhibit slow growth in height, higher proportion of unsaturated fatty acids and with possible special adaptation to climates with long dry seasons and possible resistance to bud rot and other diseases. However, the hybrids also suffer from certain defects. They have low fruit-to-bunch ratio and low percentage of oil to mesocarp; i.e., about 17% oil to bunch extraction rate compared with 22-23% of the commercial E. guineensis tenera. They are also heavily attacked by Cercospora elaeidis.

The present NIFOR E. oleifera hybridization programme is based on only two individual plant introductions. This is just too narrow a base for a breeding programmme. NIFOR should obtain more introductions of E. oleifera from South and Central America. The IRHO has undertaken systematic prospection of E. oleifera in South America. The collections have been planted in Colombia and Ivory Coast. It should be possible to request materials from these countries.

Tissue Culture. The oil palm is a perennial monocot with no known means of natural vegetative propagation. Commercial planting materials which are hybrids of two fruit forms are highly heterozygous and heterogeneous. It is estimated that as much as 20%-25% progress could be achieved by cloning the best individuals in such hybrid progenies.

IRHO-ORSTOM in France and Unilever in England launched large research projects in the early '70s, with a view to obtaining true-to-type reproduction of selected individual palms. In spite of the difficulties generally encountered with monocots, successful methods have been set up. Other organizations initiated similar programmes recently and now several laboratories in Malaysia, Indonesia, Ivory Coast, England, and France produce small quantities of clones for experimentation and field testing. Some commercial supplies are expected in the 1990s.

There has been some debate on the actual gains that could be achieved through tissue culture. Moreover, there have been reports of certain abnormalities (somaclonal variations) in some cloned materials, probably either due to the culture process itself or associated with certain genotypes. Nevertheless, the general consensus is that tissue culture will play a significant role in the commercial propagation of elite oil palm materials in the future. Morerover, with the advent of molecular biology and genetic engineering, as with other plants, tissue culture will be a valuable tool in the hands of oil palm researchers as a research tool in the future.

For these reasons the Mission sustains the previous decision of the NIFOR board to develop tissue culture capability in the institute.

However developing the capability to clone the oil palm will require time and considerable effort. It took IRHO and Unilever, each with plenty of corporate support, about 10-12 years to set up a working tissue culture facility.

Nigeria has two options:

- purchase the existing technology under commercial terms from organizations like IRHO and Unilever; or

- adopt a self-reliant posture and try to develop tissue culture capability utilizing Nigerian scientists at NIFOR and in the universities.

Both options require the training of Nigerian scientists and technicians. The first option will enable the country to save time and to immediately clone and field test outstanding individual palms from NIFOR's best families. The time saving could be in the order of 3 to 6 years.

However, considering the other constraints to the oil palm industry in Nigeria, the Mission is of the opinion that the immediate supply of superior clonal material is not a pressing issue. Without discounting the difficulty involved in tissue culture research, the Mission is confident that Nigerian scientists at NIFOR and at the universities, given the proper support and encouragement, should be able to develop the technology on their own. The Mission therefore suggests that Nigeria take the second option.

The two young scientists at NIFOR who recently returned from training abroad in tissue culture could form the core of NIFOR's tissue culture initiative. They should team up with a university group such as the University of Ibadan to develop a full programme.

To accelerate the process, it should be possible to recruit under bilateral or multilateral assistance an expatriate who has had extensive experience in oil palm tissue culture work.

In the immediate, the mission suggests that NIFOR be provided a modest facility capable of producing 12,000 - 15,000 plantlets a year. This will be sufficient for the multiplication and experimental testing of clones. This small unit will cost around $150,000 to set up and about US$40,000 per year to operate.

In the medium to long term, Nigeria should plan in terms of a fully equipped laboratory with a capacity of producing 150,000 to 200,000 plantlets per year. Such a commercial facility will cost about US$ 1.1 million to build and about US$ 145,000 to operate each year. The decision to build a commercial tissue culture facility can be made at a later stage.

Seed Production

NIFOR is the only source of tenera hybrid planting material in Nigeria. During the period 1982-86 NIFOR produced a total of 22.5 million seeds. Orders for seeds totalled 23.2 million, but actual deliveries were only 13.5 million, as many orders were cancelled for one reason or another.

The estate growers who have had experience with the NIFOR materials are generally satisfied with the quality and potential of the NIFOR seeds. There were some remarks about the lack of uniformity in some batches, which the Mission traced to the practice at NIFOR of not segregating the individual families. Two or three years back, planters complained of delayed deliveries of sprouted seeds. However, the more recent deliveries have been on time.

With 1744 mother palms under seed production, NIFOR has an estimated capacity of producing seven million seeds per year. This should be adequate for planting 25,000 hectares each year, which is slightly above the most commonly expected establishment rates during the next ten years. Other projections indicate that Nigeria needs about 600,000 hectares under improved tenera in the 1990s to meet domestic demands. With an assumed plantation life of 25 years, the current seed potential at NIFOR will just be adequate to meet the annual replacement rate.

Some of the original parents in the first selection cycle are getting too tall and difficult to pollinate artificially. Starting in 1987, NIFOR has taken steps to reproduce some of the first-cycle parents. Should the Government decide to commit to an establishment rate exceeding 25,000 hectares per annum, NIFOR can be instructed to replant more first-cycle parents.

So far NIFOR had been meeting the need of the industry for improved seeds. Given the facilities and available support at NIFOR, the institute had done an admirable job of keeping pace with industry. However, as soon as the projected oil palm planting programmes get under way, NIFOR will be hard pressed to supply the sprouted seeds in the quantity and delivery dates required.

In anticipation of future needs and to even out availability of seeds, NIFOR should have a seed storage capacity of at least 10 million seeds. This would enable NIFOR to keep seeds for a longer period of time without loss of germination and would build up seed supplies while demand is still low.

Moreover, the entire seed production facility set-up needs to be rehabilitated and streamlined to better organize the flow of seeds, prevent mixtures, and minimize the loss of germination. Details are provided in the annex.

In addition to segregating and releasing the sprouted seeds as families to have uniform batches of seedlings, some immediate improvements in the selection process are suggested:

- eliminate dura progenies with less than 20 trees to avoid bias in reproducing hybrids;

- reduce the number of hybrids being reproduced by discarding those with below-average oil extraction rates, those with excessive vertical growth and apparent susceptibility to fusarium wilt.

The rehabilitation and streamlining of the seed production operation at NIFOR deserve immediate attention. The Mission suggests that an early disbursing funding facility be extended to the Institute for this purpose and other very urgent needs identified elsewhere in this report.

Seedling Production. The role of raising the sprouted improved seeds into seedlings in the nursery is more efficiently accomplished by the estate growers themselves or in the nurseries of the extension service, where they are closer to the actual planting sites. Thus the Mission considers NIFOR's role in seedling production secondary and treats this as a revenue-generating activity.

4.2 Agronomy, Soil Science/Plant Nutrition, Physiology, and Farming Systems

Availability of appropriate production technology is not an immediate constraint to further oil palm development in Nigeria. The technology and practice of germinating seeds, the management of seedlings in nurseries, clearing and establishment, manuring and fertilization, weeding, pest control, and harvesting are well established. These technologies have evolved through decades of practical experience and research involving research institutions and commercial companies in Africa, Southeast Asia, and Latin America, and in the developed countries - particularly France, the United Kingdom, Belgium, and the Netherlands. As one of the earlier and leading research organizations in oil palm research in Africa, the contribution of NIFOR in this collective effort is well known.

However, not all production problems have been resolved nor will they ever be fully resolved. Research continues in all the major oil palm growing countries to attain higher levels of productivity and efficiency under their respective conditions of production.

For Nigeria, the more pressing issues include the development of technology that will allow permanent, sustainable, and productive mixed cropping of oil palm with food crops for smallholders; raising oil palm productivity under conditions of prevalent water stress; and anticipating production problems associated with planned new areas of major expansion.

Detailed commentaries are provided in the annex on the ongoing and proposed projects in these disciplines. Following are the main priority areas for research in the respective divisions:

Agronomy. Past work on germination has yielded the present method of pregerminating the seed, which ensures a better timing of the planting programme. The production of seedlings in pre-nursery beds and field nurseries was replaced by the present method of raising plants in polybags. This technique is well established and requires little research. The only minor exception is evaluation of the agronomic and economic advantages of planting and germinating seed in small polybags and transplanting them as five-leaf plants to large polybags, as compared with direct planting in large bags.

The best time and method of field planting is well known and documented in previous research. The same holds true for the frequency of interline- and ring-weeding required, the possibilities for intercropping during the first years after field planting between palms planted at full density, the establishment of a leguminous cover crop, and the intensity and frequency of leaf pruning. Some controversial agronomic techniques, such as disbudding of young plantation palms and assisted pollination, are on the current research programme and are likely to be confirmed or refuted in the near future.

Soil Science/Plant Nutrition. Past research on fertilizing on the major soil types and under the major climates of the oil palm belt, combined with soil and leaf analysis has yielded a firm basis for fertilizing recommendations for large and small plantations. Most experiments have served their purpose and can be abandoned or given an alternative use. New fertilizer experiments are needed on bench mark soils and under typical climates to assess the nutritional requirements of the second generation of NIFOR's improved tenera planting material, both in plantations and in permanent mixed cropping systems. This work is on the programme and will be implemented in the near future. Records should be extended with non-destructive estimations of the dry-matter production and of the nutrient fluxes under typical conditions of soil and climate. Many visual deficiency symptoms of single nutrients are well known and documented by past research at NIFOR and elsewhere. Additional work is required on the visual symptoms of Cl and the trace elements, except B and Fe, while knowledge of multiple deficiency symptoms, e.g., N+P, K+Mg, etc., will be of practical use for a tentative diagnosis.

Physiology. Water stress is known to be a major drawback for oil palm cultivation in Nigeria, especially in the wet and dry subhumid part of the country. More precise information on the magnitude of water stress and its effects on different soils and under different climates will help to improve the criteria for oil palm land selection and to identify agronomic measures reducing water losses. Although the technical and economic possibilities for irrigation will be limited, the

study of the value of mill effluent for this purpose is well justified. Since this effluent contains mineral nutrients and organic matter, its cumulative effect on the chemical and physical properties of the soil should be studied at the same time.

Research on oil palm physiology at NIFOR needs a major change from the present activities on chemical markers, which are of low priority, to studies on the carbon budget and the hormone husbandry of the oil palm. The first activity is a modern tool for the interpretation of both breeding work and agronomic studies; the second is needed for tissue culture. The first activity will require a plant physiologist specialized in photosynthesis and growth modeling; the second a cell physiology specialist with experience in tissue culture techniques. This expertise is at present not available at NIFOR, so that staff retraining or recruitment of trained staff will be required.

The development of yield prediction models requires a crop ecologist who is skilled in systems analysis and the construction of mathematical models. Empirical models as developed in the past by NIFOR scientists and planned in the present programme are likely to be of limited value because they are not based on thorough knowledge of the morphogenesis and growth of the oil palm. This speciality is at present not available at NIFOR, but training opportunities may be obtained in Europe (e.g., The Netherlands).

Farming Systems. Monoculture as practiced in the palm estates is a continuing area of interest but is less crucial as a research area at this stage than mixed cropping with food crops. As had been the experience with smallholder plantings in the last fifteen years, adoption of improved technologies developed for dense plantings (monoculture), apart from improved seed, had been low and erratic. There are technological, economic, and socio-cultural dimensions to the problem.

Past farming systems research has been limited to intercropping experiments during the first years after planting in oil palm plantations with densities ensuring the highest yields per hectare. Gradual replacement of the semi-wild oil palm groves by planted palms in such a way that permanent intercropping remains possible throughout their economic life, demands a spacing ensuring adequate light for the intercrops. Research on spacings and the corresponding densities, ensuring the maximum yield per palm and the highest yield per surface unit of the intercrops will be needed to provide the theoretical basis for the development of ecologically sustainable and economically sound cropping systems from which economically sound and socially just and politically stable farming systems may be derived.

4.3 Plant Pathology and Entomology

Various diseases attack the oil palm at different stages of growth. Those of most serious concern worldwide are fusarium wilt, bacterial bud rot, dry basal rot, and ganoderma trunk rot. The most serious by far in Nigeria is the fusarium wilt.

Insects, mites, nematodes, birds, and mammals attack the oil palm. Sporadic outbreaks of the oil palm leaf miner (*Coelaenomenodera elaeides*) occur in the drier, marginal areas of West Africa. The grasscutter

(Thryonomis swinderianus), a large rodent, attacks young palm seedlings up to 3 years of age. The problem could be serious to new plantings adjacent to primary or secondary forests. The only effective measure so far is to wrap the base of the young palm with a wire collar.

Fusarium Wilt. The concentration of plant pathology research at NIFOR is very appropriately on vascular wilt. While damage from the disease is still tolerable, the disease is expected to get worse as more areas are replanted with the oil palm.

As discussed in the plant breeding section of the report, the screening of wilt-tolerant progenies should be stepped up. However, the correlation between seedling reaction and field tolerance should be firmly established. The comparison between the old Prendergast screening method and the new Manchester procedure deserves high priority.

More fundamental work on the pathogen is needed. As in many other areas, close collaboration with other institutions engaged in similar work should be sought.

Leaf Miner. Leaf miner outbreaks have been controlled with chemical dusts and sprays. Since natural parasites have been observed to reduce the severity of successive attacks, the switch of focus at NIFOR from chemical to biological control is correct. NIFOR has not obtained any results so far, but parasitism of Coelaenomenodera has been studied in detail elsewhere by Morin and Mariau. They have reported that the leaf miner eggs are parasitized by a chalcid fly (Achrysocharis leptocerus) and by Oligosita longiclarata (Trichogrammatidae). In addition, three eulophid flies attack the larvae at the later stages, namely, Dimmockia aburiana, Pediobus setigerus and Cotterellia podagrica. Another eulophid, Closterocerus africanus, parasitizes young leaf miner larvae.

NIFOR has a lot of basic entomology work ahead of it in sorting out which of these natural enemies could provide the most practical control of the oil palm leaf miner. The biology, effectiveness, and rearing requirements of the several potential biological control agents must be studied in detail.

The Mission suggests that the priorities of the entomology division be carefully reassessed. It would appear that the potential for a breakthrough on the biological control of leaf miner is quite high and would require a concentration of staff resources in the immediate term.

4.4 Socioeconomic Research

Socioeconomic research can and should play a more prominent role in NIFOR than it has so far. Since the 1960s only about 100,000 hectares of hybrid teneras have been established by smallholders in spite of the succession of oil palm production schemes which had smallholders as their primary targets.

The most common reasons cited for the lack of success include:

- complexity in land tenure arrangements, which has discouraged individual farmers from investing in oil palm cultivation;

- lack of capital among smallholders;
- inadequacy of marketing and oil processing facilities;
- poor profitability, particularly during the oil boom years;
- inadequacy of input distribution, particularly fertilizers;
- failure to completely comprehend the pressure on the smallholder to produce food for the immediate needs of his family during the palm establishment phase and thereafter;
- production constraints, such as inherent infertility of soil, drought stress, and weed competition, which result in low yields; and
- gross mismanagement by some officials in the previous rehabilitation schemes.

Each of these contributing factors has researchable social, cultural, economic, and policy dimensions. Many of the circumstances, perhaps, have changed, but the endemic structural ones remain. Adjustments are now being made in the proposed oil palm schemes; unfortunately without the benefit of systematic scholarly analyses.

Very clearly, the research tasks of a socioeconomics unit in NIFOR would include:

1. social science research that will inquire into the social and cultural environment within which smallholders live and their implications in oil palm cultivation as a means of livelihood;
2. research on the constraints to production and the adoption of improved technologies;
3. market and market development research for palm oil products;
4. techno-economic feasibility studies; and
5. policy studies.

There are two senior agricultural economists on the staff. NIFOR needs a senior sociologist or anthropologist to provide the social science perspective to the new socioeconomics division.

4.5 End-use Research

Within the last 20 years Nigeria has moved from being a significant exporter of vegetable oils to requiring imports of 130,000 - 150,000 tonnes in recent years. The End-use Research Programme of NIFOR is based on the expectation that vigorous steps to revive the palm oil industry will result in a substantial increase in local supplies and eventually in self-sufficiency.

The end-use research programme is new, and due mainly to the lack of general and specialized facilities and to inexperience, little progress has been made. The projects existing in the 1987 research programme were

critically examined. Most of them were in appropriate work areas, but the project proposals were deficient in various ways.

To ensure that the End-use Programme has a practical impact, it is essential to develop an effective liaison and dialogue with the end-user industries. The industrial sectors involved are different from those to which NIFOR's other work areas are naturally linked. At the outset this liaison will require a significant proportion of time from senior staff.

In addition to these industrial links, the staff need to develop outside technical and scientific contacts appropriate to their assigned work areas. Within Nigeria there are university food science and technology departments, the Federal Institute for Industrial Research, other institutes under the Ministry of Science and Technology, and corresponding contacts for the engineering research group.

Because it is a new program, there is a need for specific training of the project staff, which should be industrially oriented rather than academic. It may be advisable to associate an experienced expatriate food technologist with the program, perhaps by way of periodic advisory visits lasting for 4-6 weeks. Participation in international conferences is also an important training opportunity.

However, there are many areas in end-use research where NIFOR, in the Mission's opinion, need not develop research capability. Although no specific recommendations can be made at this stage, a budgetary allocation should be made available which would enable the Institute to sponsor or conduct joint research with the universities and other institutions which have the trained staff and facilities to conduct such work.

Detailed recommendations for improving the preparation and selection of projects are given in the annex.

4.6 Design of Small-scale Processing Equipment

NIFOR Mini Oil Mill. NIFOR has designed a mini oil mill package consisting of fruit bunch cookers, manual bunch strippers, a motorized digester, an imported hydraulic press, and a clarification unit (heated tank with water and oil slurry). The system has a ¼ ton/hr of fruit capacity but could handle ½ ton/hr with additional fruit bunch cookers. The claimed extraction efficiency is 87%, with a free fatty acid content below 4%. The system employs 10 laborers.

The weak element in the mill appears to be in the imported hydraulic system whose seals become defective after about two years of operation, resulting in incomplete extraction of oil.

Overall, the NIFOR mini mill is an appropriate package for the situation in Nigeria, where there are many locations at which fruits are wasted for lack of access to a processing facility. Some 30 NIFOR mini mills have been produced. NIFOR continues to fabricate the mini mills at the rate of about 10 orders a year. The steady demand for mills is an indication that they are meeting a need, and that the mills are

profitable in operation. Our rough calculations based on the production figures from a village operation we visited tend to confirm this profitability.

Nevertheless, there is always room for further design improvement. The processing of mixed dura and tenera fruit wears out the seals of the screws very quickly. It is recommended that as an alternative, a hydraulic press should be designed for local manufacture, incorporating modern concepts of seal design.

The village operation we visited has made an improvement over the NIFOR model. The wood furnaces for cooking and heating of fruit bunches were replaced with a low-pressure boiler which is more fuel and labor efficient.

Design of Palm Kernel Equipment. One thing that impressed the Mission was the observation that a lot of palm kernels are wasted in village processing operations. Practical equipment is needed for separating the fiber from the nuts and sorting the different nut sizes.

NIFOR is designing small machinery and equipment for the various steps in the processing of nuts: cleaning, separating, sorting, cracking, and expelling. The Mission considers the efforts in cleaning, separation, and sorting appropriate but doubts the utility of small-scale nut crushers and kernel processors. In addition to practical technical design difficulties, there are five large modern extraction plants in Nigeria which are operating below capacity for lack of kernels.

Palm Wine Bottling. Palm wine is an important byproduct of the oil palm and by far the principal product from the raphia palm. Palm wine is extensively produced and consumed in the villages and towns.

The palm wine ferments and loses its quality rapidly under existing ambient conditions. The problem is how to keep the freshness of the drink for a longer period of time. NIFOR's solution was to pasteurize the palm wine in bottles. The resulting product has a sugar and alcohol content of 8% and 2% respectively. The product apparently is highly acceptable, as NIFOR has no problem disposing of the daily production from its palm wine bottling unit in Benin headquarters.

The NIFOR palm wine bottling process is a common-sense package of small-scale technology that works. The challenge to NIFOR now is to popularize the technology, offer the design to local fabricators, and advise small entrepreneurs who may want to engage in the business.

4.7 Extension and Research Liaison Services Programme

An extension and training division was established at NIFOR as early as 1963. The unit was renamed as the Advisory and Information Division in 1965 and again in 1979 as the Extension and Research Liaison Services Division. Starting 1983 the ERLS division was upgraded to the status of a programme.

The listed current activities of the ERLS programme include:

- production of audiovisual materials on different aspects of oil palm production;
- dissemination of scientific and technological information to producers, extension officers, and to the general public;
- training of extension officers, farmers, and estate workers;
- organization and/or participation in field days, demonstrations, exhibition, and trade fairs; and
- action research on extension problems.

However, the current level of activity in the programme is rather limited. Except for the supply of hybrid seedlings, the impact of NIFOR extension activities on the programmes of state tree crop units appears minimal. The extension staff attribute their inability to pursue their activities more aggressively to lack of subject-matter specialists, lack of mobility, obsolete audiovisual equipment, lack of operating funds, and insufficient coordination with the research divisions at NIFOR.

The Mission cannot over-emphasize the need for a strong technology transfer effort at NIFOR to complement technology monitoring and generation capability. The current level of staffing and support in extension is grossly inadequate and needs to be substantially increased as a matter of first priority.

In further developing and expanding NIFOR's extension program, the Mission calls the Institute's attention to the following considerations.

Priority for Smallholders. Smallholders account for 80% of the palm oil produced in Nigeria. For social, economic, and political reasons, the dominant role of smallholders is expected to continue into the future unless Government drastically reverses present policy. NIFOR's principal extension efforts should therefore be oriented to smallholders without, of course, absolutely neglecting the needs of the palm estates.

Supportive Role to the State Smallholder Tree Crop Extension Units. The proposed extension programme at NIFOR lays emphasis on increased direct contact/communication with end-users of technology. The interest is laudable but should be qualified. Increased direct contact and communication with end-users of technology by NIFOR is essential for guiding research and extension efforts in the Institute. However, NIFOR does not possess a comparative advantage or the legal mandate to engage in direct extension to producers, particularly to smallholders. The more appropriate strategy is for NIFOR to support the smallholder tree crop units in the state ministries of agriculture by way of training the extension officers, providing appropriate extension materials for use by state extension agents, and conducting active research to assist states in diagnosing and analyzing extension problems.

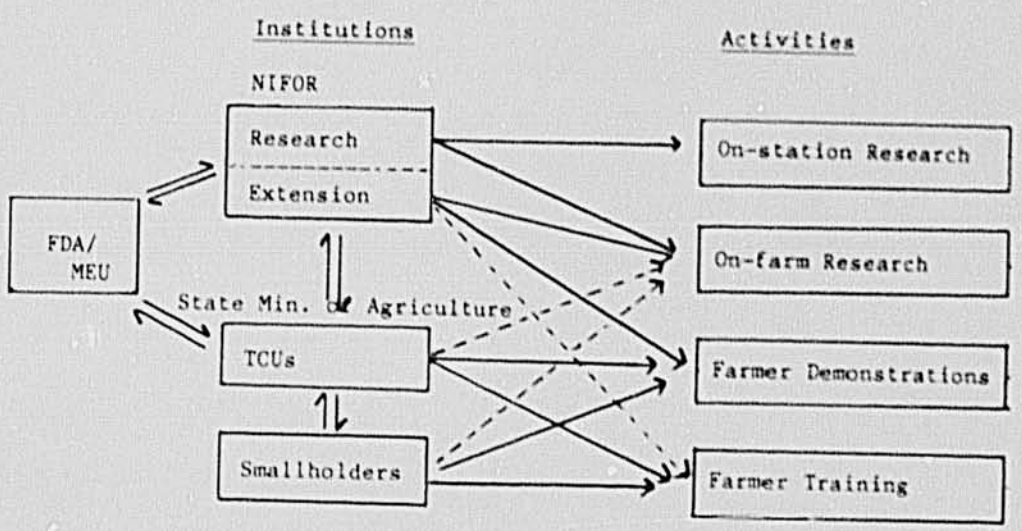
Advisory and Technical Services to the Estates — a Revenue-generating Activity. The palm estates require continuing advisory and technical services to improve efficiency and performance. These services include identification of potential sites, soil and foliar analyses for fertilizer recommendations, diagnosis and control of pests and disease, and advice on milling operations. Some of the estates still depend upon foreign institutions for their technical needs.

NIFOR may fill part but certainly not all of these industry needs. However, the Mission proposes that the Institute approach its relationship with the estates on a commercial basis. The palm estates are business operations which should be able to meet the costs of their needs for technology. NIFOR should organize a separate unit to handle the business aspects of its advisory services to the estates. This unit should be treated as a revenue-generating center (see Management Section).

A Framework for Research Extension Linkages

The technology-generation-transfer-utilization process in the oil palm industry in Nigeria involves a multiplicity of agencies. Following is a conceptual framework which NIFOR may wish to use in organizing its extension programme. The framework identifies the roles of the institutions in respect to specific research/extension activities. The solid lines connote principal responsibility and the dotted lines more of a secondary role. Crucial to the concept is the adoption of on-farm adaptive research as a principal vehicle for bringing researchers, extension subject-matter specialists, extension agents, and farmers together and thereby forging linkage among them.

A Framework for Research-Extension Linkages



The framework recognizes:

1. The primary responsibility for extension belongs to the state ministries of agriculture.

2. The primary responsibility for research belongs to NIFOR.

3. The FMAWRRD, in particular the FDA/MEU, has responsibility for planning, project preparation, monitoring, evaluation, and coordination.

On-farm research, both of the applied and of the adaptive research type, are increasingly employed in annual crops research. Because of time, cost, and space constraints, on-farm research on the oil palm is extremely constrained in numbers of experimental combinations that can be tested. Thus on-farm research in oil palm will tend to gravitate to the adaptive research type.

NIFOR has started a number of such on-farm trials in its farming systems research programme. These on-farm studies, which at this point concern almost exclusively the scientists alone, could be planned and implemented in such a way that the subject-matter specialists in extension at NIFOR, the extension agents in the state tree crop units and local government authorities, and the local farmers could be involved, thereby expanding the utility of the on-farm trials from strictly research to include extension.

Subject-matter Specialists. An expanded programme for training of tree crop agronomists, nursery workers, and smallholders; for the production of appropriate literature and extension materials; and for supervision of on-farm trials and farm demonstration plots require a new category of staff not available at present in the ERLS programme. The ERLS programme would require four subject-matter specialists in the relevant areas of agronomy, crop production, socioeconomics, and processing. These four SMS will be heavily involved in the translation of research results into extension materials, in the organization and conduct of training, and in actual liaison with the TCUs and smallholders.

Decentralization of Extension Activities. The major production areas in Rivers, Akwa Ibom, and Cross Rivers are several hundred kilometers away from NIFOR headquarters in Benin. In order to respond more expeditiously to the extension needs of the sub-region, NIFOR should contemplate partly decentralizing its extension services.

The oil palm substation at Abak is an ideal second location for training, advisory services, extension, and distribution of improved seeds and seedlings.

At present the Abak station has no research officers. All experiments are planned from Benin. Routine application of fertilizers, grove maintenance, and gathering of agronomic data are done by support staff. All the data are sent over to Benin, where they are analyzed and interpreted.

The absence of scientific officers in a principal substation like Abak is not healthy. The Mission understands that there have been plans to post scientific officers at Abak but none have been detailed so far for lack of suitable housing.

The Mission recommends that housing provisions be made as soon as possible to allow the posting of at least an agronomist, a crop protection specialist, and a socioeconomist at Abak to supervise all experiments at the station and to form the core of an oil palm extension subunit for the surrounding states.

Organization of a Training Unit. The future development of smallholder plantings in the proposed second World Bank-assisted tree crops project revolves around the organization and/or rehabilitation of 80 tree crop extension units in the local government administrations. Each unit will be composed of at least two tree-crop agronomists, a seedling nursery crew, and other support staff. NIFOR is expected to play a key role in training and in the technical backstopping of the tree-crop units. Should the scheme succeed, more tree-crop units are contemplated to be organized in the expansion areas.

In order to reduce the lag time in project implementation, NIFOR should immediately organize a training unit built around the present four core staff of the ERLS programme and the four proposed subject-matter specialists. The training programme and the relevant training materials should be developed in advance in anticipation of the recruitment and/or secondment of the tree-crop agronomists and nursery workers.

The ERLS programme would need some resources in the quick disbursing facility, which the Mission recommends, together with the seed production facility.

4.8 Raphia Palm Research and Development Programme

Introduction

Rapia palms grow wild, particularly in the delta areas of the south. The genus *Raphia* has 20 recognized species in Africa, among which eight are indigenous to Nigeria. The most commonly exploited species is *R. hookerii* Mann & Wendl. It has many local uses but the most important are as source of palm wine, of piassava fibers for brush-making, of raffia fiber for weaving, and potentially as a raw material for pulp and paper manufacture.

The area occupied by raphia is not known, but some estimates place the raphia palm population at 100-175 million trees. The volumes and value of production of raphia production were not available to the Mission. Nevertheless, there has been and there still seems to be sufficient local and national interest to pursue a raphia research and development programme.

Raphia Research at NIFOR

NIFOR is probably the only institution in the world where there is a concentrated and sustained effort to investigate the economic potential of *Raphia* spp. Responsibility for raphia research was formally

incorporated in NIFOR's mandate in 1964, although earnest research did not commence until 1970. Through the years NIFOR has made a significant number of original contributions in the following areas:

1) taxonomy of the genus Raphia;

2) seed physiology;

3) characterization of the hydromorphic soils in southern Nigeria, the natural habitat of raphia;

4) survey of pests and diseases afflicting raphia;

5) nursery management of raphia;

6) processing and bottling of palm wine;

7) exploratory studies on the potential of raphia for pulp and paper manufacture.

Staffing. Currently there are nine scientific officers who have full-time responsibility for raphia research. Four have Ph.D. degrees and the rest have M.Sc. degrees. They cover the disciplines of botany, agronomy, plant husbandry, soils, entomology, plant pahtology, biochemistry, and plant physiology. Two other staff have part-time responsibility for raphia research.

In addition there are seven staff members at the agricultural superintendent level.

Resources. Apart fron the direct personal costs, information on the budgetary resources actually devoted to the raphia programme was not available. In any case, like the other activities at NIFOR, it is quite obvious that resources had been grossly inadequate to meet the operating requirements of the current scientific staff.

A major concern at this time is the location of a suitable site for raphia field experiments. Since the Benin headquarters is not ideally suited for raphia, the raphia programme needs a principal station at which it will conduct the bulk of its on-station field research. The site which serves this purpose for the moment is the Oredo station in the delta area of Bendel State. The station has a planned area of 400 hectares, of which 83 hectares have been acquired and 30 have been planted. The Otegbo station at present is bare of facilities.

The Mission was made to understand that negotiations are under way for alternative sites in Rivers State, where there is a great concentration of natural raphia stands.

Future Program

Need for A Strategic Plan for Raphia Development and Supporting Research

The staff has made a laudable effort to lay the bases for the continuation and further prosecution of the raphia R&D effort at NIFOR. Nevertheless, the Mission feels that while the major elements of a

plausible strategic plan may be apparent in the present plan of work, there remains the need for a well-articulated brief which will define the potentials of raphia to contribute to the economic and social development of Nigeria, alternative scenarios for the attainment of those potentials, the role of NIFOR and of research in the realization of those potentials, the specific goals for research, the resource requirements and schedules of activities.

The raphia programme will make a claim to research resources which could very well be devoted to our activities within NIFOR itself, as well as in the other research institutions in the FMST family. A policy decision at this stage to invest in further raphia R&D at a certain level of resource allocation needs to be rationalized in terms of the potential benefits and costs associated with raphia relative to other alternative investment possibilities.

For example, among the major uses of raphia as a source of palm wine, of piassava fiber, of raffia fiber, and of raw material for pulp and paper manufacture, what are the economic potentials of each in the intermediate and in the long term? What sort of priorities for development should be accorded to each use? Are there other uses which need to be explored? How much attention should be given to species other than R. hookerii?

Should palm wine production and pulp and paper manufacture appear to provide the most attractive long-term economic and social benefits, how are these subsectors anticipated to evolve and develop? Will the pulp and paper subsector develop along two parallel lines with an estate section and a smallholder section, like what one finds now for other tree crops?

What are the likely constraints to the development of these subsectors? What institutions will likely play a major role in the development of these subsectors? What might be the likely role of research and of NIFOR?

It is ironic that these kinds of questions have to be raised and plausible answers hypothesized at a time when ignorance is highest. But this is always the case for applied research. Research institutions need to anticipate the possible alternative lines of development of the industry it is organized to serve.

Need for Feasibility Studies. Pursuing the pulp and paper potential of raphia, it should be possible to prepare a detailed paper study of the technical and economic feasibility of raphia production using existing information and informed estimates where such data are not available. In collaboration with forest production specialists and pulp and paper experts, it should be possible to assess the potential of raphia as a source of long fibers versus other known sources.

Such a feasibility study should bring out gaps of information which research needs to fill and the technical and economic parameters raphia as an alternative source must attain to be viable and competitive vis-a-vis other sources.

Nevertheless, the present indigenous uses of raphia, its prevalence in the natural vegetation of vast tracts of land in the deltas, and the unknown potential ecological consequences of its exploitation or displacement are sufficient arguments for reaffirming raphia's inclusion in the NIFOR mandate.

However, a strong case is still to be made for what specific activities and at what level of resources.

Need for More Fundamental Botanical and Agronomic Studies

As relatively new species still very much in the process of domestication, the pool of fundamental knowledge about Raphia spp. is still limited. NIFOR has made significant contributions in the literature but a lot remains to be done. The phenology, reproductive mechanism, cytology, morphology, anatomy, physiology, adaptation, nutrient requirements, fertilizer responses, and potential pests and diseases are all exciting areas for scientific inquiry.

The Mission notes the early pioneering attempts at plant selection and improvement. However, with the paucity of information on the nature of the characters as bases for selection, one wonders how effective and useful those initial attempts would be.

The Mission therefore encourages the staff to conduct more of these fundamental exploratory studies to cover the range of basic information needed for further work on raphia. However, there should be a careful review of priorities before the individual staff decides to pursue in depth particular lines of investigation. Since practically all of these areas are virgin fields of inquiry, it is very tempting for individual scientists to give full play to their curiosity and intellectual bent and pursue lines of investigation of extreme scientific interest but which may not be immediately relevant to advancing the cause of raphia development in Nigeria.

Need for More Plant Accessions. Regardless of the scale of effort which is decided as appropriate for raphia, the staff should resume its plant collection, characterization, and evaluation efforts on the different species of raphia. After exhausting Nigerian sources, plant prospection expeditions could be sent to Zaire, Cameroon, and Congo.

Staffing. Pending the outcome of a more carefully considered strategic plan for raphia, the Mission considers the present senior staff complement of 4 Ph.D.s and 5 M.Sc.s in the major areas of botany, agronomy, plant breeding, soil chemistry, and crop protection, to be more than adequate.

Need for an Experiment Station. Should the decision be reached that NIFOR will be asked to fully exercise its mandate on raphia, then the problem of an appropriately located and adequately equipped experiment station should be resolved.

Based on a strategic plan which the Mission suggests as a top priority, the major growing areas and ecologies for future raphia development should be identified.

Empirically it is best that the raphia main station be located in a major growing area to take into account the location-specificity of most agricultural research. Of course, other considerations will have to come into play such as land tenure, accessibility, security, and costs. If the present Oredo site satisfies most of these requirements, then a decision can be made to make further investments in this station.

Alternatively, if the Niger Basin Development Authority is developing a large tract of land for raphia production and other purposes in Rivers State it might be a good idea to explore the possibility of obtaining a site in the same area to save on acquisition and development costs and to foster close linkage between NIFOR and one of its major potential clients.

The Mission cannot over-emphasize the importance of this basic decision on the future of the raphia programme.

Capital Requirements of a Modest Raphia Programme

The following could be the capital requirements of a modest raphia research and development programme. These estimates are based on a number of assumptions which need to be validated after a careful consideration of a strategic plan for the raphia programme as suggested. If a suitable site could be negotiated with another Government agency, such as the Niger Basin Development Authority, it might be possible to reduce some of the infrastructure requirements.

Assumptions:
200 hectares main station (new)
100 hectares test sites
10 senior scientific staff (full-time equivalent)

Major Capital Requirements:

Land Acquisition, Development, and Establishment	700,000
Naira 3,500/ha for 200 ha	
Buildings and Other Facilities	200,000
400 m^2 @ Naira 500/m^2	
3 houses @ Naira 50,000	150,000
Laborers' quarters	150,000
Access and Utilities	300,000
Equipment	
1 Pick-up	70,000
1 Car	60,000
1 Tractor, trailer with attachments	100,000
Laboratory and office (for main station only)	100,000
TOTAL Naira	1,850,000

4.9 Coconut and Date Palm Programmes

The documentation available to the Mission on these two programmes was very limited. In any case, the Mission did not really have the time to make an in-depth assessment. Following, therefore, are only brief superficial commentaries on the status of these programmes.

Coconut Palm. Coconut does not seem to play a major role in Nigerian agriculture. Its cultivation is limited to some coastal areas of Lagos and Rivers State. The palm is also frequently grown around compounds.

Coconut research at NIFOR started in 1965-67 by collecting local populations and introducing a few exotic ecotypes. Seed gardens comprising mixed dwarfs and local talls have been established recently at Badagry and Abak substations.

Proposed research programmes appear too ambitious and should be re-examined to take into account the real needs and the main problems of the country. A proper survey should try to determine the actual situation of coconut plantations (hectarage, age, number of farmers, crop management) and the actual needs (estates, smallholders, compound planting) and uses (copra production, fresh nut consumption, ornamentals).

The main limitation for breeding is the extremely narrow genetic base. Most of the exotic tall cultivars are represented by two to five palms, which is far from representative samples. Any breeding programme should begin by introducing new ecotypes from other countries.

For seed and seedling production, we advise production of Malayan yellow dwarf x Nigerian tall hybrid seeds. This hybrid is known elsewhere as "Mawa" and has been extensively tested in more than 30 countries. This cultivar largely out-yields local tall coconuts for earliness and for nut and copra yields. The seed gardens already established should enable NIFOR to meet the demand.

For smallholders and compound cultivation, high-yielding tall x tall hybrid varieties could be an interesting planting material. Some of these hybrids are known for their high individual yield and allow for intercropping with food crops, cocoa, banana, and cattle when grown at low density.

Lethal yellowing is reported as a serious disease in parts of Bendel, Imo, Rivers, and Cross River States. Similar diseases are drastically limiting coconut development in countries like Cameroon (Kribi disease), Togo (Kaincope disease), or Ghana (Cape St. Paul disease). A thorough survey of the extension of the disease is necessary before any development project. Testing of various ecotypes with broad genetic background appears the most practical way to come up with a solution at present. This, again, calls for new introductions in the country.

Date Palm. Research started in 1979 with the collection of 24 date palm types in northern parts of Nigeria. Two other collections were further added to the gene pool in 1984-85. The breeding programme is aimed at increasing fruit yield, sugar content, resistance to diseases, and at improving the growth habit and the color and consistency of fruits. Half-sib families were raised in an attempt to start a recurrent selection breeding scheme.

Water deficit is the main constraint at Dutse substation. A solution to this problem has to be found if the research is to be resumed.

One of the first objectives in date palm research could be to introduce some of the varieties developed in other countries (U.S.A., Algeria, Tunisia, Morocco) and to study their adaptation and value under Nigerian conditions. Literature, genetic materials for exchange, and opportunities for training may be available from the FAO Regional Project for Palm and Dates Research Centre in the Near East and North Africa in Baghdad, Iraq.

CHAPTER V - ORGANIZATION, MANAGEMENT, AND RESOURCES: ASSESSMENT AND RECOMMENDATIONS

5.0 The Policy Environment for Oil Palm Research

Nigerian scientists themselves are the first to point out the weaknesses and constraints to the country's agricultural research system[1/]. Indeed, if one looks at the performance of Nigerian agriculture as a whole during the last 20 years and farm productivity levels obtained in many developing countries in Asia and Latin America, Nigerian agriculture has a long way to go.

The Okigbo panel of 1981, which reviewed the performance of the agricultural research institutes, cited the following major problems of the country's agricultural research system:

- grossly inadequate and erratic funding;
- inadequate equipment and facilities;
- lack of trained manpower;
- lack of coordination between research, on one hand, and extension and development agencies on the other;
- need for rationalization of number and location of research institutions;
- need for improved management to provide a more favorable environment for productive research.

However, one should not overlook Nigeria's accomplishments in this field. Since independence the country has committed significant investments in scientific research, particularly agricultural research. There are now 17 research institutes wholly dedicated to agricultural research in the country. In addition, a significant research capacity has been built into the university system. In 1984 Nigeria accounted for 80% of the reported national expenditures for agricultural research in West Africa. Forty-four percent of the agricultural scientists in West Africa are Nigerians. But more significantly, first among the countries in Sub-Saharan Africa, Nigeria has succeeded in completely indigenizing its agricultural research system.

Nevertheless, the observation is quite true that real support for agricultural research, and for that matter everything else, has been declining for the last few years. Increasingly, many Nigerian research institutions find themselves with little operating funds to spare after paying salaries and wages. Often there are no funds to replace or repair obsolete or worn out equipment. Real wages of scientists have declined drastically with the devaluation of the naira.

1/ Idachaba, F.S. 1980. Agricultural Research Policy in Nigeria. IFPRI.
B.N. Okigbo et al.: Report of Research Institutes Review 1980-81.

Unfortunately, this situation in general will continue to be so until Nigeria's economic fortunes turn around. If the 1987 to 1988 transition is an indication, there are some grounds for optimism.

The federal recurrent budget was doubled between 1987 and 1988. The budget of the FMST, and that of NIFOR, correspondingly doubled.

Moreover, finally the Government has approved a white paper on science policy indicating therewith the plans of Government with regard to the development of the science and technology sector.

At the time of the Mission, the Government approved the upgrading of salary structure in research with that of the universities. This will grant scientists the parity with university faculty that they have been asking for for so long.

The outlook for the agriculture sector, including oil palm, is on the upbeat. The structural adjustments which the country is undergoing had been salutary to the agricultural sector. With devaluation most agricultural export crops are now very attractive to produce once more. With the banning of imports, local agricultural produce no longer has to compete with cheap imports. With the decline in the mining sector, people looking for jobs in the urban centers are now returning to the countryside.

The second phase of a World Bank-assisted Tree Crops Project is expected to increase domestic production of palm oil by 69,000 MT p.a. Another major oil palm planting project is being negotiated with EEC.

These new developments will step up the demand for hybrid tenera seeds which NIFOR produces exclusively and will increase the demand for improved technology, particulary for smallholders and in the new areas of production. Considering all of the above, the outlook for oil palm research should be positive.

5.1 NIFOR's Mandate

Need for a Reassessment of the Commodities Mandate. NIFOR is responsible for oil palm, coconut, raphia, date palm, and for other palms which for the moment are only of minor ornamental interest. While NIFOR's mandate is historically recognized as oil palm plus other minor palms, the Mission encountered variances from this interpretation.

A very responsible official in the Federal Ministry of Agriculture expects NIFOR to give a lot of attention to raphia. Within the Institute itself, the demand for more equal treatment among the commodities is quite common. In the last reorganization of NIFOR approved by the Board, two of the three objectives had to do with the more equitable distribution of trained research staff and funds among the various palms.

Mandates eventually translate to programme priorities and resource allocations. A full programme on each species will require roughly similar levels of efforts and resources regardless of the commodities' current and potential importance to the country. The Mission doubts very seriously whether NIFOR will have sufficient resources to fully address

the research needs of its four mandated crops now and in the near future. And even if such resources were made available, whether the same resources could be better used for other agricultural commodities and/or research problems.

The Mission therefore urges the incoming governing board to reassess the priorities of the commodities in its mandate as a policy issue of first priority.

In order to assist the NIFOR governing board and the FMST in making the assessment, NIFOR management should prepare a brief on the current and potential economic, social, and ecological value and impact of research on the four commodities, including the requirements for trained manpower, facilities, and operating funds, and an objective evaluation of NIFOR's chances for achieving progress in those commodities.

Since quite obviously a political decision has been made to undertake research on the other palms which have different geographical adaptations from that of the oil palm, perhaps the clarification necessary is on the level of commitment and timing to be assigned to the other palms. The Mission anticipates that given the current and intermediate prospects for revenues, either through Government subventions and/or operating incomes, the board and the FMST will have to restrain NIFOR's level of commitment to some of the commodities at a minimum level. Management should be ready to put forward to the Board and FMST the minimum threshold level of support for a commodity.

Need for a Review of Non-Research Activities at NIFOR. As far as research is concerned, NIFOR's mandate is a very comprehensive one indeed. In addition, the catch-all objective: any other matter related to the specified crops allows NIFOR to rationalize any and every activity remotely associated with palms. Thus technology transfer, training, advisory services, production, sales and distribution of seeds and seedlings, management of an oil mill and palm estates, commercial production, sale and distribution of palm products and palm processing equipment, and other non-research activities are all legally within the purview of NIFOR.

In this sense its formal mandate has not constrained NIFOR's activities.

Obviously a very broad mandate formulation works both ways - it allows for institutional flexibility on the one hand, and proliferation and dispersion of efforts on the other. The conduct of non-research functions, if not carefully regulated, can detract from the main function of technology generation and adaptation.

The Mission endorses very strongly the necessity for NIFOR to engage in technology transfer, training, communications, and advisory services. These types of activities are effective mechanisms for forging linkages between research institutions and the clients for their research and ensuring the relevance of research to the needs of industry.

Seed production for most crops need not be a regular function of research agencies, except for the production of the basic breeders and foundation seeds. However, in view of the perennial habit of the oil palm plant and the breeding methodology adopted, where the control of the genotype is a continuing activity requiring constant supervision of the plant breeders, hybrid seed production is most appropriately handled by NIFOR.

The other non-research activities are not core to the operations of NIFOR as a scientific organization. Their justification lies mainly in administrative considerations of revenue generation, employment, and public relations. The Mission recognizes the validity of these other concerns and understands the historical context by which the activities came to be part of NIFOR. However, the Mission has serious misgivings about their continuing demand for material resources, funds, senior staff time, and management time in the Institute.

The Mission therefore recommends to the governing board that these non-research activities be very objectively reviewed and that arrangements be made to gradually phase out those activities which are deemed not really crucial to the performance of NIFOR's charge.

Need for an Operational Mission Statement

The foregoing section reflects a concern strongly felt by the Mission that a significant source of NIFOR's institutional difficulties is the liberal, unconstrained interpretation of its mandate.

As they ought to be, mandates are broad, eloquent statements of organizational purpose which founding fathers invariably bequeath their creations. The expansiveness is deliberate and correct for two reasons: first, the statements are meant to lift the spirit, and second, the organizations are meant to last and, since no person can pretend to divine the future accurately, the organization ought not to be confined by a restrictive charter.

The Mission does not consider a formal change in mandate necessary at this time. What NIFOR needs is an operational mission statement which defines more narrowly the specific objectives of NIFOR, its major programs, and major clients and beneficiaries.

5.2 Governance

The parastatal status NIFOR enjoys is a privilege many research institutions in developing countries have been seeking, often with little success. In principle this arrangement should allow institutional flexibility to meet the special needs of research without diminishing accountability.

In reality the institutes, including NIFOR, however, are essentially governed by federal rules and regulations concerning conditions of service and fiscal management. Their autonomy therefore lies more in their authority to determine strategy, set priorities, generate and keep their incomes, and allocate resources within the broad agenda set in their respective mandates. Much of this emanates from the substantial delegation of authority from the office of the Federal Minister of Science and Technology.

Parenthetically, the delegation of such authority from the Federal Minister to the director of an institute need not pass through the mediation of a governing board. Nevertheless, the Mission believes a governing board is essential to the proper functioning of NIFOR and the research institutes. The following comments apply to how NIFOR could make more use of its governing board.

The Mission was made to understand that there was less than satisfactory experience with some of the previous governing boards and for this reason all institute boards were disbanded in 1983. NIFOR had been operating without one since then.

The Mission is convinced that the major role of the governing board is in providing guidance to management and to the FMST regarding objectives, strategy, priorities, and external linkages of the institutes. All too often institutional objectives, strategies, priorities, and external linkages are very much driven by the disciplinary expertise and experience of the senior staff, to the neglect of the perspectives of producers and consumers, of partner institutions and of broader socioeconomic and political considerations. A well-selected and broadly representative board can be extremely useful in generating breadth, depth, balance, and wisdom in the consideration of institutional programs, organization, and management.

The idealized dichotomy of roles between boards and management is policy versus implementation, governance versus management. However, there is often a broad gray area in between. Within a given policy, there is often a variety of implementation choices. Management normally should be allowed to exercise its judgement on these choices. However, some implementation choices can have major implications to structure, organization, staffing, and resource allocations. Where such major decisions require a broad consensus among the staff and among the institute's clientele and partners for their successful implementation, the concurrence and full backing of a highly respected board is essential. This second vital role of the board will become more apparent as we dwell on other management issues in NIFOR.

Board's Role in Strategic Planning, Priority Setting, and Audit

The new NIFOR board may wish to consider as part of its first order of business setting into motion the development of a strategic long-term plan. Management has taken the first positive step by preparing a ten-year development plan as an input to this review and in preparation for the Institute's golden anniversary.

However, before NIFOR's management can proceed further they will need the board's guidance on basic policy issues regarding the commodity mandate and magnitude of non-research activities as discussed in the preceding section (Section 5.1).

Moreover, the previous boards appear to have been more active in their oversight responsibility on business transactions and financial audit. The Mission hopes that the present board will give as much time to programme matters and to performance monitoring and evaluation.

Membership of the Board

The members of the board are appointed by the President upon recommendation by the Federal Minister of Science and Technology. In retrospect, part of the non-performance of previous boards may have been due to lack of recognition and common understanding among the members of the board of their basic functions and due to unfortunate choice and/or unwanted pressure in the selection of board members.

Given the major responsibility of the board for defining objectives, strategy, priorities, and external linkages, the Mission believes that the members should have, among their personal qualifications, a familiarity with the needs of producers and consumers, an appreciation of and respect for the scientific process, management and business expertise, and a broad understanding of the socioeconomic and political context in which NIFOR as an institution needs to operate. In many countries these types of representation are commonly achieved by having leaders or representatives of different sectors sit on boards as ex-officio members.

In the case of NIFOR, ex-officio membership can come from the following:

FMST	-	Director for Agricultural Sciences
FMAWRRD	-	Director, Federal Department of Agriculture
Universities	-	Vice Chancellor of a university
Small Producers	-	Leader, smallholders group or cooperative
Large Producers and Processors	-	Representative of the Chamber of Agriculture, oil palm subsector

Additional members at large can be selected to represent state and local governments and consumer interests.

In the international agricultural research centers, the trustees or boards are self-perpetuating; i.e., they have a hand in the selection of their successors. The FMST may wish to involve the existing boards in the selection of the members-at-large replacements. The board might be asked to endorse names from among whom the Federal Minister of Science and Technology would select for appointment by the President. This arrangement might somewhat reduce the flexibility of the FMST, but on the other hand the board is made more fully accountable for its performance as they are given a role in the selection of the institute director and the board membership.

Reporting Relationship of the Board to FMST

The recent decision conferring direct line responsibility over the research institutes to the department directors in FMST raises the question of the membership of the department directors in the boards. If the boards will be made to report to the department directors, then the directors should not sit on the boards. The Ministry should give some further thought to this.

5.3 Structure and Organization

The objective of organizational design is to bring about coherence among goals, structure, people, reward systems, information and decision processes, and available resources. Structure and organization, therefore, is only one of several key intertwined variables among which management has to make strategic choices over time.

In assessing NIFOR's present structure, the Mission was fully aware that the Institute has not had the opportunity to fully implement the reorganization approved by its previous governing board. The research programmes are operational, although the working relationships between the programmes and the divisions have not been fully worked out. The major support departments have not been organized as distinct operating units and thus at present most of the divisions and units still report directly to the Director. And because of rapidly declining Government subventions in recent years, a program-budget system has not been fully installed.

The Mission recommendations on structure and organization were influenced by three considerations:

1. The perception that the Director is unduly tied down by routine day-to-day matters, leaving him less time for top management responsibilities.

2. The non-research activities absorb a very sizeable part of the Institute's resources. There must be ways of further streamlining the operations of these activities, of reducing staffing and costs as much as possible, while improving their revenue-generating potential and making them more supportive of the core activities in research.

3. The need to reinforce the programme/discipline matrix to provide an environment that is more conducive to relevance, excellence, and cost effectiveness in research.

5.3.1 Research

The Mission supports the previous decision to establish research programmes cutting across the traditional discipline divisions not so much to equitably distribute resources among commodities as intended but more so to promote interdisciplinary interaction and relevance. Too-discipline-oriented research tends to lose its farmer focus.

However, in discussing the change with the NIFOR staff, the Mission encountered a lot of questions and reservations on how the matrix should operate. There is an apprehension among some staff that the pendulum has swung excessively to the programme end, leaving little initiative to the divisions and their heads.

The dilemma is not unique to NIFOR and is always an issue when commodity and discipline approaches are mixed. It should be pointed out that the discipline structure has its own merits. The division provides a home to scientists working along similar lines of research. Close contact within the division encourages intradisciplinary exchange and facilitates sharing of common facilities and resources. It would be a

pity, therefore, if in the effort to achieve more relevance and interdisciplinarity, NIFOR lost its strength in the discipline divisions which have served the Institute so well in the past.

In clarifying the functions of the programmes and the divisions, the Mission suggests the following interpretation: the divisions implement research, while the programmes coordinate. The relationship takes on a client-contractor format. The programme contracts out research to be implemented by the divisions. The programme allocates funds for projects which the divisions implement on the basis of agreed work plans.

The staff are assigned and appointed into the divisions under the administrative supervision of the heads of division. However, the recruitment and assessment of the performance of research officers should be a joint responsibility of the head of division and the relevant programme leader(s).

The programme leaders are responsible for relevance, coherence, and balance of effort within the commodity. The heads of division, on the other hand, monitor appropriateness of methodology and quality of research implemented by staff within the division.

In this proposed set-up, the discipline divisions will remain as line units, while the commodity programmes assume staff functions. However, the commodity programmes will have line functions over their respective substations and outstations.

Note that the foregoing discussion applies to the four commodity programmes. The other programmes - Extension and Training and End-use - may likewise draw from the scientific divisions, but they will have their own staff and facilities under their direct administrative supervision. In other words, the commodity programmes are essentially staff units, while the end-use and extension programmes are line units.

The Research Programmes. The research programmes as presently constituted are:

Oil Palm
Date
Raphia
Coconut
Farming Systems
End-use
Extension and Training.

The commodities are logical focal points of integration and coordination and should stay.

Farming systems research is treated in various ways in different research organizations. For fund-generating purposes and to highlight the need for systems research and on-farm types of research activities, separate farming systems research units are often organized.

Others argue that farming systems is not a branch of research per se but an approach or a perspective. The agronomists and farm management specialists of the old school insist that they had FSR all along and are quite amused over its supposed novelty.

The Mission recognizes that in fact there are at least two major disciplines involved - agronomy and socioeconomics. The broad overlap between agronomy and FSR has been partly resolved by designating the head of agronomy as concurrently FSR programme leader.

Since the point of its relevance has been made and acknowledged, the Mission tends to take the latter view and proposes to elevate FSR as a fundamental perspective in NIFOR's approach to its mandate. For consistency and to avoid further unnecessary confusion, FSR should cease to exist as an independent programme and its research functions should be taken over essentially by agronomy and a new socioeconomics division. Multidisciplinary integration will be addressed or built into the commodity programmes.

The End-use programme will involve the disciplines of food chemistry, microbiology, and engineering, which at present are lodged in two divisions. However, a strong case could be made to the effect that end-use is concerned with processing and utilization, while the rest deal with production problems. Indeed, in many organizations end-use and processing research are organized as separate departments or separate institutes altogether. Weighing both options, the Mission goes along with the present structure of a separate end-use programme. However, the present biochemistry and agricultural engineering divisions could very well be reorganized into a single larger end-use programme with sections on food chemistry, food microbiology, and engineering.

The Extension and Training programme cuts across the discipline divisions and across the commodity and End-use programmes as well. For purposes of integration and coordination, it should therefore be kept as a separate programme.

The proposed set-up is shown in Figure 4. The four commodity programmes, as indicated earlier, will have coordinating staff functions relative to the discipline divisions, except for the substations and outstations, which are under the direct supervision of the programme leaders.

The End-use and Extension and Training programmes, on the other hand, have implementing functions.

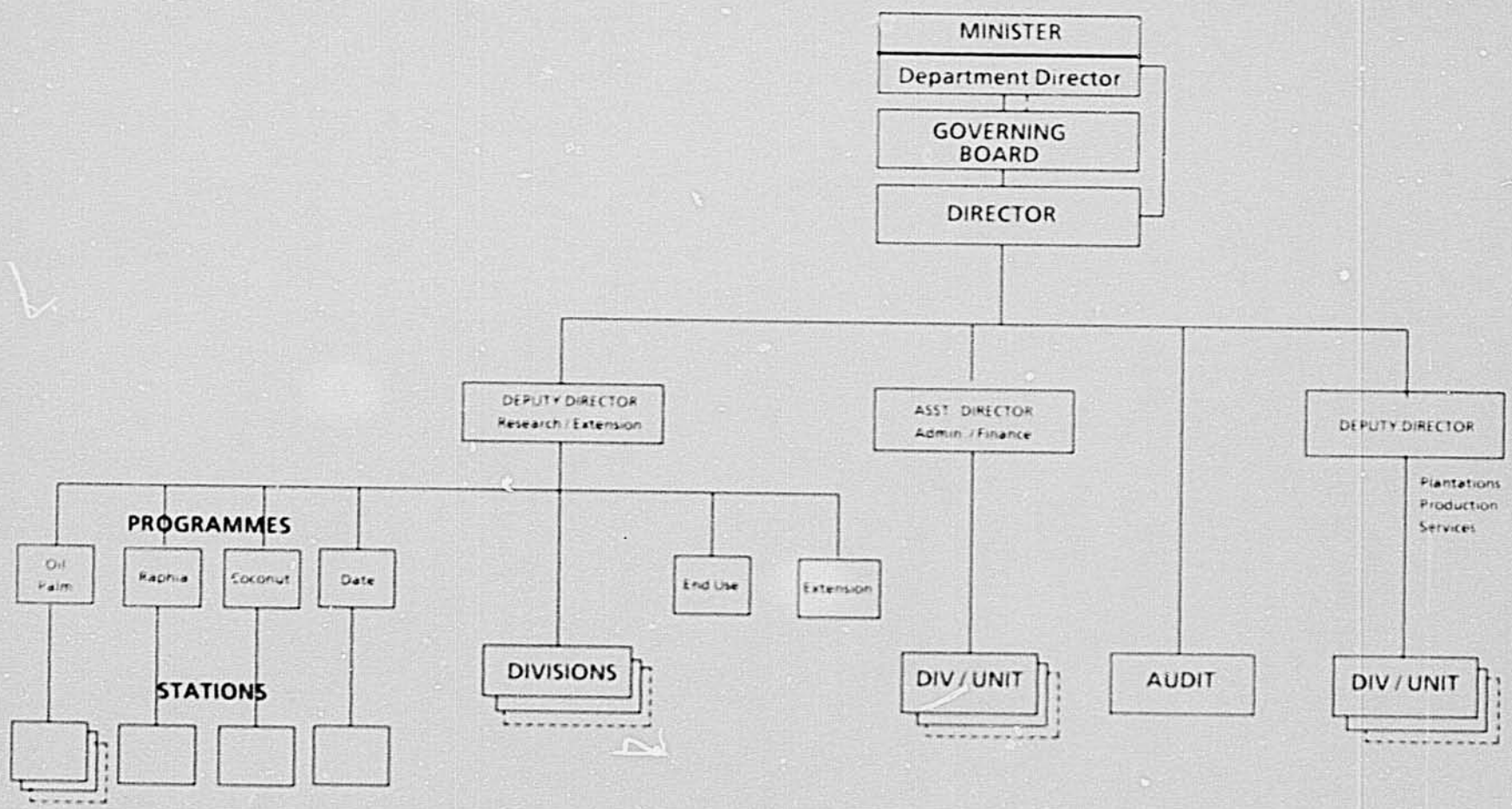
The activities of the six research programmes and of the disciplinary divisions will still have to be rationalized, integrated, and coordinated at the Institute level. This will require an almost full-time deputy director for research, extension, and training.

5.3.2 Administration and Finance

General administration, personnel, catering, and medical presently report to the Institute Secretary, who is the chief of administration. Accounts, stores, audit, and security report directly to the Director.

The Mission's preference is to make all of these units report to a single manager to reduce the number of people reporting to the Director. The chief of administration, the medical chief, the chief accountant, etc., will report to this individual, who will have the rank of Assistant Director for Administration and Finance. The only exception is the audit unit, which shall continue to report directly to the Director.

Figure 4: Proposed NIFOR organizational chart



5.3.3 Plantations, Production, and Services

The concern for the magnitude and cost-effectiveness of these support activities is expressed elsewhere in this report. They do tie up a lot of resources and constitute a drain on management attention. The Mission believes very strongly that there is scope for further streamlining these support activities, reducing staff and costs, and enhancing their revenue potential without impairing the core function of research.

In order to achieve these multiple objectives, NIFOR needs someone in top management who has a strong business sense, someone who enjoys a high credibility with the Institute's partners and clients but one who at the same time fully appreciates the support role of these activities to research, training, and extension. The Director obviously will not have time for these activities, given his other responsibilities.

The Mission therefore recommends that the revenue-generating and support services units be placed under the supervision of a full-time deputy director who will have the clear brief of slimming down staffing and costs, and generating more operating incomes while further strengthening support services to NIFOR's core functions.

Further, the Mission does not consider it necessary to cluster these support divisions into departments as previously approved. These support divisions can report directly to the second Deputy Director.

5.3.4 Rationalization of Divisions and Other Operating Units

Following are some observations and comments which management may wish to take into account in rationalizing the structure of the operating units:

1. The operating units can be broadly classified into the three major functional areas of research, administration, and revenue generation and services. Considering the size of NIFOR, the research units can report to one deputy director; the revenue generating activities and services to a second deputy; and administration, finance, and other sundry units to an assistant director for administration and finance.

2. A number of existing units are too small to stand alone.

3. The Chemistry Division is more appropriately called Soils and Plant Nutrition Division. Its routine soil and foliar analysis functions can go to the central analytical laboratory.

4. If there is a strong wish to retain the Farming Systems Research (FSR) appellation, the agronomy division may be renamed accordingly.

5. Statistics is a very small unit. Since the bulk of its present work is associated with plant breeding, it could very well be merged with the plant breeding division. The statisticians can still exercise their advisory function from a merged plant breeding/statistics division.

6. Agricultural economics should be broadened to include other social sciences.

7. Tissue culture can be organized as a new division. However, since tissue culture is the physiology of growth regulation, the Mission believes it should go with the physiology group, which is another very small division.

8. There is a need for a centralized facility for routine chemical analyses and to house sophisticated and expensive analytical equipment. The central lab should go under research, although the central analytical lab could be another revenue-generating facility.

9. The library would probably get more attention and support if it were considered a unit under research.

10. As personal computers get more powerful and less expensive, there is a definite trend towards dispersed computer and information-handling capability. Among the divisions, plant breeding, socioeconomics, agronomy, physiology (proposed modelling research), the library, and general administration can justify PCs right away. Should NIFOR obtain a mini computer, the alternative locations are plant breeding and general administration.

11. Should a new post of assistant director for administration and finance be created, the administrative officer may be relieved of some of the units reporting to him to spread the administrative burden more equitably.

5.4 Physical Facilities and Resources

5.4.0 Present Situation

Main Station. Most of the buildings, laboratories, and housing are at least fifteen years old. For the most part they are adequately designed for natural lighting and ventilation. By and large they are functional, although many are in obvious need of repair and some are quite overcrowded.

The grounds, the plantations, the road network, and the surroundings appear to be well maintained, giving the campus a generally pleasant atmosphere.

However, the situation in terms of essential services and laboratory facilities is pathetic. Experimental work in the laboratories is almost at a complete standstill. Electricity and water supplies are out for lengthy periods of time. Analytical equipment is mainly obsolete and inoperative. Spare parts are not available; the shelves bare of chemicals and other supplies. The library has not purchased foreign journals and books since 1982. Very few vehicles and transport are in operating condition for lack of spares and fuel.

It is clear that an almost total programme of re-equipment is required.

Substations and Outstations. The Mission was able to observe only the substation for oil palm at Abak. The office buildings, workshops, and the plantation appear to be well maintained. The station, however, needs to improve its access road to the main highway, connect its electric supply to the main grid, improve water supply and sanitation in the staff housing, and be provided with sensible transport.

The Mission was made to understand that the other substations and outstations have very little infrastructure as yet.

5.4.1 Research Laboratories

We have discussed the requirement in detail with the NIFOR research staff and obtained detailed lists of apparatus from them. We then pruned the lists to what we consider the essential basic "modern research kit" for the subjects to be covered. This means that we have included all the analytical techniques which are of established value. We have excluded requests for techniques whose relevance is still speculative or which are not of immediate value to the present work programme.

We therefore believe that provision should be made for some additional apparatus over the next five years.

In our discussions with the NIFOR management we found that their thinking on future organization was in the direction of a Central Analytical Laboratory. We found this concept extremely helpful and have developed it further so that it is an essential feature of the proposed re-equipment.

It is proposed that each divisional laboratory will contain the basic equipment that is specialized to its needs. As far as possible all analytical equipment to be used across divisions will be placed in the central laboratory. This will operate in two ways. A routine analytical service will be provided, for example for protein analyses, moisture determinations, fat content by soxhlet, etc. A group of technicians will be trained to handle the specialized equipment and provide the service.

In addition, research staff from the divisions will have full access to equipment which will be available for general use, for example high-speed centrifuges, semi-micro balances, photo micrography.

The advantages of this system are as follows:

1) avoids duplication of expensive hardware;

2) ensures maximum utilization;

3) enables electronic and optical equipment to be provided with adequate air conditioning so that it will not deteriorate;

4) makes possible the assignment of trained technicians who will regularly handle and service sophisticated and expensive equipment;

5) reduces fire risk by concentrating use of organic solvents in a specially designed area.

The Central Analytical Laboratory will be placed in the proposed new Administration/Laboratory building. The central laboratory should be as close as possible to the user divisions, and therefore this should form part of the present research quadrangle.

With a few exceptions, our equipment recommendations do not specify make and model at this stage. The cost figures have been derived from catalogues of suitable equipment. The actual choice should be made when orders are placed. In choosing each item, the following considerations should be borne in mind.

1) Are specialized servicing engineers available in Nigeria? If not, what servicing capability does the supplier offer, and what will it cost?

2) Can professional friends/colleagues in Nigeria or elsewhere offer advice on specific models from personal experience?

3) The most highly automated equipment is not necessarily the most appropriate, in view of cost and serviceability.

4) Full drawings, circuit diagrams, and service manuals should be required for every major piece of equipment. They should be studied by the NIFOR instrument section at the time of installation and should be filed by them.

5) If the choice of several pieces of equipment is from one of the large manufacturers, it should be possible for the NIFOR instrument engineers to receive specific training from them.

6) It may be desirable to order certain essential spare parts with the main equipment. The supplier's advice should be sought.

5.4.2 Engineering Workshops

Here our recommendations are also for substantial re-equipment, with the provision of some additional fabrication techniques not at present available.

However, it is recommended that the engineering facilities should similarly be placed in one central workshop, which would serve both the maintenance requirements and the prototype fabrication requirements of the research engineers. An additional objective of the workshops should be to fabricate some of the simpler items of laboratory equipment. Considerable savings in foreign currency and in time could be achieved by using the combined talents of the scientists, research engineers, and workshops staff.

As in the case of the Central Laboratory, the main advantages of the Central Workshop will be the avoidance of duplication, better maintenance, and the maximum utilization of hardware.

5.4.3 Library

The library has been unable to purchase any books or journals from overseas since 1982.

It is recommended that sufficient funds be provided for subscriptions to a minimum list of journals and for the purchase of some essential back numbers. A similar recommendation is made for textbooks, where an additional budget is required for the renewal of basic reference books.

In addition, the library requires a microfiche reader and a small computer. It is assumed that the library will be rehoused in the new Central Administration block and will be air-conditioned.

5.4.4 Computer Facilities

The Institute should get rid of its IBM System 3 which is based on the obsolete card system and which is now too expensive to maintain. However, the Mission is unable to make a firm recommendation for its replacement. With the advent of cheaper and more powerful microcomputers, there is now a trend towards more decentralized computer capacity. In the Institute the principal users are plant breeding and general administration. Other units like economics, agronomy, FSR, and physiology (crop modelling) should generate more demand for computing capacity if micro computers became available.

The Mission therefore recommends that NIFOR hire the services of a consulting firm in Lagos to assess the Institute's present and future computing needs, and make recommendatins on hardware, software, and training needs. A week-long consultancy should be adequate. As with the other laboratory equipment, availability of local service and maintenance will be an important consideration.

5.4.5 Glasshouses

The Institute has only one glasshouse which, incidentally, was just newly repaired. This is inadequate. Provision is made for additional glasshouse space of at least 500 quare meters. The glasshouse requirement will expand some more as the tissue culture facility gets under way.

5.4.6 Electricity

NIFOR at present depends upon a number of separate generators for its electricity supply.

The total capacity is distributed as follows:

350KW at the central powerhouse
200KW at the NIFOR oil mill
60KW for the water pumps

In addition, there are a number of smaller generators, not linked to the general Institute supply for specific units, like the palm wine bottling unit, the engineering research workshop, and the village maternity unit.

The most important capacity - i.e., that in the central powerhouse and for the water pumps - is defective, and as a result the research work in the laboratories is more or less at a standstill for long periods.

NIFOR should be linked to the national grid system as soon as possible. The cost is estimated at 4,350,000 Naira - approximately one million US dollars. Standby capacity should be provided sufficient for:

a) Central Analytical Laboratories;
b) seed production unit;
c) tissue culture;
d) water pumps;
e) computer.

It is probable that some of the existing generating capacity will be available after the mains link-up is completed. A budget of US$ 100,000 is recommended for additional capacity.

5.4.7 Water Supply

The water supply is not metered, but estimates for consumption are as follows:

NIFOR Mill Co.	200,000 gals/day
Nursery	150,000 gals/day
Institute and domestic uses	200,000 gals/day
TOTAL	550,000 gals/day

It is recommended that capacity for 850,000 gals/day should be provided.

Three pumps should be purchased, each rated at 400,000 gals/day and driven by electricity from the mains supply. The pumps should be connected to the standby generator. The cost is estimated at $250,000.

5.4.8 Vehicles

Minimum requirement. It is assumed that heavy land preparation and transport will be contracted out. Each of the four substations should have at least a pick-up and a tractor.

For the main station the following minimum vehicles are recommended:

a) Assigned to units:

Physiology	1 x 504 estate
Entomology	1 x 504 estate
Chemistry	1 x 504 estate
Agronomy	1 x 504 estate
Pathology	1 x 504 estate
Breeding	1 x 504 estate and 2 pick-ups
Harvesting	7 x motorcycles
Extension	2 x 504 estates

b) Vehicle pool:
3 four-wheel drives
3 504 estates
2 lorries
4 tractors
1 grader
1 hoist
1 rome plough
1 disc plough

5.4.9 Improvement of other Facilities at Main Station

NIFOR has a long list of facilities requiring improvement at the main station. In addition to the normal wear and tear of facilities, the situation undoubtedly has been exacerbated by the funding situation in the last several years, when funds for capital outlays had to be diverted to operating expenses to make up for shortfalls in subventions for personnel costs.

These needs must be attended to in time, and all the Mission can do at this stage is to highlight those which appear more urgent than the others. For the main station immediate provisions should be made for:

General repair of labs, offices, and housing	300,000
Improvement of sanitation in staff quarters	70,000
Improvement of the telephone system	30,000
Construction of additional housing units for research officers	120,000
TOTAL	$ 520,000

5.4.10 Improvement of Facilities at the Oil Palm Substation at Abak

The most immediate needs of the Abak station include:

Improvement of the water supply	100,000
Linking with the national electic grid	100,000
Improvement of sanitation in staff quarters	40,000
Construction of housing for 3 research officers	90,000
TOTAL	$ 330,000

The improvement of the 7 kilometers access road and the bridge to the other half of the property should not be the burden of NIFOR alone. Several villages use these as much as or maybe even more than the station. Arrangements should be made with the state government or with the Federal Directorate of Food, Rural Infrastructures, and Rural Development.

There are no research officers at Abak. All the experiments are conducted by remote control from Benin. The Mission recommends that at least three research officers be assigned at Abak to supervise all field experiments and to form the nucleus of an extension and training sub-unit for the delta area.

The Mission did not visit the substations for the other commodities and is unable to make any comment on their condition or needs.

5.4.11 Construction of a New Administration/Central Laboratory Annex

The need for a central laboratory has been dealt with in an earlier section. The administrative and other support offices are very cramped and scattered all over. New offices are necessary to relieve the congestion. The Mission therefore recommends the construction of a new annex which will put together under one roof the laboratories which require a lot of sophisticated equipment, most of the administrative offices, and an air-conditioned library.

The estimated floor requirements for the new administration/central laboratory annex are:

Administration	450 m^2
Library	200 m^2
Tissue culture	120 m^2
Central analytical laboratories	300 m^2
End-use	130 m^2
End-use pilot plant	100 m^2
Computer	100 m^2
	1,400 m^2
Passages, stairs, toilets	200 m^2
	1,500 m^2

The following elements should be taken into account in the design:

1) fully air-conditioned building on two floors;

2) administration and library upstairs;

3) air-conditioning in tissue culture and instrument rooms of Central Analytical to be linked to standby generator;

4) small separate rooms for soil preparation and for leaf preparation, designed to avoid cross contamination. These rooms will also contain drying ovens and should not be air-conditioned;

5) a small room with flame-proof fittings in the End-use Laboratory, to contain hydrogenation equipment and experiments using large quantities of inflammables;

6) four fume upbounds are required in the Central Laboratory and two in the End-use Laboratory;

7) the pilot plant should have large double doors to the outside;

8) a separate room should be provided for balances and optical instruments;

9) atomic absorption spectrometer requires its own exhaust system;

10) vacuum pumps and air compressors should be housed outside the building to minimise vibration;

11) consultancy should be sought for the design of the tissue culture facility, which has very specialised demands.

Cost of new building estimated at US$ 300/sq. metre = $ 450,000.

5.4.12 Summary of Budget Recommendations for Equipment and Capital Outlay

NIFOR management prepared a detailed list of equipment and facilities which the Institute would require in the next years to implement the work plan they had in mind.

Except for some unnecessary duplication of major pieces of equipment, a good case could be made for practically all of the proposals. Since, obviously, the total amount was in excess of what could be made available to the Institute within a reasonable period of time, the Mission went over the list very carefully and debated the merits, especially of the major items, with essentially three considerations in mind:

1) immediate relevance to the Mission work programme recommendations;

2) availability of staff to utilize facilities adequately;

3) maintenance and service implications.

The Mission recommendations are summarized in Table 9. The total is US$5,810,670. Additional provisions have to be made for freight, insurance, installation, and local taxes, if any.

The breakdown for each of the major headings is shown in the Annex for illustrative purposes. The list of equipment should not be taken as an absolute listing but merely indicative of the relative needs of the units/activities they are identified with. The final listing should be determined by an Institute equipment and facilities committee constituted by management for the purpose.

Unfortunately, many deserving proposals could not be accommodated in the present list. The Mission expects that they would be provided in the regular annual capital subventions of NIFOR after the more urgent ones have been attended to.

Table 9: Summary of Equipment and Capital Requirements

Laboratories	
Central Analytical/Soil Science	346,150
Soil Physics	112,560
Weed, Pest Control, Entomology	57,050
End-use	263,050
Pathology	41,450
Provision for glassware (all labs)	120,000
Provision for chemicals (all labs)	75,000
Subtotal ($1,015,260)	
Seed Production, Plant Breeding, and Tissue Culture/Physiology	
Plant Breeding	99,500
Seed Production	176,500
Tissue Culture	154,000
Physiology	42,450
Subtotal ($472,450)	
Other/Support Units	
Engineering Workshops	131,000
Electronics/Instrument Workshop	44,100
Statistics/Office Equipment	36,700
Library	80,000
Computers	50,000
Meteorology	6,700
Fire Service	58,000
Extension Service	198,460
Subtotal ($604,960)	
Vehicles	
Cars, Trucks, Tractors	698,000
Spares for Vehicles	70,000
Subtotal ($768,000)	
Utilities	
Electicity	1,100,000
Water	250,000
Subtotal ($1,350,000)	
Building	
New central laboratory/administration	450,000
Subtotal ($450,000)	
Improvement of other Facilities at Main Station	520,000
Improvement of Facilities at Abak substation	330,000
Subtotal ($1,300,000)	
Training	300,000
TOTAL US$	5,810,670

5.5 Human Resources

5.5.0 Introduction

The following comments are based on the Mission members' recommendations on work programmes, tempered somewhat by realistic expectations of what resources might be available to NIFOR. To highlight some of the points we wish to raise, we are presenting the human resources data at NIFOR with those of the Palm Oil Research Institute of Malaysia (PORIM) as the other institution that comes closest to NIFOR in terms of its commodity mandate. The PORIM data are not strictly comparable with those of NIFOR but should be useful as a point of reference.

5.5.1 Staffing Levels and Ratios

The staffing levels and ratios for NIFOR and PORIM are summarized in Table 10. The most obvious difference is in the overall level of staffing. NIFOR has more than three-and-a-half times the personnel complement of PORIM. Less obvious but equally significant is the staff distribution. Only 31% of NIFOR staff are assigned to the research programmes, compared with 60% of PORIM.

Table 10: Staffing Levels and Ratios - NIFOR and PORIM 1/

	NIFOR			PORIM		
	Senior	Junior	% of Total	Senior	Junior	% of Total
Director's Office	3	4	<1.0	2	9	2
Administration/Finance	61	171	15	4	38	8
Research	145	421	31	70	242	60
Development, Maintenance, Services, Others	82	756	54	12	143	36
Subtotal	291	1552	100	88	432	100
TOTAL	1843			520		

1/ 1987 figures for NIFOR; 1985 figures for PORIM

In the critical measure of number of researchers, NIFOR and PORIM are even (69 vs 70). However, if we consider the research staff exclusively assigned to oil palm, NIFOR has 38 vs 70 for PORIM.

Thus, while NIFOR has 3.5 times more total regular personnel, it has only half as many people in the crucial category of researchers actually engaged in oil palm research as its counterpart in Malaysia.

This comparison, to our mind, expresses as eloquently as one could, one of the major critical management issues facing NIFOR. Again, fully aware of the human and political considerations involved, the Mission must urge the governing board, FMST, and management to resolve this policy issue as soon as possible and to adopt a strategic plan for realigning staffing levels and ratios in favor of research.

Related to the overall staffing issue is the level of staffing and size of programme for the other palms in NIFOR's mandates. The other palm programmes, in order to be effective, must be provided with adequate levels of staffing, facilities, and other resources. If these resources are not forthcoming, again a policy decision needs to be reached as to which of the palms deserves the next priority; or whether it is more judicious at this time to concentrate on oil palm and keep NIFOR's commitment to the other commodities to the minimum.

One of the ironies at NIFOR is that in spite of the very large staff, there are many unfilled posts and many more are added each year. The staff operating expenses ratio is already ludicrously low, and there is no point in adding new posts and recruiting new people. There should be a moratorium on the filling of unfilled posts and on the creation of new ones, except in very meritorius cases, pending the outcome of the board's decision on the level of activity for the other palms.

5.5.2 Staff Expertise and Training

The Mission considers this aspect one of the strengths of NIFOR. Very few research institutes in Africa and in most of the developing world would have as high a proportion of staff with graduate training as the Institute. And the spread of disciplines is adequate, except in one or two areas.

The Mission commends management to carry on with its staff development programme. As the Nigerian universities develop competence in most disciplines, there is less need to send Nigerians abroad for their Ph.D.s, except perhaps in a few cases. The staff with master's degrees should be encouraged to complete their doctoral studies in the country but with provisions for a semester or so of pre- or post-doctoral training in an appropriate university or research laboratory abroad.

The senior staff who would be due for sabbatic leave should be given the opportunity to visit and/or spend some time in a research institution abroad to update himself/herself on the latest developments in their respective fields of science.

The few areas where the Mission believes NIFOR needs immediate beefing up are in the social sciences, biometrics, systems modelling, and end-use.

5.5.3 Appointments, Compensation, and other Conditions of Service

These personnel concerns are covered by federal civil service regulations and did not arise in our discussions with the staff. However, the Mission was fully aware of the significant adverse consequences of the recent devaluations of the Naira to actual compensations. By and large, the scientific staff were encouraged with the recent decision to align research salaries with those in the universities.

5.5.4 Tenure of Research Managers

In assessing which aspects of the university conditions of service to adopt for the research institute system, the FMST may wish to consider the university practice of fixed but renewable terms of office for academic managers. For flexibility and to guarantee periodic renewal of leadership in the institutes, there is a virtue in fixed but renewable appointments for research managers. Research managers will have the option to return to full-time research after completing a term. Exceptional managers can always be reappointed.

5.6 Financial Resources

Level of Federal Government Subventions. Federal subventions to NIFOR in 1987 were only 45% of the level in 1981. In real terms, considering the devaluation of the naira, the value that the Institute received in 1987 was much much less. The Mission understands perfectly the explanation for this severe cutback in subvention but nevertheless flags this phenomenon to call attention to its adverse consequences to the smooth functioning of research institutions like NIFOR, for in many ways much of the explanation for whatever problems NIFOR may have at present can be traced to the severe decline in resources in recent years.

The approved recurrent subvention for 1988 has been substantially increased to Naira 10 million, double that of 1987. However, much of the increase will go to personal services.

There is no fixed optimum level of research support for a commodity. The World Bank recommends that at least 1-2% of the value of the agricultural gross domestic product be spent on research[1/]. If we go by this rule of thumb, oil palm research alone should get a least Naira 16 to 32 million per annum.

For comparison purposes, the Palm Oil Research Institute of Malaysia (PORIM) spent 48 million Malaysian dollars in 1985, half of which was spent for operations. In other words, the operations expenditure of PORIM was equivalent to roughly US$ 10 million or Naira 40 million per annum. In comparison, NIFOR gets a quarter of this amount for oil palm, plus the other commodities in its mandate.

The Mission reviewed at length the operating budget projections prepared by NIFOR. Considering the work programme being endorsed and the number of qualified staff to perform these activities, the Mission believes that NIFOR should be able to operate effectively with a recurrent budget of 16 to 18 million naira p.a. at current prices during the next two years.

This estimate excludes any projected salary increases contemplated by Government and the requirements of the other palms.

1/ 1% of value of 740,000 MT of palm oil at Naira 2,000/MT, plus value of 350,000 MT of palm kernels at Naira 500/MT.

Actual Expenditures for Research. The effective amount of money that goes into research at NIFOR is relatively small. About three quarters of the budget goes to personnel and related costs. But among the regular personnel, only 42% and 17% of the senior and junior staff, respectively, are engaged in research. In comparison, 80% and 56% of the senior and junior staff at PORIM in Malaysia are directly engaged in research.

Among the operating expenses for research, 78% goes for the maintenance of the plantations in the main station and substations which are almost "fixed" costs. The supplies money at the disposal of the research divisions was only about 150,000 Naira per annum during 1983-85.

Thus the problem at NIFOR consists of not only increasing the total budget but also balancing expenditures in favor of research.

Revenue-generating Activities. The existing revenue centers include:
palm produce;
nursery seedlings;
sprouted seeds;
bottled palm wine;
processing equipment;
advisory/consultancy services.
Palm produce in terms of fresh fruit bunches are byproducts in the maintenance of the research plantations in headquarters and in the substations.

Sprouted seeds is a monopoly of NIFOR, since nobody else produces hybrid tenera in Nigeria. NIFOR supplies only part of the demand for nursery seedlings. The estates and the tree crop units in the state ministries of agriculture can grow their own seedlings from the sprouted seeds supplied by NIFOR.

Bottled palm wine and minimill processing equipment are demonstration products as far as NIFOR is concerned.

NIFOR's consultancy and advisory function with regards to Obotme and Erei estates and to other parastatals have elements of choice to them. NIFOR can decline or keep its presence at a minimum.

Thus palm produce and sprouted seeds take the nature of mandatory products, while the rest are optional. For the optional products, as suggested elsewhere, the Board has to take a policy decision as to what extent the Institute should engage in the production of these goods and services over what period of time.

Managing Revenue-generating Activities. A basic assumption to the parastatal status of the research institutes is their potential to generate revenues. Among all the institutes of FMST, NIFOR probably has the greatest potential at present to earn income from operations.

The Mission has expressed concern over the magnitude of non-research activities and the extent to which these activities drain resources and management attention from the core functions. A number of these non-research activities are not vital to the Institute and should probably be phased out over a period of time. These are major policy decisions only the Governing Board, in close consultation with the Federal Minister, can take. Whatever those activities might be, the following guidelines should apply in organizing and managing the revenue-generating activities:

1. A full personnel audit should be conducted in each of these activities to determine the minimum staffing requirements. Staff may be reduced through attrition, redeployment, and/or voluntary termination, with generous separation benefits, to the extent allowed by existing regulations.

2. There should be full accounting of all costs.

3. The activity should generate more than it costs.

4. A sunset clause should be provided for activities which are initially justified for testing and demonstration purposes.

5. Incentives should be provided to staff in the revenue-generating units, based on profitability.

In recognition of the different management needs and standards appropriate to business units and to sharpen accountability, the Mission recommends that all the revenue-generating activities be placed under the responsibility of a second deputy director. Moreover, the staff in these revenue centers should be rewarded and recognized according to profitability.

Revenue Estimates. NIFOR's revenues have been increasing steadily during the last several years. For 1988 the revenue estimates are as follows:

	AMOUNT (NAIRA)
Palm produce	1,185,000
Nursery seedlings	1,017,250
Sprouted seeds	900,000
Palm wine sales	200,000
Substations produce and services	20,000
Publications	750
Rest house	10,000
Rent	95,000
Electricity charges	8,000
Water rates	800
Investment interest	
Deposit interest	
Interest on advance	8,000
Miscellaneous sales	10,000
TOTAL (NAIRA)	3,500,000

Management should be congratulated for putting down these estimates, for by themselves they constitute a commitment. Nevertheless, there are still possibilities for improving revenues further: the present price of 30 kobo per sprouted tenera hybrid seed can be increased to 50 kobo. Second, NIFOR is probably selling its nursery seedlings at a loss. NIFOR sells at 2-2.50 Naira per seedling, while the estates which grow millions of seedlings very systematically and with mechanized irrigation facilities estimate their cost of production at 3 Naira/seedling.

NIFOR should charge standard bank interest rates on its two million naira advance to the NIFOR oil mill, in addition to pressing for revised expectations of annual dividends.

The rents, electicity, and water charges to the staff housing units are very likely heavily subsidized. These charges probably need to be readjusted by now and the proceeds plowed back into the rehabilitation of the units. In similar situations elsewhere, the tenants/residents are encouraged to advance the supplies for home repairs and the institution's service crew supplies labor. The advances are applied to future rents.

In encouraging NIFOR to generate as much income as possible, the Mission assumes that the NIFOR annual subventions would not be proportionally reduced by FMST. Otherwise, the Institutes would find the effort counter-productive, and it would revert to indifference and/or resort to subterfuge.

NIFOR Oil Mill Company. NIFOR operates a 6-ton FFB/hour oil mill at its main station to process the palm produce of its own plantation and of the growers in the surrounding areas. The oil mill was intended also partly for research and partly for training and demonstration. In 1983 the oil mill was incorporated as a limited company with the objective of operating the facility along commercial lines to thereby generate more income for NIFOR. The Mission agrees with this previous decision, as the oil mill hardly serves the purposes of research, training, and demonstration.

The oil mill has not been performing well as a business. In terms of tonnage of fruit processed, the latest figures are barely half of the produce processed in 1982-83 (Table 11). It had two profitable and two losing years during the period 1983-86, with a net after depreciation of only 151,000 naira. In terms of available funds, the oil mill has accumulated about 1 million naira. However, the oil mill has yet to pay a dividend to NIFOR.

The Mission sees no reason why the oil mill cannot be made more profitable than it has so far been. However, it is fundamental that the oil mill be allowed to operate as a profit-oriented organization and its devolution from NIFOR be expedited.

The Mission recommends the following on the NIFOR oil mill operations:

1. Separate and distinguish the memberships of the NIFOR and the oil mill boards to encourage the development of a proper business relationship between the two.

2. Discourage the secondment of NIFOR staff to the oil mill. Those who opt to stay in the oil mill should be encouraged to transfer, while those who cannot be accommodated in the oil mill should be provided generous separation benefits or reabsorbed into NIFOR.

3. The conditions of service in the oil mill should be patterned after business operations, with significant provisions for bonuses based on profitability.

4. Settle the terms of the two million naira loan from NIFOR to the oil mill. It should be advantageous to NIFOR to offer a long grace period for loan repayment, while charging the maximum interest permissible and collecting the interest semiannually.

5. All the transactions between NIFOR and the oil mill should be conducted on a business-like basis; e.g., sales of plantation produce, buy-back of palm oil for NIFOR staff, supply of water to the oil mill, share of maintenance of station facilities.

The most pressing problem to the oil mill management is the sourcing of fresh fruit bunches to process. Management should make every effort to win back their private suppliers. Likewise, the oil mill may have to put up its own water system to make it less dependent upon the Institute water system.

The Mission expects the oil mill to generate at least half a million naira for NIFOR by 1990.

Table 11: Selected Performance Indices of NIFOR Oil Mill

	FFB Processed (1000 tons)			Turnover	Profit/loss	Available 1/
	NIFOR	Other Sources	Total	(1000 Naira)	(Naira)	Fund (Naira)
1981	5.8	6.9	12.7	N.A.	N.A.	N.A.
1982	5.0	8.6	13.6	N.A.	N.A.	N.A.
1983	3.6	3.6	7.3	1,110	198	177,235
1984	6.0	2.4	8.5	2,770	308,045	548,655 2/
1985	4.8	0.9	5.7	1,737	(97,421)	144,130
1986	5.1	1.0	6.1	1,706	(59,281)	190,831
1987	4.9	0.6	5.5	N.A.		

1/ Profit/loss plus depreciation.

2/ Excludes Naira 637,160 provision for bad and doubtful debts.

Source: Audited Accounts

5.7 Research Planning, Programming, and Review

Annual Research Planning and Programming. As indicated in Chapter III, in broad form NIFOR has a research planning, programing, and review process in place. However, the process is rendered ineffective by the gross mismatch between plans and available resources. This has been self evident for some time, but somehow the system has yet to come to grips with this reality.

The problem comes to a head at the research programing and implementation stage, when programme and project leaders find out that resources are simply not available to back up approved research plans. The outcomes are vividly documented in the annual progress reports, where project leaders lament their inability to prosecute projects for lack of logistics.

Need for a Project Management and Accounting System. It is very facile to advise that management should commit funds to each of the projects at the start of the year. However, this is easier said than done. A close scrutiny of the budget should reveal that regular Government subventions, which have declined by 55% during the period 1981-87, could hardly cover the salaries, wages, and benefits of staff and the bare minimum requirements for utilities, transport, and maintenance, which management is obliged to make provisions for before anything else. Other expenditures depend upon generated incomes whose volumes and cash flow are difficult to predict with certainty. Under such conditions, management understandably proceeds conservatively, ties up a bit of resources for contingency, and releases them only as incomes are actually received towards the end of the year, by which time research will have little use for them.

In describing the above, the Mission does not in any way condone the practice but simply underscores the dilemma of management. With a little more careful planning and daring, management could perhaps program and commit minimum levels of resources to individual projects at the start of the year, but in the Mission's view the greater part of the solution must come from a conscious policy decision by the governing board, FMST, and the Nigerian Government to make objectives and available resources more coherent; i.e., increase subventions and income and/or formally down-size plans and objectives and Government's expectations of NIFOR.

The existing research programmes and projects are adequately described in terms of their scientific contents. What are urgently needed are firm commitments of resource allocation; i.e., personnel assignments, funds for travel and for purchase of supplies and services and purchase of equipment. Without the corresponding resource allocations, the programme and project leaders and division heads are unable to schedule their activities in advance with any degree of certainty.

Staff time, particularly that of the senior researchers, is a most valuable resource. The project management system should be able to capture how the research staff time is distributed among activities. The project management system should indicate how much time each individual devotes to a project.

Likewise, in order to monitor expenditures more accurately and to inject more discipline into the use of resources, it is desirable that a system of charging projects for services actually rendered by the service units be instituted.

Monitoring and Evaluation. The Mission found the capsule research outlines concise, informative, and in a format suitable for quick monitoring and evaluation. The Mission assumes that top management and the programmes do in fact use these brief outlines of programmes of work for monitoring and evaluation purposes, albeit in a less formal manner.

There has been no governing board during the last four years, and therefore the Mission has no basis for assessing how well the board performs this very important governance and management function. If the minutes of the previous board deliberations are any indication, it would appear that the previous boards have been very keen on their financial oversight and have been less concerned with programme matters.

The Mission repeats its recommentation to the incoming board to be as concerned with substantive matters of objectives, priorities, and progress, even as they scrutinize budgets and expenditures.

Development of a Strategic Long-term Plan

There are four key elements in strategic planning:

- an analysis of the present and future environment, the threats, the problems, and the opportunities;
- an assessment of the institution's past performance, its current resources, strengths, and weaknesses;
- definition of goals and design of a desired future for the institution; and
- a plan of action to attain the desired future over a specified period of time.

Part and parcel of overall strategic planning is the narrowing of broad institutional mandates into more operational statements of objectives; the setting of priorities; the development of alternative futures; the development of strategies for generating resources and laying down of target dates for completion.

The Mission appreciates the effort the management and staff have put into the development of the institution's 10-year development plan which was printed in time for the review. NIFOR has taken a most important first step in articulating its view of the future and resources required for attaining that future.

What the Mission finds missing at this stage is a sharper, more narrowly focused statement of objectives and of expected outputs. Referring back to the section on the mandate, the Mission is quite concerned over the broad liberal interpretation of NIFOR's formal mandate. While such a broad statement of objectives could be one strategy by itself, the Mission expresses its reservations over the appropriateness

of such a strategy in the light of the severe resource constraints imposed on NIFOR and the rest of the Nigerian agricultural research system at present and in the foreseeable future.

The Mission therefore recommends that management, with guidance from the new governing board, should develop a strategic long-term plan more or less building upon the present 10-year development plan but taking into account the board's policy decisions on the commodity mandate and on non-research activities.

5.8 Information, Communications, Documentation, and Data Processing

Scientific Information. The geographical isolation of NIFOR is exacerbated by the staff's lack of access to extant scientific literature. The situation of NIFOR's library is pathetic and needs immediate rehabilitation. The Mission considers the upgrading of journals and reference books in the library of utmost concern. Provisions are made in the Mission recommendations for acquisition of journals and reference books and a personal computer to facilitate better organization of the library holdings.

Agricultural Communications. NIFOR has the extension and research staff to perform these tasks, and what they need are facilities and resources. Similar provisions for upgrading of printing and production facilities are incorporated in the Mission recommendations.

Management Information. NIFOR management has put together a comprehensive human resources data base. Budget information is also available but not in the entries/format useful for research management. The Mission commends the management for the initiative and recommends that administration be provided a new computer to replace its obsolete IBM 3 system.

Data Processing. Similarly, NIFOR has managed to cope as best it could in handling the voluminous plant breeding data. The proposed systems modelling project would also require greater computing capacity. The Mission included these needs in its recommendations.

5.9 Institutional Linkages

The management and senior staff at NIFOR are fully aware of the need for linkages. The Mission is convinced that the relative lack of linkages is not due to lack of awareness or willingness but rather imposed on NIFOR for the most part by lack of resources and lack of time of senior management.

Nevertheless, the Mission would flag the following opportunities which should be pursued:

Linkages with smallholders. This could be strengthened with more farm visits by NIFOR extension staff and through on-farm research. Both of these are being planned.

Linkages with Nigerian universities and other institutions. Provisions for collaborative research projects can be provided in NIFOR's budget in order to mobilize expertise in these institutions on researchable oil palm problems; better yet, the FMST, through the Directorate for Agricultural Sciences, could perform this bridging role.

Linkages with the outside world, in particular with other oil palm research organizations. NIFOR should be allowed to provide in its budget resources for exchange of scientific staff and visits, exchange of materials, and for NIFOR's participation in international research networks.

Finally, the cultivation of external linkages is largely a function of senior management. With the proposed reinforcement of top management, the director and his/her deputies will have more time for such linkages.

5.10 Proposal for a Quick Disbursing Facility

Activities at NIFOR have slowed down quite a bit due to inoperational facilities and general lack of resources. In preparation for the major rehabilitation effort and to save time, the Mission proposes that a modest emergency fund be taken out of the overall requirements and be made available at the earliest possible time.

The following activities should get support from this emergency fund:

	Amount
Generating set	100,000
Seed production	138,000
Vehicles (mostly repair)	90,000
Journals and books	18,000
End-use research	67,000
Extension	40,000
Training abroad of key researchers	20,000
Immediate running costs	50,000
US$	523,000

The objectives are to provide electricity, mobility to the research, to provide bridging support for seed production, to get started with a new end-use programme, and to advance preparation of training and extension materials.

CHAPTER VI - SUMMARY AND MAJOR RECOMMENDATIONS

6.0 Background

From the world's leading producer and exporter of palm produce Nigeria has in recent years become a major importer. Current projections indicate a shortfall of as much as 610,000 metric tons of palm oil by 1995.

The oil palm grows in semi-wild stands on vast tracts of land in southern Nigeria. It is estimated that the semi-wild groves are equivalent to 2.4 million hectares of regularly spaced plantings. Eighty percent of Nigeria's palm oil comes from these semi-wild stands. Only 150,000 hectares are planted to high-yielding hybrids which can produce 3-5 times as much as unselected materials. In comparison, Malaysia, the current dominant producer and exporter, has all of its 1.4 million hectares of oil palm planted to hybrids.

The Nigerian Government is determined to attain self-sufficiency once more in palm oil and is taking steps to rehabilitate and further develop the country's palm oil industry. Following the very modest gains in replanting schemes in the 1960s and 1970s, the country is presently negotiating with the World Bank for a second tree crops project and with the EEC for external support.

In anticipation of stepped-up efforts to promote the industry, the Nigerian Government, through the Federal Ministry of Science and Technology and the Federal Ministry of Agriculture, Water Resources and Rural Development, commissioned the International Service for National Agricultural Research (ISNAR) to review the role of the Nigerian Institute for Oil Palm Research (NIFOR) in oil palm development, to assess its current capacity and potential, and to recommend ways and means for enabling the institute to meet present needs and anticipate further demands of the industry.

The following is the summary of the Mission's findings and major recommendations, hewing closely to its Terms of Reference.

6.1 Prospects of the Industry and the Research Challenge of NIFOR

The Mission shares the optimism of the Nigerian Government over the future of the oil palm industry in the country. The crop is adapted to local conditions, and areas suitable for its cultivation are available. Domestic demand for food purposes continues to grow at over 3% per annum, in line with natural population increase. Demand is expected to grow further as palm oil products and derivatives find niches in the market.

With attractive domestic prices and with the provision of more efficient and better distributed mini-mills and modern oil mills in the major growing areas, the country in the short run should be able to derive more oil from its semi-wild groves.

However, obviously the oil palm industry of Nigeria cannot continue to depend heavily on the semi-wild groves. As population pressure increases further, the semi-wild groves will have to give way to hybrid oil palms which produce 3-5 times more than unselected materials under proper cultivation, to other more productive food and cash crops, or some other forms of land use.

In contemplating other forms of land use, oil palm and other tree crops enjoy the advantage of being more benign to the existing environment. Because of the fragility of the soils in these areas, the periodic water deficits, and the possibility of intercropping with food crops, the oil palm stands a good chance of holding its own as a major food and cash crop of choice among farmers.

The last item is particularly important in view of the existing land tenure. Most of the land is communally owned and tilled by smallholders. Unless there are major changes in land policy, prospects for establishing large commercial estates, such as in Malaysia, are fairly limited. Thus major oil palm expansion in the future will be in the hands of smallholders who will want to grow food crops for their own needs alongside the oil palms.

Given the above scenario, the research challenge to NIFOR goes beyond the task of producing more of a commodity in short supply, as most commodity-oriented institutes perceive their mandates, but includes the following additional dimensions, namely,

- the challenge of rural employment and food production in the high-population-density areas in the south, and

- the challenge of proper, sustainable land use in a humid to sub-humid tropical environment.

As a commodity institute, NIFOR is appropriately organized for the first challenge, which is its core responsibility. The Institute has recognized the importance of the second and has initiated a farming systems approach to research. The ecological perspective has yet to influence NIFOR's research. The problem is expected to get more acute as more of the forests are cleared and brought under cultivation. However, NIFOR is only one of several actors and must collaborate with other institutions with which it must share the responsibility.

6.2 Capacity of NIFOR to Produce Improved Seeds and Seedlings, including Tissue Culture

Seed Production

NIFOR materials, like all other modern oil palm cultivars, are hybrid teneras. Under Nigerian conditions they produce 8 to 20 tons FFB/hectare/year equivalent to 2.0 to 4.5 tons palm oil/ha/year. Malaysian plantations produce as much as 25-30 tons FFB/ha/year, but rainfall is higher and more evenly distributed in Malaysia than in Nigeria.

With 1744 mother palms under seed production, NIFOR has a potential capacity to produce seven million seeds per year. This number should be adequate to establish 25,000 hectares each year.

During 1982-86, NIFOR produced an average of 4.5 millions seeds/year. However, actual deliveries were only about 2.7 million/seeds/year. Thus so far NIFOR has been able to meet industry demands. However, as soon as

the projected oil palm planting programmes get under way, NIFOR will be hard pressed to supply the sprouted seeds in the quantities and delivery dates required.

In anticipation of future needs and to even out the availability of seeds, NIFOR should have a seed storage with a capacity of at least 10 million seeds. This will enable NIFOR to keep seeds for a longer period of time without loss of germination and to build up seed supplies while demand is still low.

The entire seed production facility at the Institute needs to be rehabilitated and streamlined to better organize the flow of seeds, prevent mixtures, and minimize seed losses. The Mission considers this need of utmost priority and recommends that an early disbursing funding facility be extended to NIFOR for this purpose.

Seedling Production

The role of raising the improved seeds into seedlings in the nursery is more efficiently accomplished by the estate growers themselves or with better supervision in the nurseries of the extension service. Thus the Mission considers NIFOR's role in seedling production secondary and treats this as a revenue-generating activity.

Plant Breeding

The main breeding programme at NIFOR is appropriately designed and implemented. The modified reciprocal recurrent selection method which NIFOR adopted is perfectly suited to the allogamous nature and the desired hybrid fruit form character of the oil palm. The Mission does not contemplate any major change but recommends the following improvements:

- broaden selection criteria to include high oil extraction rate, slow vertical growth, and tolerance to fusarium wilt;
- broaden variability in the second recurrent selection cycle by introducing advanced lines developed in other countries;
- eliminate progenies with insufficient numbers of dura parents to remove bias in selection; and
- segregate and distribute seeds into families to obtain more homogeneity in the nursery and in the field.

Tissue Culture

Tissue culture is fast becoming a standard technique in crop improvement research. Its commercial application has been demonstrated for a number of crops. Its potential is very attractive, especially for a perennial monocot with no means of natural vegetative propagation, like the oil palm. Expected gains from the use of clonal materials are in the order of 20%-25%.

The testing of cloned oil palm materials is under way in a few countries. Their exponents claim that commercial plantings will become a reality in the 1990s.

As a major oil palm producer, Nigeria must acquire the capacity to clone the oil palm, both as a method of asexual propagation and as a research technique.

Nigeria can acquire the technology either by buying the technology in the market or by developing the capacity on its own, using Nigerian scientists at NIFOR and at the universities. Buying the finished technology would enable the country to immediately clone and test the best progenies and elite individuals in the NIFOR main breeding programme and thereby gain a lead time of 3 to 6 years.

However, considering the other constraints to the oil palm industry in Nigeria, the Mission is of the opinion that the immediate supply of superior cloned material is not a pressing issue and would not recommend trading long-time technological dependence for an ephemeral advantage. The Mission therefore recommends that Nigeria take the self-reliant route and mobilize its scientists at NIFOR who have had training in tissue culture abroad and its faculty in one of the universities to mount a full programme on oil palm tissue culture. To accelerate the process it should be possible to recruit an expatriate who has had extensive experience in oil palm tissue culture work, under bilateral or multi-lateral assistance.

In the short term, the Mission recommends that NIFOR be provided a modest facility capable of producing 12,000 - 15,000 plantlets a year.

The decision to build a commercial tissue culture facility can be made at a later stage.

6.3 Adequacy of Agronomic Packages for Oil Palm Production

Availability of appropriate production technology is not an immediate constraint to further oil palm development in Nigeria. The technology and practice of germinating seeds, the management of seedlings in nurseries, clearing and establishment, manuring and fertilization, weeding, pest control, and harvesting are well established. These technologies have evolved through decades of practical experience and research involving commercial companies and research institutions in Africa, Asia, Latin America, and Europe. As one of the earlier and leading research organizations in Africa, the contributions of NIFOR in this collective effort are well known.

However, not all production problems have been resolved nor will they ever be fully resolved. Research continues in all the major oil palm growing countries to attain higher levels of productivity and efficiency under their respective conditions of production.

For Nigeria the more pressing issues include the development of technology that will allow permanent, sustainable, and productive mixed cropping of oil palm with food crops for smallholders; raising oil palm productivity under conditions of prevalent water stress; and anticipating production problems associated with planned new areas of major expansion.

NIFOR is relatively well-staffed in the relevant areas of agronomy, soils, farming systems, entomology, and plant pathology. Except for farming systems, these disciplines have been traditionally strong in NIFOR. The Mission has specific recommendations on the relative priorities among research themes in each of these disciplines.

The Mission notes the progress that has been achieved by the newly organized farming systems programme. However, in order to avoid confusion the Mission recommends that farming systems be elevated as an approach to research and its implementation be largely picked up by the agronomy and socioeconomics divisions.

Moreover, the agricultural economics division should be expanded to cover other social sciences.

6.4 End-use Research and Small-scale Processing

End-use

The end-use programme at NIFOR is new, and for lack of general and specialized facilities and inexperience, little progress has been made.

The Mission is quite convinced of the opportunity for NIFOR to make a significant contribution to the downstream development of the palm oil industry in the country, and hereby sustains the decision of the previous board to develop such competence in the Institute. In developing this competence the Mission recommends that NIFOR take the following steps:

- establish close liaison with palm oil user industries to establish priorities and develop joint research and development activities;
- send NIFOR end-use scientists to selected laboratories abroad for short training opportunities in priority applications;
- recruit an experienced expatriate for brief, recurrent periods to assist in the initial formulation and implementation phase.

The Mission likewise wishes to point out that a great deal of expertise in the application of palm oil products has already been developed in other countries. NIFOR's programme should therefore focus initially on the transfer of technology and not on new or over-sophisticated developments.

Moreover, the majority of oils and fats applications are not of very high added value. Thus new complex processing technologies cannot usually be justified economically.

Based on very brief visits in a few palm oil concerns, the Mission outlined six possible areas of immediate research interest. However, they need to be further validated with more in-depth and thorough analyses of industry needs.

Design of Small-scale Processing Equipment

NIFOR has designed a mini oil mill package consisting of fruit bunch cookers, manual bunch strippers, a motorized digester, an imported hydraulic press, and a clarification unit. The system has a rated capacity of ¼ ton FFB/hr but could handle as much as ½ ton FFB/hr with additional fruit bunch cookers.

The Mission observed one unit in operation at NIFOR and a second one in a village nearby and was impressed with the system's practicality and robustness. The only weak element appears to be the imported hydraulic system whose seals become defective after about two years of operation, resulting in incomplete extraction of oil.

Some 30 of these NIFOR mini mills have been produced, and NIFOR continues to fabricate the system at the rate of 10 orders a year.

The system undoubtedly would undergo further improvements as people gain experience with the mini mill. What is important at this stage is the popularization and further commercialization of the equipment. The system ought to go into the hands of private fabricators and manufacturers who would aggressively market the product.

The Institute has also started to design small machinery and equipment for the various steps in the processing and handling of the palm kernels. The Mission considers the effort in cleaning, separation, and sorting appropriate but doubts the utility of small-scale crushers and kernel processors. In addition to practical design difficulties, there are five large modern extraction plants in Nigeria which are operating below capacity for lack of kernels.

Moreover, the Institute justifiably takes pride in its institute-designed palm wine bottling equipment. Palm wine is a very popular drink in the countryside, but the liquid ferments and loses its quality very rapidly under local conditions. The NIFOR process pasteurizes the drink in bottles and results in a product with sugar and alcohol contents of 8% and 2% respectively. The product apparently is highly acceptable, as NIFOR has no problem disposing the daily production from its palm wine bottling unit in Benin headquarters.

The Mission considers design and development of prototypes as proper functions of a research institute like NIFOR. The ultimate objective is the popularization and commercialization of the equipment. The NIFOR mini mill and the NIFOR palm wine bottling technologies are sufficiently mature and NIFOR should take the necessary steps to share the designs with private fabricators and commercial manufacturers on such terms as the governing board may deem appropriate.

6.5 Research-Extension and Other Linkages

Extension

The future expansion of the oil palm industry will rely heavily on smallholder producers. Thus in the proposed second World Bank-assisted tree crops projects, 80 tree crop extension units (TCUs) are proposed to

be organized in different local government administrations throughout the oil palm belt. More TCUs are contemplated to be established as the programme expands.

NIFOR is expected to play a key role in the training of extension agents and their support staff, in the preparation and development of extension messages, and in providing technical backstopping to the state ministries of agriculture and the Monitoring and Evaluation Unit of the Federal Department of Agriculture.

The Mission therefore envisions a much expanded role for NIFOR in the area of extension and technology transfer. Our recommendations include:

1. appointment of subject-matter specialists in the relevant areas of agronomy, crop protection, socioeconomics, and processing to strengthen the extension program;

2. organization of a training unit;

3. decentralization of part of the extension activities to the Abak substation for the delta area;

4. establishment of on-farm type of research/demonstration to bring NIFOR closer to the extension agents and farmers; and

5. improvement of printing and production facilities in its agricultural communications unit.

Other Linkages

NIFOR's linkages with the FMST and FMAWRRD appear adequate. NIFOR perhaps should participate more actively in the National Tree Crops Committee convened by the Federal Department of Agriculture. The liaison between NIFOR and the Monitoring and Evaluation Unit of the FDA is expected to get even closer when the new oil palm schemes are put into stream.

However, NIFOR's association with the universities and other research institutions is weak. There is expertise, particularly in some of the universities, which could be mobilized for oil palm research. One way of forging these linkages is through collaborative contract research under NIFOR's budget. Alternatively, the FMST, through the Directorate of Agricultural Sciences, may wish to serve this bridging role to bring the institutes of the FMST and selected Nigerian universities together in national task forces to resolve major problems.

Reference has been made earlier to the need for more liaison with end-user industries.

NIFOR could also benefit a lot from a closer association with other country institutions engaged in oil palm research by way of staff exchanges, exchange of genetic materials and information, and participation in research networks. Some of these initiatives would require foreign exchange, but others simply require contact.

The development of external linkages is a major responsibility of top management. The Mission noted that top management is heavily weighted down by day-to-day management issues. The Mission is recommending a change in the top management structure to allow more time for strategic issues and for such other matters as external linkages and resource generation.

6.6 Physical Infrastructure, Plant, and Equipment Requirements

As experiment stations go, NIFOR should feel privileged for inheriting its present infrastructure. The 1700-hectare farm is adequate for its purposes, tenure is more or less secure, and existing facilities are functional and serviceable. The grounds, the plantations, the road network, and the surroundings appear to be well maintained, giving the campus a generally pleasant atmosphere.

However, since many of the buildings are getting old, a lot of repairs are required. Almost all the existing equipment and moving stock are dated and ready for replacement. The utilities, which NIFOR is forced to maintain on its own because of its previous isolation, are run down. It was clear to the Mission that an almost total programme of re-equipment is required.

Several of the laboratories and offices are already congested. The administrative offices are scattered all over and need to be brought together to facilitate the conducting of business. Moreover, there is a need for a central analytical laboratory to provide routine service to the research divisions and to house expensive and sophisticated equipment.

The Mission therefore recommends the construction of a two-storey building which will accommodate the administration and library on the second floor and new laboratories on the ground floor.

The NIFOR management and senior staff prepared very detailed lists of their infrastructure, equipment, and other facilities requirements. In preparing its recommendations, the Mission considered the immediate research work programmes being contemplated and the availability of staff who can use the facilities adequately. The following list can only accommodate part of their perceived requirements, but in the Mission's opinion is sufficient to allow the Institute to operate effectively. A provision for training is included in this summary.

The Mission's recommendations for physical infrastructure, plant, and equipment are summarized as follows:

	Amount (US$)
Laboratories	1,015,260
Seed production, plant breeding, tissue culture	472,450
Other support units	604,960
Vehicles	768,000
Utilities	1,350,000
New Central Laboratory/Administration	450,000
Improvement of other facilities at main station	520,000
Improvement of facilities at Abak substation	330,000
Training component	300,000
GRAND TOTAL	5,810,670

6.7 Organization and Management Issues

The Policy Environment for Oil Palm Research

The Nigerian economy is like a glass partly filled with water: it is both half-empty and half-full. The same could be said for agriculture and for the science and technology sectors and general environment for agricultural research in Nigeria.

Without discounting the difficulties that still lie ahead, the Mission looks at the horizon with the latter prism for the following reasons:

1. Nigeria's economy seems to have turned around.

2. Agriculture appears to be benefitting from the economic and fiscal adjustments that the present Government has set in place.

3. The domestic demand for palm oil continues to increase at the rate of at least 3% per annum; the gap between production and demand continues to widen and the Government appears intent to attain self-sufficiency in the commodity.

4. The Government has recently adopted a white paper on science and technology policy.

5. Conditions of service for scientists have been upgraded to those of the faculty in the universities.

6. External donors appear willing to support the country's drive for self-sufficiency in the commodity.

Organization and Management: An Overview

NIFOR derives much of its institutional strength from four major factors:

- a highly trained scientific staff;
- a well-established experiment station infrastructure with functional facilities;
- a tradition of scholarship and relevant research; and
- operating management processes in place.

The Institute's scientific staff are very well-trained. Ninety-six percent of the researchers at the Institute have advanced degrees from reputable academic institutions in Nigeria and abroad. The scientific staff possess the appropriate competencies in the major fields of agricultural science relevant to the Institute's mandate. And they are backstopped by a sufficient cadre of agricultural technicians, and laboratory, clerical, and administrative staff with appropriate educational backgrounds and training.

NIFOR has a large, well-established main experiment station at Benin which is adequate for its purposes and endowed with functional, albeit ageing, facilities.

The Institute has a tradition of scholarship and relevant research. Its previous contribution to oil palm technology is widely recognized. NIFOR's tenera hybrids are highly regarded locally.

Finally, being part of the Nigerian Federal Civil Service, fiscal, personnel, and other operating management processes are more or less in place.

On the debit side, NIFOR has its share of shortcomings and liabilities, namely:

- an ageing infrastructure;
- acute shortage of operating funds;
- relative isolation;
- lack of manpower and/or experience in certain essential, highly specialized fields;
- heavy burden of providing social services to its staff, dependents, and the community around its main station;
- overcommitment to non-research functions; and
- eroding staff benefits (and presumably morale) which is not unique to NIFOR.

As usual, many of these liabilities can be mitigated by more generous resources - both operating and capital. However, that conclusion is an oversimplification, since the Institute for the past few years has been receiving about 10 million naira per annum - equivalent to US$2.0-2.5 million p.a.

While arguing very strongly for the need for additional resources, the Mission nevertheless came to the major conclusion that NIFOR's present difficulties trace back fundamentally to a gross mismatch between objectives and available resources and the inability of the system to come to grips with this reality.

Need for a Narrower Operational Definition of the Mandate

NIFOR is responsible for oil palm, raphia, coconut, and date. The Institute now and in the near future simply does not have the resources to adequately address all the research needs of these four crops. Moreover, it is quite obvious that these commodities' current and potential contributions to Nigeria's well-being are nowhere equal.

In the light of the above, the governing board and FMST must resolve what are its expectations of NIFOR and proceed to formalize these with a narrower operational definition of the mandate.

Overcommitment to Non-Research Functions. Only 31% of NIFOR's staff are directly assigned to the research programmes (compared with 60% in an institute with a similar mandate - PORIM of Malaysia). The rest are assigned to administrative, research support, community services, and revenue-generating activities.

These other activities drain resources and draw valuable management time away from the core functions of research, extension, and training.

The Mission understands the background to these extra commitments and fully appreciates their humanitarian and political implications. Initially these non-research activities can be made more efficient and the redundant staff reassigned to other units, preferably to the core functions. Similarly, the income-generating units can be made to yield more revenues to support NIFOR.

However, the fact remains that NIFOR is far too large for its core functions of research, extension, and training. The governing board and FMST must resolve which activities to keep at NIFOR and which to divest and/or pare down significantly in the interest of the long-term health of the Institute.

Governance. The Mission notes favorably the relative autonomy that NIFOR enjoys from the supervising ministry. A lot of initiative rests with the governing board, and its vital that the members thereof be selected very carefully to bring wisdom and vision in the deliberations of the board.

In the choice of board members, the Mission considers the following personal qualifications very important: familiarity with the needs of producers and consumers, an appreciation and respect for the scientific process, management and business expertise, and a broad understanding of the socioeconomic and political context in which NIFOR operates. The above qualifications are self-evident, but the Mission nevertheless wishes to stress them in the light of unsatisfactory experiences in the performance of some previous governing boards at NIFOR and elsewhere.

The Mission had some ideas on the composition of ex-officio membership of the governing board. They turned out not to be too different from the guidelines observed by FMST in the appointment of the new board, and so this does not appear to be a significant issue at this stage.

Structure and Organization

In order to give more time to the Director to attend to strategic matters and to properly integrate, coordinate, and control the functional areas of research, services, and revenue generation, and administration at the institute level, the Mission recommends that he be assisted by a deputy director for each of the first two areas and an assistant director for administration and finance.

The Mission supports the previous decision to establish research programmes over the old discipline divisions for better integration and coordination. However, the Mission would discourage the management from totally emasculating the discipline divisions.

The Mission recommends that a client-contractor relationship be established between the programmes and the divisions. The programmes contract research which the discipline divisions implement. The programmes will essentially have staff functions but will have substantial control over funds. The divisions, on the other hand, will have line functions and will have administrative supervision of staff and facilities in the divisions. The recruitment and promotion of scientific staff, however, will be a joint responsibility of the appropriate programme leaders and division heads.

The above applies largely to the commodity programmes. The End-use and Extension programmes, while drawing upon the divisions for part of their requirements, will have their own staff and facilities and will operate essentially as line units.

The Mission will retain the existing research programmes, except for the Farming Systems Programme, which the Mission proposes to elevate as an institutional approach to research. In order to avoid confusion and uncertainty, the Farming Systems Programme should cease to exist as such, and its implementing research taken up by the Agronomy Division and an expanded Socioeconomics Division.

The Mission recommends rationalizing the scientific divisions as follows:

Agronomy (and Farming Systems)
Soils and Plant Nutrition (old Chemistry)
Plant Breeding (including Statistics)
Plant Physiology (including Tissue Culture)
Entomology
Plant Pathology
Socioeconomics

Part of the old Biochemistry Division and the Agricultural Engineering Division will constitute the core of the new End-use Programme.

All routine chemical analyses will be performed by the Central Analytical Laboratory. The Central Laboatory will likewise house all major pieces of sensitive equipment which are used by all divisions.

Human Resources. In spite of the heavy retrenchments in 1984 and 1985, NIFOR still has a very large staff. In hindsight, the Mission believes the cuts should have gone further. We are not at all convinced that all the current personnel are necessary. Based on a personal audit of the different units, those who are considered redundant should be reassigned to the core functions of research, extension, and training to improve the balance in favor of the core functions. Those who cannot be accommodated should be encouraged to retire with generous separation benefits.

In the meantime, there ought to be a moratorium on the filling of authorized posts and on the creation of new ones, save for very exceptional instances, such as the recruitment of social scientists to the Socioeconomics Division. Other staff needs should be met by reassignment and retraining.

The scientific staff development programme should continue to encourage those who are qualified to proceed for higher degrees. Whenever possible, the staff should be encouraged to study for their doctoral degrees in local universities, with provisions for brief pre- or post-doctoral experiences abroad. Some of the senior staff should be eligible for sabbatic or post-doctoral studies. Some retraining of staff is indicated for biometrics, plant growth modelling, and end-use research.

Financial Resources. Between 1981 and 1987, Government subventions to NIFOR have declined by 55%. In real terms, the decrease has been much more because of the devaluation.

The approved recurrent subvention for 1988 was doubled to 10 million naira from the 1987 base. However, much of the increase will go to personal services.

In comparison, PORIM in Malaysia spent the equivalent of more than 40 million naira in 1985 for operations. Thus PORIM spent four times more than NIFOR, which has yet to share its 10 million naira budget with the other palms in its mandate.

There is no fixed optimum level of research support for a commodity. The World Bank recommends that one to two percent of the gross domestic product of agriculture be devoted to research. If we go by this rule of thumb, oil palm research in Nigeria should get 16 to 32 million naira per annum.

The point being made is that Federal Government subventions to NIFOR have been grossly inadequate.

Based on the work programme being endorsed and the number of qualified researchers to perform it, the Mission believes that NIFOR should be able to operate effectively with 16-18 million naira per annum during the next two years. This does not include any salary increases being contemplated by Government and the requirements of the other palms in NIFOR's mandate.

NIFOR's financial problems are compounded by the relatively low proportion of its budget devoted to research per se. Actual expenditures for research were not readily available, but only 31% of the regular staff are assigned to the research programmes. Thus the problem of NIFOR consists not only of low gross total expenditures but also of the high proportion of expenditures devoted to non-research functions.

NIFOR's operating incomes have been increasing steadily during the last few years. For 1988 the estimated revenue is 3.5 million naira. The Mission believes that revenues can be improved further by raising prices of sprouted seeds and seedlings to more realistic levels.

The third major potential source of income is the NIFOR oil mill. The devolution of the oil mill from NIFOR should be accelerated, and a board of directors distinct from that of the NIFOR board should be appointed. The NIFOR oil mill should be operated more on a business basis. For its part, NIFOR should insist that interest be paid on its advance to the mill and annual dividends be declared and paid.

Finally, the Mission assumes that federal subventions will not be reduced proportionately, as institutes like NIFOR enhance their ability to generate income. NIFOR's needs are far more than the minimum suggested in the previous paragraphs. Otherwise, this will be a disincentive to generate revenues and encourage management to indulge in subterfuge.

Need for a Project Management and Accounting System. The research planning, programming, and review process in the Institute is rendered ineffective by the gross mismatch between objectives and available resources. It is very self-evident, but somehow the system is unable to come to grips with this reality.

It is hoped that new resources will be brought forward by fresh federal subventions and additional operating incomes. In any case, effective research cannot go on without resources. If additional resources are not forthcoming or resources cannot be diverted from other non-research functions, NIFOR should drop the charade of approved projects without budgets and proceed to programme only the few key research projects that can be supported by resources. The Institute is advised to install a project management and accounting system in order to monitor expenditures more closely and to inject discipline and accountability in the utilization of these resources by the responsible programme and project leaders and division heads.

6.8 Proposal for a Quick-disbursing Facility

The Institute needs an emergency package in the amount of US$523,000 to get things moving again while waiting for the main tree crops project to get started. This amount will be used to purchase a new generating set, rehabilitate the seed production facility, repair vehicles to provide mobility to researchers, advance preparation of training and extension materials, and start the end-use programme.

Annex I

REVIEW OF THE NIGERIAN INSTITUTE FOR OIL PALM RESEARCH (NIFOR)
Mission Members

1. Kurt G. BERGER

B.Sc. Natural Sciences, Cambridge; 34 years experience in private-sector food research as Group Research Manager, Central Research Laboratories, Lyons Group, London, on use of oils and fats in foods; major role in the organization of chemical research and technical services in the Palm Oil Research Institute of Malaysia as Special Adviser to Director General and Director for Technical Advisory Services (1978-86); major scientific contributions in palm oil chemistry and utilization.

2. Johnson A. EKPERE

Ph.D., Wisconsin, Professor of Agricultural Extension, and Head of Department, Ibadan; field experience as agricultural extension officer Bendel State; 48 publications on agricultural extension and community development; consultancies with Nigerian Government and FAO on agricultural development projects.

3. Jan Dirk FERWERDA

Dr. Agric. Sc., Wageningen; Professor of Tropical Crop Science, Wageningen; former Director of Research, Unilever Plantations, Zaire; major scientific contributions in oil palm ecology, physiology, and agronomy; consultancies in Malawi, Indonesia, Thailand, Sri Lanka, Vietnam, Philippines, Brazil, Peru, Surinam, Cameroon, Nigeria, Tanzania, Australia, Kiribati, Palau, Micronesia, Vanuatu; study tours and missions in 40 countries of the humid and sub-humid tropics.

4. M. O. KAYODE

Ph.D., Ibadan; Professor of Management and Industrial Economics, Ibadan; Director of University Consultancy Services Unit; Chairman and/or member of various management and planning development committees in Nigeria; extensive journal and book contributions in management and planning of public enterprises.

5. Jacques MEUNIER

Dipl. Agronomy, Montpellier; Agronomist and Geneticist, IRHO; field experience in palm oil breeding and agronomy in Ivory Coast (6 years); 27 publications in "oleagineux" journal; consultancies and missions in oil palm and coconut development in Benin, Cameroon, Ivory Coast, Nigeria, Indonesia, Malaysia, Brazil, Colombia, Costa Rica, Dominican Republic, Ecuador, Honduras, Nicaragua, Panama, Surinam, and Venezuela.

6. Emil Q. JAVIER, Head of Mission

Ph.D., Cornell; Professor of Agronomy, University of Philippines at Los Baños. Previous positions in The Philippines include Minister of Science and Technology; Chancellor, University of the Philippines, Los Baños; Director, Institute of Plant Breeding; Director, National Institute of Biotechnology; Vice Chairman, TAC/CGIAR 1981-1986; presently Senior Research Fellow, ISNAR, The Hague, Netherlands.

ITINERARY - NIFOR REVIEW MISSION

February - March 1988

7th Arrival. Mission Briefing

8th Visit with Federal Ministry of Science and Technology
- Mr. U. Asielue, Secretary for Finance and Administration
- Mr. Abdullahi, Director, Projects and Planning Department
- Mr. Nwalusi

Visit with World Bank Mission, Lagos
- Mr. Tariq Husain, Chief of Mission

9th Visit with Federal Ministry of Science and Technology
- Call on the Honorable Minister for Science and Technology, Prof. E.U. Emovon

Visit with Federal Department of Agriculture
- Mr. O. Phillips, Asst. Director, FDA

Visit with Federal Ministry of National Planning
- Mr. C.C. Chukwura, Asst. Director of Planning (Agriculture)
- Mr. Alabi, Director, Data Bank (formerly Director of Macro Planning)
- Director of Budget

Visit to Seward Co., Ikeja
- Mr. S.O. Johnson, Development Manager
- Mr. C.I. Uhunmwangho, Gen. Technical Manager

Visit to Paterson Zochonis, Ikoyi
- Mr. G. Vassiloulis, Managing Director

10th Depart for NIFOR Benin
Review of NIFOR documents

11th Visit with NIFOR
- Discussions with Director D. Ataga and NIFOR Senior Staff

12th Visit with FDA Monitoring and Evaluation Unit, Benin
- Discussions with Mr. Mike Ejemba, Head, and MEU Staff

Visit with Bendel State Ministry of Agriculture and Natural Resources, Benin
- Mr. E.A. Nmamdi, Gen. Manager, and Extension Staff

Visit to small farms and mini-mill at Ogharieife

13th Continuation of discussions with NIFOR individual senior staff

TEAM A (J. Ekpere, J. Ferwerda, and E. Javier)

14th Departure for Port Harcourt

15th Visit to RISONPALM Limited, Port Harcourt Headquarters.
- Mr. A.I. Uchendu, General Manager

Visit to Ubima Estate, RISONPALM
- Mr. G.O. Omereji, Estate Manager

Visit to Elele Estate
- Mr. J.J. Mansholt, Project Manager
- Mr. C. Mubana, Asst. Agronomist

16th Visit to ADAPALM Ohaji Estate
- Mr. S.I. Anumudu, Estate Manager

Visit with Imo State Ministry of Agricultural Natural Resources, Owerri
- Mr. Azubike, Deputy Manager Smallholder Unit

Departure for Calabar

17th Visit with Cross River State Ministry of Agriculture and Natural Resources, Calabar
- Mr. E. Eni, Chief Agricultural Officer
- Mr. A. Duke, Oil Palm Unit Head

Visit to Marimore Farm and small-holder farms around Calabar

18th Visit to NIFOR Abak Station
- Mr. F.O. Ede, In Charge and Staff

TEAM B (K. Berger, M. Kayode, and J. Meunier)

15th Visit to Aden Estate
- Mr. Fitzpatrick, Manager SOCFINCO

Visit to Okomu Oil Palm Co.
- Mr. J. Van Gysel, General Manager

16th Continuation of discussions with individual NIFOR senior staff

17th Visit to Nsukwa Oil Palm Co.
- Mr. Thomas Isharo, Estate Manager

Visit to Presco Oil Co.
- Mr. R.C. Dutt

18th Visit to Edewor Vegetable Oil Co.
- Mr. R.A. Inaba
- Mr. R.O. Adigbo

Visit to Okhuo Oil Palm Co.
- Mr. T.E. Agbudu, Mill Supervisor

WHOLE TEAM AT NIFOR HEADQUARTERS

19th Continuation of discussions with individual NIFOR senior staff

20th Team discussion and comparison of notes
Planning of next activities

21st Writing up of preliminary notes

22nd Continuation of discussions with individual NIFOR senior staff

23rd Continuation of discussions with individual NIFOR senior staff

Visit to Rubber Research Institute of Nigeria (E. Javier and J. Ekpere)
- Dr. E.K. Okaisabor, Director RRIN

Visit to University of Benin (E. Javier and J. Ekpere)
- Dr. Grace Alele Williams, Vice Chanceller
- Dr. P. Egharevba, Dean, Faculty of Agriculture, and Staff

Departure for Lagos (K. Berger)

24th Discussions with Director Ataga of mission; preliminary assessment and recommendations
Discussion with NIFOR senior staff of mission; preliminary assessments and recommendations

Proceed to Lagos

Visit to Cadbury Nigeria Ltd. (K. Berger)
- Dr. Teju Bogunjoko, Tech. Manager
- Miss Yetunde Benson, Lab. Manager

25th Pre-departure briefing of mission; preliminary assessment and recommendations, with Federal Ministry of Science and Technology
- Dr. S. Adetunji, Director, Agricultural Sciences
- Dr. O. Odegbaro, Asst. Director

Pre-departure briefing of mission preliminary assessment and recommendations, Federal Department of Agriculture
- Mr. I. Eleje, Director, and Senior Staff

Dialogue with World Bank Oil Palm Project Appraisal Mission
- Mr. S. Singh and colleagues

Departure for IITA, Ibadan (J. Ferwerda)

26th Further Discussions with World Bank Staff (E. Javier and J. Meunier)

- Mr. Mohsin Alikhan, Senior Operations Officer, WB Lagos
- Mr. Surjit Singh, Leader, Oil Palm Project Appraisal Mission

Visit with Farming Systems Programme, IITA, Ibadan (J. Ferwerda)

- Dr. T.L. Lawson (Agroclimatology)
- Dr. B.T. Kang (Soil Science)
- Dr. I.O. Akobundu (Weed Science)
- Dr. H.J.W. Mutsaers (Agronomy)
- Dr. K. Mulongoy (Microbiology)

27th Departure for The Hague

28 February to 12 March Writing of Report at ISNAR Headquarters, The Hague

ANNEX II - BREEDING AND SELECTION, SEED PRODUCTION, AND TISSUE CULTURE RESEARCH AT NIFOR

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Annex II

BREEDING AND SELECTION, SEED PRODUCTION, AND TISSUE CULTURE RESEARCH AT NIFOR

1. BREEDING AND SELECTION

1.0 Introduction

As in other crops, oil palm breeding is aimed at increasing the total potential income a farmer can get from his crop per unit area per unit time. This is achieved, in conventional breeding, through the directed manipulation of numerous characters towards increased yield in terms of fresh fruit bunches (FFB) and oil per hectare, reduced cost of production, better oil quality and adaptability to the environment.

In the following pages we shall review the current status of oil palm breeding at NIFOR, and then make a critical examination of the programmes before suggesting some modifications.

1.1 Current Status of Oil Palm Breeding at NIFOR

Background (see also Note I). Oil palm breeding at NIFOR started in 1949. The first programme was rather complicated and could not be properly realized. Nevertheless, it had the advantage of supplying the Institute with good tenera palms which could be used as a basis for further work.

The main breeding programme was established in the late fifties. The breeding method adopted was the so-called "modified reciprocal recurrent selection" (RRS), as described by SPARNAAIJ, MENENDEZ and BLAAK (WAIFOR, seventh annual report and journal of WAIFOR. Oct 1963) and consisted of:

a) Progeny trials comparing DxT, TxD and TxT crosses[1/]

b) DxD and TxT crosses and selfings using the same parents as in the progeny tests. These crosses allow the reproduction of the parents of the best crosses selected from the progeny tests, and are used as a new improved population for the next breeding cycle.

The first trials were planted in 1959. However, for a number of reasons (among them the civil war) this programme was not fully carried out and exploited until 1975 when a team from U.K. evaluated the programme.

The U.K. team of J.M. Ross and H.J. West made a thorough analysis of 426 progenies in 41 trials. They studied the inheritance of most quantitative characteristics, and estimated the heritabilities and breeding values of the parents. They proposed to resume the RRS scheme by initiating a second cycle using 13 teneras and 13 duras as parents in order to create 30 TxT, 30 DxD and 45 TxT progenies.

1/ D = dura, T = tenera, refer to the varieties of oil palm.

Unfortunately, this period was followed by a phase of instability due to changes in leadership in the breeding programme and misunderstandings about the U.K. report. It was not before 1982, when Dr. (Mrs.) C.O. OKWUAGWU returned from United States that the proposed programme could be implemented.

Current Breeding Programme. The breeding programme at NIFOR is subdivided into six projects (17 experiments), to which we must add three projects in cooperation with other divisions (physiology and plant protection).

Project 1: Main breeding programme. The main objective of this project is to improve the yield of the oil palm (precocity, FFB, oil-to-bunch ratio, total oil yield per hectare). Its design follows the reciprocal recurrent selection method. It involves:

- 3 DxD, 4 DxD, and 1 TxT (field 28.3A and 28.3B) planted in 1981 and referred as population I of the second cycle.

- 60 hectares of DxD, DxT, and TxT crosses field planted in 1983-84 (fields 28/6.7.8 and 38-1 to 6), known as population II of the second cycle. Selfings of the parents were planted in 1985 (field 37-1).

- 210 DxD, DxT, and TxT crosses belonging to population III of the second cycle. About 75% of these crosses were field planted in 1987, the balance being expected for 1988.

This project also includes an experiment of continuous inbreeding of the oil palm and a project for a direct evaluation of selection progress.

Project 2: An evaluation of the gene pool collection planted in experiments 45-1 and 28-1 (1973 collection in semi-wild groves in Nigeria and E. oleifera from South America).

Project 3: Breeding for short-stemmed palms. It involves assessment and use of introduced dwarf palms (Dumpy from Malaysia, Pobe from Benin), indigenous short-stem materials and interspecific hybridization with the American species E. oleifera.

Project 4: Mutation breeding in oil palm. Evaluation of palms obtained after mutagenic treatment. The first generation was planted in 1980 (fields 28-1 and 61). A second generation was planted in 1986-87 (fields 37-4 and 5).

Project 5: A genetic study of the inheritance of sterility in the pisifera forms of oil palm.

Project 6: Tissue culture in oil palm. Some preliminary results have been obtained, but this programme has been totally hampered so far by the absence of equipment.

Project 7: Breeding for drought resistance. The research in this area is mainly conducted by the physiology division in collaboration with the breeding division. The programme consists of screening advanced progenies using physiological tests such as: germination under low osmotic potential, heat stability, water-soluble metabolite accumulation.

Project 9: A study of oil composition among the NIFOR oil palm populations in order to improve unsaturation of the oil.

Project 16: Breeding for resistance to vascular wilt disease (*Fusarium oxysporium*). This research is managed by the Pathology Division. So far 768 progenies have been screened for tolerance using the Prendergast method of inoculation. Among them, 357 were recorded as highly tolerant.

1.2 Evaluation of the Breeding Programme

The objectives of the programme are well defined. Breeding for high yield, slow vertical growth, oil unsaturation, resistance to fusarium wilt, and drought tolerance are obviously the main factors relevant to the oil palm industry. Nevertheless, there is a need for a better evaluation of these objectives in terms of priority and complementarity. Due to the administrative separation into projects, each programme is carried out almost independently from other projects.

The methodology used for the main breeding programme (RRS) is the most efficient for improving an allogamous plant like the oil palm. This program, delayed for quite a long time, has been reactivated, thanks to Dr. Okwuagwu. There was not enough time to check into details of the complementarity of all crosses, but in relation with the material currently available for NIFOR, the main breeding programme appears satisfactory, both in its conception and in its size.

An attempt should be made to introduce advanced materials selected by other oil palm-breeding organizations. Their introgession into the second cycle of RRS would enlarge the genetic variability and thus increase the potential for progress.

More specific programmes need to be formulated in their priorities, objectives, and designs.

The programme on *E. oleifera* and interspecific hybrids must be reassessed. All the work carried out is based on two palms (one from Brazil 1954, one from Panama 1959). The genetic base of this breeding programme is too narrow. Introduction of *E. oleifera* germplasm from Central and South America is a prerequisite to any programme. The breeding design should be thoroughly studied and planned before making new crosses.

Multilocational trials with this kind of material will not be very useful, as F_1s and F_2s on backcrosses have no agronomic value.

Some programmes have to be strongly reinforced. This is the case for project no. 16: breeding for tolerance to fusarium vascular wilt. Although of relatively low economic significance at present, this disease is likely to become one of the most serious problems in oil palm replantings. More emphasis should be given to better understanding of the biology of the fungus, higher screening capacity, and field trials.

Other programmes should receive second priority or should be reexamined in connection with other disciplines. For example, mutation breeding is unlikely to yield practical results. Such a technique

usually requires considerable screening among thousands of individuals. The probability of favorable events is rather low and introgression of interesting gene combinations will require multiple generations.

Breeding for drought resistance seems to be a very difficult task in the oil palm due to extremely complex interactions between water stress, floral initiation, bunch yield, crop management, and cultural practices. The work carried out at NIFOR seems to ignore recent results obtained elsewhere, particularly in P. Rep. of BENIN - Pobe Station - where it has been shown that physiological tests, such as germination under various osmotic pressures, chlorophyl stability, proline accumulation, etc. were able to discriminate among progenies but were not correlated with drought tolerance in the field.

1.3 The Main Limitations

The scientific staff of the breeding division is adequate, dedicated and well-trained. However, one of the breeders should perhaps specialize in quantitative genetics. The main programme is scientifically sound. Thus the main limitations in the implementation appear to be:

Lack of Appropriate Facilities. The constant failure of power supply renders most research activity almost impossible. Materials and equipment have not been replaced or repaired for the last 20 years. They must be completely renewed. The division needs scales, ovens, deep freezers, refrigerators, soxhlets, microscopes, isolation boxes, etc. Some laboratories are to be improved (air-conditioning).

Isolation from the Scientific Community. No textbooks have been acquired since 1982. Almost no scientific reviews/journals were received in the same period.

No cooperation with other institutes working in the same region on the same problems. NIFOR has very little or no participation at all in regional research networks. E.E.C., for instance, is funding research networks. Among the programmes proposed for the oil palm are: water management and drought tolerance, soil fertility, biology and control of fusarium in West Africa.

Very little contact with other scientists in the same discipline within Nigeria (universities) or outside Nigeria. Visits to foreign research centers, attending conferences/workshops are very limited.

This isolation, both geographic and scientific, leads to lack of awareness of results obtained in other centers and unintended duplication of experiments.

Need for Better Planning of Research Activities. There is a need for better planning of programmes on a medium-term basis (five years) in terms of priorities, objectives, budget.

There is also a need for a redistribution of tasks among services or divisions. The yield data from breeding experiments should be recorded and handled by the breeding division prior to statistical analysis. Data processing and retrieval should be modernized in coordination with the statistics-computer division.

1.4 Recommendations

Following are our recommendations on various aspects of the breeding programme:

Research Organization. A five-year research programme for breeding should be spelled out with the following suggested priorities:

- The main breeding programme must be given first priority. Along with this programme are attached the short-stem programme and the oil quality programme.

- The interspecific hybrid programme should also receive first priority (new introductions and planning of new experiments).

- The fusarium wilt programme must be strongly reinforced. This includes the expansion of screening facilities in Adjagbodudu (ex Cowan estate). Most of the individual progenies from the extension work seed (E.W.S.) programme should be screened for fusarium wilt tolerance (250-300 progenies per year as a minimum). Field experiments should be planted on infected sites to check field tolerance.

- Other programmes have secondary priority. The mutation breeding programme should be kept to a minimum and eventually phased out.

This medium-term plan should enable the formulation of a yearly budget, including:

- number and cost of pollinations;

- field-trial planting (30 to 50 hectares/year seems a reasonable target);

- number and cost of individual palm recording and bunch analysis.

Facilities and Equipment (see also Note II). The basic equipment normally in use in a breeding division have to be almost entirely replaced. This includes:

- Pollen collection and storage facilities:
  1 vacuum pump, isolation boxes (locally manufactured)
  1 deep freezer, 1 refrigerator, sieves, glassware
  1 incubator

- Pollination facilities: provision for pollination bags (two-year period), local manufacture of fixed iron ladders, portable ladders.

- Bunch analysis equipment:
  2 large ventilation ovens, 1 Berkel scale (50kg), 10 full electrical soxhlets and 3 gas soxhlets, supplies.

- The pollen processing laboratory and the oil analysis laboratory must be air-conditioned.

New equipment is to be purchased to modernize or start new research. This includes:

- 1 micro computer for yield and bunch analysis, data inputting, calculators;

- 1 electrophoresis system.

Training, Documentation, Cooperation. One of the breeders should be retrained in quantitative genetics. Another one in oil palm electrophoresis techniques.

A few up-to-date scientific textbooks have to be purchased by the library. There ought to be permanent subscriptions to scientific journals, such as: Crop Science, Euphytica, Theoretical and Applied Genetics (TAG) Oleagineux, PORIM Bulletin.

We suggest that a specialist in oil palm breeding pay a yearly fifteen-day visit to NIFOR to closely examine the breeding programme and to discuss new orientations. We strongly recommend to make a provision to allow one breeder to visit other stations abroad working on oil palm. Every year one different breeder could select one or two centers to study a specific field for two to four weeks.

Participation in congresses, conferences, and workshops, within and outside Nigeria, should be encouraged.

2. SEED PRODUCTION

2.0 Introduction

Seed and seedling production is the natural end product of a breeding programme. We shall assess the capacity of NIFOR to meet the requirements of the oil palm industry in Nigeria on both qualitative and quantitative criteria.

2.1 Past Seed Production

In the past five years NIFOR has always been able to supply the quantities of seed required by the industry.

Year	No. of seeds produced	No. of seeds ordered (millions)	No. of seeds actually supplied 1/
1982	8.6	8.4	3.6
1983	3.2	3.4	2.1
1984	2.6	3.1	2.1
1985	3.4	4.6	2.3
1986	4.7	3.7	3.4
TOTAL	22.5	23.2	13.5

1/ 2.3 million seeds by third quarter of 1987

2.2 Present Seed Production

Value of Seeds Produced by NIFOR

The yield potential of the materials is difficult to assess, as bunch production is highly affected by environmental conditions and particularly by water deficit.

It is nevertheless thought that these materials have a potential of producing eight tons FFB in marginal areas (350 mm water deficit) and up to 20 tons FFB in the best areas, with an average mill extraction rate around 22%.

This potential should be easily improved in the next years.

Seed Production Capacity. The seed production capacity depends on the number of adult mother palms available. With 1744 seed trees currently in use, NIFOR has an estimated capacity of producing about seven million improved seeds annually. This is sufficient to establish 25,000 hectares each year, which is slightly above the most commonly given figures expected for the next ten years and would meet the ideal projection of replacing 600,000 hectares in 25 years.

However, some of the mother palms are growing too tall and are difficult to pollinate artificially, but NIFOR has taken steps to reproduce the original parents.

2.3 The Limitations

Although NIFOR is performing a good theoretical programme and possesses the potential to respond to the needs of the industry, many limitations, of practical order, could handicap this implementation of the programme. The limitations include lack of dependable supply of electricity, lack of medium-term storage and germinators and other equipment, and poor layout of facilities.

2.4 Recommendations

Emergency Support. Seed and seedling supply has in past years been the main linkage of NIFOR with the oil palm industry in the country. The situation has reached a point where this activity could be seriously impaired if basic facilities are not made available. Immediate decisions on the following have to be taken to ensure that this activity will keep on going.

a. Electricity supply is absolutely necessary for pollen processing and storage and seed processing. A standby generator is necessary, even after NIFOR has been hooked to the national grid.

b. Essential equipment comprises one vacuum pump, one deep freezer, one refrigerator, three isolation boxes, one pick-up vehicle for bunch collection.

c. One storage room fully equipped with air-conditioners and shelves is required.

d. Five thousand pollination bags must be purchased, along with other products (kapock, insecticides, fungicide labels, and other supplies).

We propose that a special emergency fund be allocated to NIFOR as soon as possible before the main rehabilitation could take place.

Rehabilitation of Laboratories (see also Note III). Seed processing is dispersed among five different buildings in an illogical sequence, making seed transport and handling difficult and time-consuming. We advise restructuring the whole division as follows:

a. The first building will be used for bunch reception, fruit separation, fermentation, depericarping and seed drying, cleaning, and packing.

b. The reception room will be equipped with individual wired boxes to avoid any mix-up of seeds. An additional part has to be built to shelter the fermentation boxes and digesters.

c. The present storage room is inadequate and should be replaced with a new storage room unit. This room should provide facilities for 10 million seeds, with air-conditioning, thermographs, and hygrometers.

d. The second building will be modified to include a room for seed preparation (soaking) and a new germinator (capacity two million seeds).

e. The third building will provide space for sorting of sprouted seeds, conditioning, and shipping.

Equipment. Most of the equipment has to be completed or replaced. In addition to materials listed under Emergency Support, there is a need for:

- seven additional isolation boxes for pollen handling
- individual wired boxes
- wired shelves
- one digester
- thermometers, hygrometers

Improving the Seed Production Programme. In the oil palm, a seed production programme is evolving continuously. It keeps upgrading regularly as more information is derived from previous years' results. The following measures are recommended:

a. A seed production programme should be drawn up yearly. This programme will include: basis of selection, list of selected progenies (with newly selected and discarded ones), parent selection, number of mother trees, pollinators, potential number of seeds.

b. This annual programme is an opportunity to regularly increase the genetic potential of the seeds. In the next two years this potential should be improved substantially by:

- eliminating dura progenies with less than 20 trees (to avoid bias in reproducing hybrids);

- reducing the number of hybrids reproduced. The 47 progenies currently reproduced have been selected on their FFB yield only. A new selection should be made, taking into account oil extraction rate as well. Moreover, some progenies might be discarded for specific characteritics, such as excessive vertical growth or high susceptibility to fusarium wilt.

Seed production capacity would not be affected by these modifications, since an increased number of selfed progenies from the best parents will compensate for elimination of the poorest progenies.

c. Seedling heterogeneity was the main complaint of the farmers we visited during our mission. This problem can be easily solved by keeping each one of the 73 families carefully separated until the nursery and planting stages.

The breeding division and the extension division have then to cooperate to define a clear and well-advertised policy of nursery and plantation management. The seeds should be delivered in homogeneous individual families. Large estates establish standard blocks of 20-25 hectares. The number of seedlings for the different families should meet this standard block-size requirement.

Seed Production Management. For technical reasons, the seed production programme must be supervised by the breeding division (yearly selection of parent trees, number of seeds, checking of pollinations) but as a commercial activity, seed production can be administratively managed as a separate specific entity. The plant breeding division should therefore continue providing technical supervision, but the seed production division, as an income generating unit, can be placed under the second deputy director.

3. TISSUE CULTURE

3.0 Introduction

In vitro tissue culture of oil palm can be used in two ways:

- as a technique of mass multiplication of a given interesting individual;

- as a tool for more advanced breeding methods, such as haploidization, *in vitro* selection, and genetic engineering.

The oil palm has no natural vegetative propagation and is a highly heterozygotic plant. It has been estimated that as much as 30% progress could be achieved in yield by cloning of the best palms from the best progenies. Furthermore, oil palm is a perennial species with a long breeding cycle. *In vitro* tissue culture is seen as a possibility to increase breeding progress during a reduced period of time and to rapidly transfer these results to the plantations.

Thus, IRHO-ORSTOM in France and Unilever Research in England launched large research projects in the early 70s, with a view to obtaining true-to-type reproduction of selected individual palms. In spite of the difficulties generally encountered with monocots, successful methods have been set up. Other organizations initiated similar programmes more recently, and several development laboratories have been set up in Malaysia, Indonesia, Ivory Coast, England, and France. Small quantities of ramets are already supplied for experimentation, and commercial supply is now beginning for 1990 plantings.

3.1 Tissue Culture at NIFOR

Tissue culture is expected to play a major role in the future of the oil palm, both for the rapid and true multiplication of elite planting material and for more advanced breeding methodology. Clones produced by IRHO, Unilever, and PORIM are now under assessment in different countries. How much of the theoretical yield gain of 25-30% of selected clones over seedling material will be realized will be known in the next few years. Nigeria, through NIFOR, should therefore acquire this capability.

The first objective for NIFOR is to clonally propagate outstanding individual palms among its best families and to compare their field performance vis-a-vis the performance of regular NIFOR seedlings and vis-a-vis clones released by other research organizations.

However, developing the capability to clone the oil palm will require time and considerable effort. IRHO and Unilever, with more than ten permanent scientists and technicians each, took about 3-5 years to produce the first plantlet, about 10-12 years to set up a workable practical process, and about 20 years to release the first commercial clones.

Nigeria has two options:

- Purchase the existing technology and guarantees of further access to improvements under commercial terms from organizations like IRHO and Unilever.

- Adopt a self-reliant posture and try to develop tissue culture capability utilizing Nigerian scientists at NIFOR and the universities. The process could probably be accelerated by hiring an expatriate who has had a lot of actual experience in oil palm tissue culture to work with Nigerian scientists at NIFOR.

The first option will enable Nigeria to save time and immediately clone and field test individual palms from NIFOR's best families. The time saving could be in the order of 3 to 6 years.

However, considering the other current constraints to the oil palm industry in Nigeria, the Mission believes that the supply of clonal material is not that pressing. The Mission therefore suggests that the country take the second option.

4. ACTIVITIES IN OTHER DIVISIONS RELATED TO PLANT BREEDING

The breeding division must maintain close contacts with the other discipline divisions which are conducting plant-breeding-related research.

4.0 Plant Pathology Division

The breeding programme to improve tolerance to fusarium wilt must be jointly operated by the breeding and pathology divisions. As previously stated, we feel that a much bigger emphasis should be given to this programme, both in terms of biological studies on the fungus and number of screened progenies. Most of the work has to be carried out outside of the main station in a highly affected area at Ajagbodudu (ex Cowan estate). We advise improvement of facilities in Ajagbodudu in order to provide for a small laboratory, a large screening nursery, and field trial plantings.

Extensive research programmes are implemented on fusarium wilt at Dabou (Cote d'Ivoire) and Binga (Zaire). Studies in these stations include large nursery screening, field testing, biological research, host-parasite relationship, studies on phytoalexins and elicitors. We strongly recommend that NIFOR try to cooperate with these centers (visits, exchange of information and breeding materials, complementary programs). NIFOR should also participate in any research network going on in West Africa on this pathogen.

4.1 Physiology Division

In the previous years, programmes have been focused on two main subjects: 1) physiology of seed germination, 2) physiological tests in relation to water stress. These activities have been hampered by inadequate facilities.

The work related to drought tolerance should be reassessed. Most of the proposed and ongoing experiments studied have already been worked out elsewhere. In this area, close cooperation with POBE (P. Rep. of Benin) should be highly beneficial to NIFOR. Furthermore, the genetic component of drought tolerance appears to be less significant compared to other environmental factors in the oil palm. In other words, water management policy is more likely to bring results than genetics alone. This includes studies on cultural practices such as irrigation, mulching, disbudding, and density, as well as physiological studies on water uptake, evapotranspiration, carbohydrate translocation. This research should thus follow a multidisciplinary approach. With this view the whole programme could be reoriented towards studying the physiological aspects of the carbon budget.

Moreover, since tissue culture involves the application of the principles of physiology of growth regulation, the tissue culture laboratory can be affiliated with the physiology division. However, they should work very closely with the plant breeders.

4.2 Statistics Division

The statistics division is assisting the breeding division in designing experiments, data processing, and statistical analysis. In 1987, 162,000 trees were under individual recording.

A new data-processing system has to be developed to replace the old card-processing system. Data should be input on diskettes through microcomputers and stored on magnetic disks.

New programmes should be written to ensure processing of yield data and bunch analysis data as well. Specific programmes are needed for complete and fast analysis of genetic trials. Some specific statistical software (SAS, genstat) could be acquired.

We suggest reinforcing the team with a biometrician. In addition, since the statistics staff is rather small, management may wish to consider merging statistics with plant breeding, with whom they work very closely anyway. The statisticians, of course, should continue providing advice to researchers in other units.

Note I

SOME CONSIDERATIONS ABOUT BREEDING AND SEED PRODUCTION IN THE OIL PALM

I Biology

The oil palm is a perennial monocot. It has a shallow rooting system. There is a single terminal meristem growing indefinitely, controlling leaf production and stem elongation. An inflorescence is initiated in the axil of every leaf. It can be male or female (monoecy). Actually, a series of successive female inflorescences is followed by a series of male inflorescences. The length and duration of each cycle is greatly affected by the environment. These cycles rarely overlap, so the oil palm is considered as a strict cross-pollinating species. Six months after pollination, the female inflorescence produces an average of 500 to 1500 ripe fruits. The fruit consists of a mesocarp (pulp) from which palm oil is extracted; a woody shell, and a kernel, from which palm kernel oil is extracted.

A major breakthrough was achieved when Belgian scientists discovered the inheritance of fruit types in 1941.

There are three fruit forms, according to the shell thickness:

dura = thick-shelled fruit (DD)
pisifera = shell-less fruit (dd), usually female sterile
tenera = thin-shelled fruit (Dd)

This characteristic is determined by a single gene, the tenera form being the hybrid between dura and pisifera. This discovery led to the replacement in the early sixties of dura plantations (60% mesocarp) with tenera (80% mesocarp), thus achieving an immediate progress of 33% in oil yield.

The most widely used spacing is the 9 m triangular spacing (density = 143 palms per ha). Sixty to 90 palms are needed to evaluate a progeny (about half a hectare per family). Individual palms are observed for at least 9 years (3 years unproductive phase + 6 years production record as a minimum). Twelve to 15 years are necessary for a breeding generation.

II Inheritance of Yield Characteristics

Oil yield can be broken up into several components:

- total fresh fruit bunch yield (FFB) = bunch number (BN) x average bunch weight (BW)

- extraction rate = oil to bunch (O/B) = % fruit to bunch (% F) x % mesocarp to fruit (% M) x % oil to mesocarp (% O).

Each one of these components is quantitatively inherited. Heritability estimates on those components show consistent results all around the world.

Some components are highly heritable: % M, % kernel, fruit and kernel sizes, fatty acid composition, vertical growth.

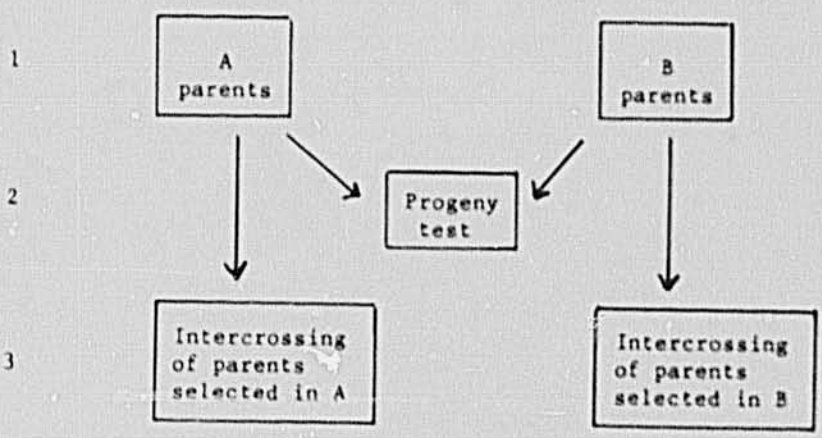
Some show intermediate heritability: BN, BW.

Others have low heritability: % F, % O. This is also the case for the two most interesting characteristics: total bunch yield and oil yield. The negative correlation between bunch number and mean bunch weight accounts for the low heritability of bunch yield.

III Selection and Breeding

The principles of plant breeding rely on heritability estimates. If we oversimplify, heritability tells us which proportion of the superiority of selected parents will be transmitted to their progenies.

As yield (bunches and oil) in the oil palm has a very low heritability, selection of parents on their own value will be ineffective in improving their progenies. In that case we have to select parents on the value of their progenies themselves (progeny testing). That is what NIFOR is doing in implementing a Reciprocal Recurrent Selection Scheme (RRS). See diagram below:



RRS can be described in three steps:

1. First-generation populations are divided into two sets, A and B. A and B should be as different and complementary as possible. In the oil palm the division is made between a group of parents exhibiting a large number of rather small bunches (A) and those with few big bunches (B).

2. Parents are selected in A and B on the basis of highly heritable traits (mesocarp, vertical growth). Parents from A are crossed with different parents from B and vice versa. The progenies are field planted, evaluated, and compared.

3. Parents of the best families in progeny trials are selected and intercrossed within each group A and B. Their progenies constitute two improved populations, which are used to initiate a new cycle.

These new populations have been planted at NIFOR between 1981 and 1988 and a second cycle started using the older plantations.

The procedure used so far is correct. However, there is a need to broaden the narrow genetic base of this second population. We suggest increasing the genetic diversity by introducing at this stage:

- a few parents selected for specific traits other than yield, such as resistance to fusarium, short stem;

- palms selected at the same stage in other breeding programmes (Cote d'Ivoire, Indonesia, Malaysia).

Attempts to exchange breeding materials with other oil palm breeding programmes abroad should start as soon as possible.

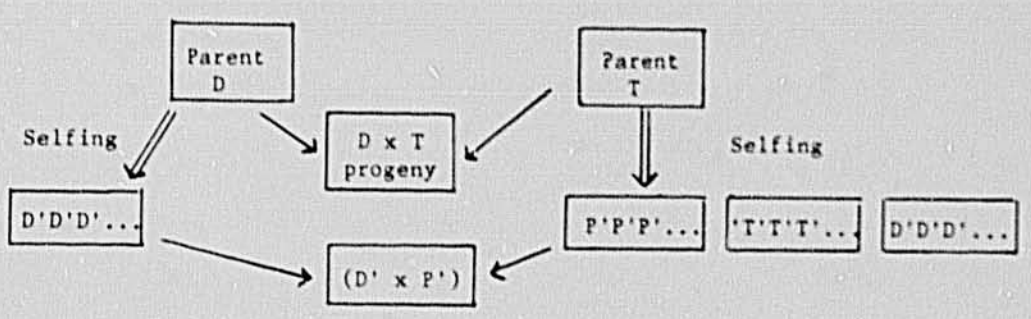
IV. Seed Production

The principle of seed production is to reproduce families performing best in the progeny trials. In this respect, one extra important advantage of progeny testing is to know the actual value of the selected family in the field and thus to allow for selection on other less-predictable traits like excessive vigor and crown disease resistance.

The difficulty in reproducing a selected family is that the breeder is left with only two parents in the field, which is far from enough for seed production (one mother palm may produce 5,000 to 10,000 seeds per annum).

It has been demonstrated that a cross could be faithfully reproduced by using the selfed progenies of both parents.

Let us take the example* of an outstanding progeny D x T (D = dura; T = tenera; P = pisifera)



* Variants from this basic scheme can be used.

1. Parent D is selfed, giving a progeny of Ds.
   Parent T is selfed, giving a progeny of 25% Ps, 50% Ts, 25% Ds.

2. A representative sample of Ds is crossed at random, with a representative sample of Ps. It has been demonstrated that the mean of teneras obtained from these crosses is exactly equal to the mean of teneras in the parental D x T cross. (Incidentally, the variance is not significantly increased in the oil palm.) Thus, to produce seeds in large quantities, it is only necessary to plant as many Ds as necessary to meet the quantity of seeds required.

3. Usually, selfings of parents are field planted at the same time as progeny tests, allowing seed production to start as soon as progeny tests have been assessed.

   Actually, further selection can be applied to the selfed progenies for traits with high heritability. Thus, the reproduced hybrid may be slightly better than the parental one.

NIFOR is using this methodology for seed production. This, once again, is theoretically sound and justified. Our suggestions deal with a few practical points in the implementation of the programme.

- More attention should be devoted to strengthening selection criteria in progeny tests to include oil extraction rate, slow vertical growth, and tolerance to disease.

- The different hybrids should be kept separate until the field plantation stage instead of mixing seeds from different reproductions. This will facilitate culling at the nursery stage and improve uniformity in the field.

- The Breeding Division should follow up where their seeds go:

  . They should have a more active role in allocating seeds (choice of families according to the destination).

  . They should have a hand in culling unwanted seedlings in the nursery. The adoption of a two-stage nursery technique is strongly advised, as it is cheaper and greatly facilitates culling.

  . They should visit plantations more to assess performance of NIFOR materials in the field.

Note II

BUDGET FOR THE BREEDING AND SEED PRODUCTION DIVISIONS

US$

I Immediate rehabilitation to keep seed production going

		$
Equipment	1 standby generator	22,000
	1 deep freezer	2,200
	1 refrigerator	1,400
	1 vacuumpump	1,500
	1 pick-up vehicle	13,000
	3 isolation boxes	900
		41,000
Buildings	1 storage room fully equipped with air-conditioning, thermometers, shelves wooden boxes	70,000
	1 germinator	17,500
		87,500
Supplies	Pollination bags	15,000
	Other supplies	9,000
		24,000
		152,500

II Provisional budget for the breeding division

1. New Equipment

Vehicles (1 4-wheel drive, 2 pick-up)		$ 37,000
Pollen:	1 deep freezer	2,200
	1 refrigerator	1,400
	1 incubator	3,300
	1 precision balance	3,300
	1 microscope	2,200
	1 vacuum pump	1,500
	5 isolation boxes	1,500
	products	2,500
	air-conditioner	600
		18,500
Pollination:	10 double aluminium ladders	1,200
	50 fixed ladders	7,800
	pollination bags products	3,000
		12,000
Bunch analysis:	2 ovens	3,600
	1 Berckel scale	1,300
	10 soxhlets extractors	6,700
	1 precision scale	3,300
	air-conditioner	600
	supplies	4,500
		20,000
Recording:	microcomputer	11,400
	1 air-conditioner	600
		12,000
	Total equipment	99,500

2. Operating costs (salaries not included)

supplies	12,000
running costs	6,000
replacements	17,500
	$ 35,000 per year

III Seed production

1. new equipment

7 isolation boxes	2,100	
1 oven	1,800	
1 digester	1,100	
1 fermentation unit	6,000	
renovation	5,500	
		$ 16,500

2. operating costs

supplies and replacements	15,000	
running costs	8,000	
		23,000 per year

IV Documentation, visits

library	850	
15 days visit expert	7,800	
1 month visit outside	9,000	
		17,650

V Tissue culture (approx. 15,000 plantlets units)

investment	150,000
operating cost	40,000 per year

VI Adjagbodudu (fusarium research)

facilities	550,000
buildings	330,000

	1988	1989	1990 and rest
Seed production	160,000	39,500	23,000
Breeding research		99,500	35,000
Documentation, visits		17,650	17,650
Tissue culture		150,000	40,000
	160,000	306,650	115,650

Note III

IMPROVEMENT OF SEED PRODUCTION FACILITIES

The most important and unique role of NIFOR is the supply of adapted, high-yielding and high-quality tenera hybrid seeds to the oil palm industry. Unfortunately, the existing seed production unit layout and facilities leave much to be desired. The improvement of these facilities should have top priority.

The existing layout and work flow are shown in Figure 1. The improvements being suggested are as follows (Figure 2):

Step 1. Bunch reception and fruit separation. This room must be equipped with individual boxes closed with wire netting to avoid any mixture of seeds.

Steps 2-5 Seed preparation. A new outside shed should be built for fermentation, depulping, and washing. Fruits could be more easily fermented in fixed individual stainless boxes with a draining rack and a waste outlet (3 rows of 30).

The depericarping section (two digesters) and the washing tanks should be located next to the fermentation boxes. Allow for sufficient water supply and a large drain for used water.

The end of the existing building will still be used for seed drying and packing. This room has to be equipped with sufficient wire shelves for seed drying and with benches for embryo abnormality checking.

Step 6. Seed storage. The existing building used for fruit fermentation and storage should be replaced. A new storage has to be built, with a capacity for 10 million seeds (two rooms of 5 million each). The equipment should include enough shelves and wooden drawers (6 to 8000), air-conditioners (to keep temperature around 22°C), thermometers, thermographs, and hygrometers. A sheltered pathway must link the storage room with the first and second buildings.

Step 7. Seed soaking. Unchanged except for equipment to be improved (clean-water tanks instead of pails).

Step 8. Germinator. A new germinator with a capacity of 2-2.5 million seeds should be constructed in the left half of the second building. A covered pathway should link this building with the third one.

Step 9. Germination. The third building remains unchanged and will shelter facilities for resoaking, keeping seeds at ambient temperature, and sorting out sprouted seeds.

See following diagrams.

Figure 1: Existing layout and facilities of seed production unit

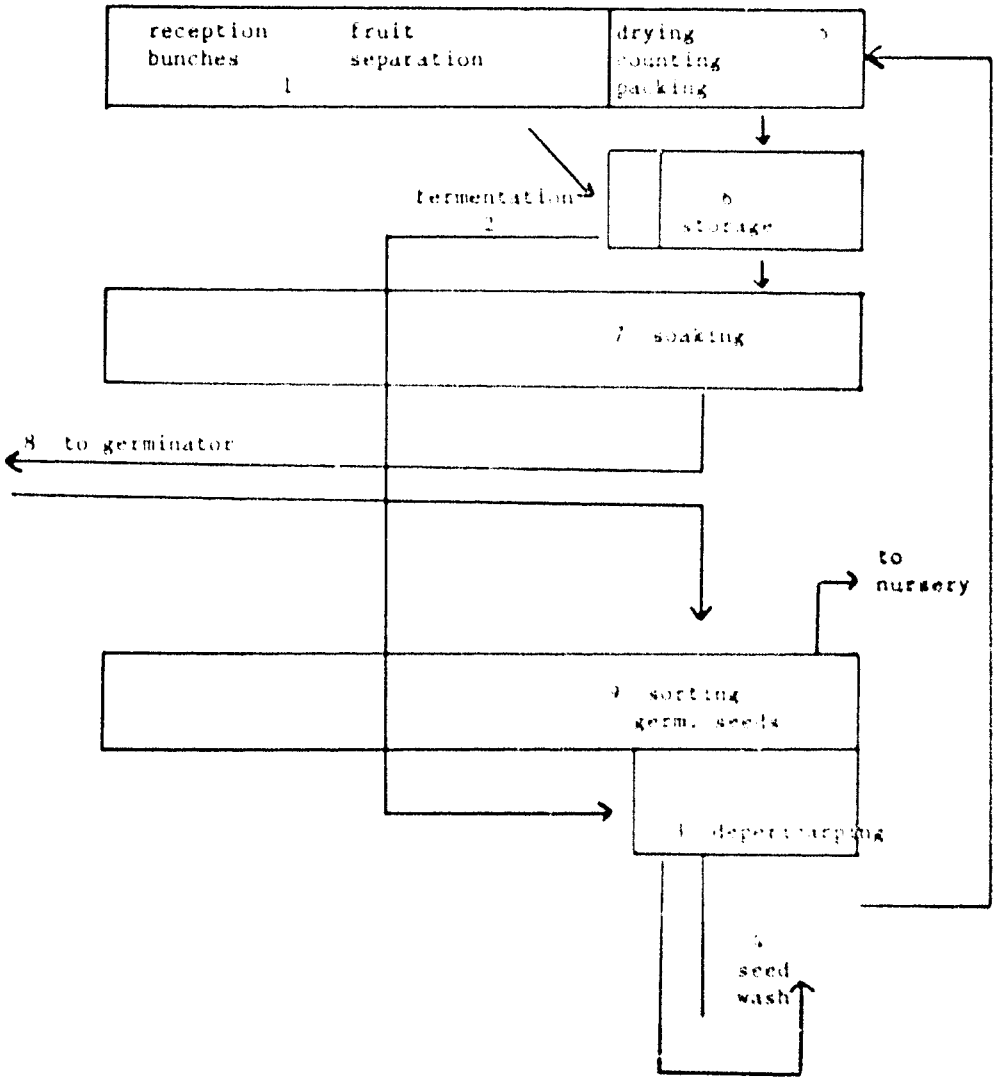
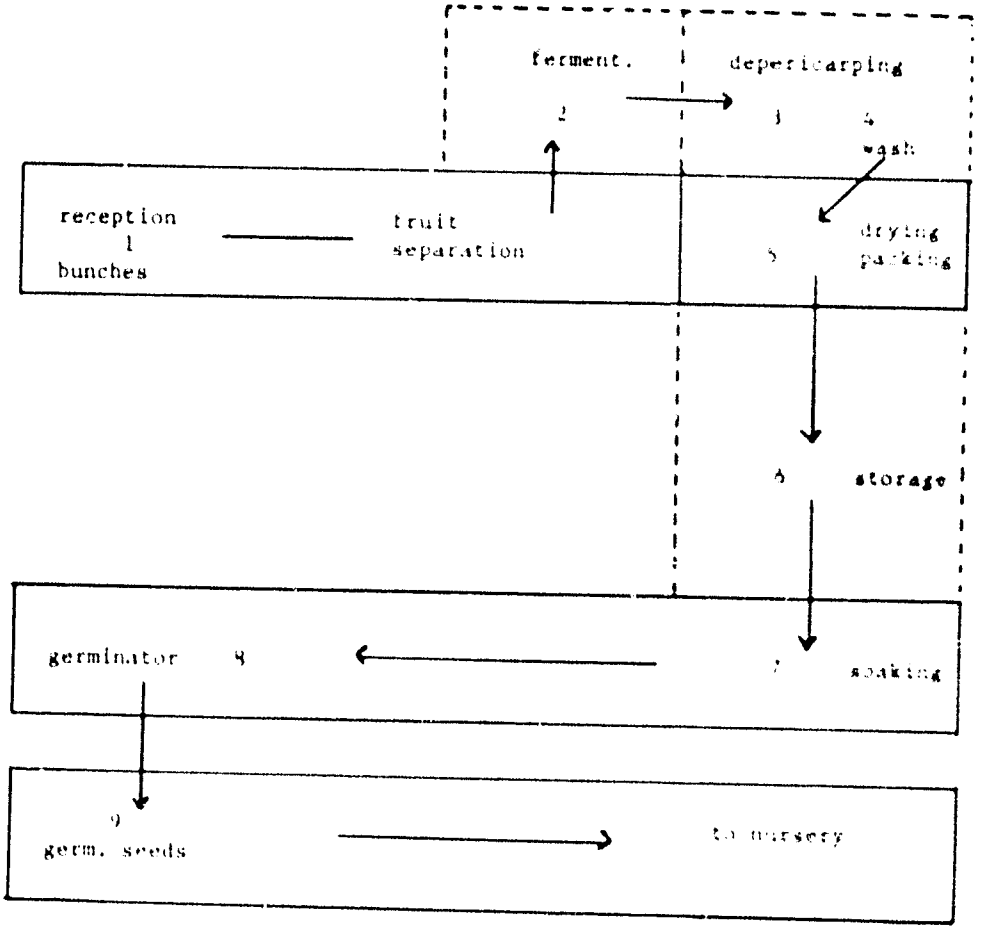


Figure 2: Proposed layout and facilities of seed production unit



ANNEX III - AGRONOMY, SOILS, CROP PROTECTION, AND FARMING SYSTEMS RESEARCH AT NIFOR

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Annex III

AGRONOMY, SOILS, CROP PROTECTION, AND FARMING SYSTEMS RESEARCH AT NIFOR

This Annex reflects the Mission's specific comments on the following:

Projects 8 (Physiology), 10 (Agronomy), 11-12 (Plant Nutrition), 13 (Agronomy), 14 (Soil Science, Yield Forecasting), 15 (Soil Science), 16 (Pathology), 17 (Pathology), 18 (Crop Protection), 19 (Entomology) of the Oil Palm Programme 1988 and Projects 1, 2, and 4 of the Farming Systems Programme

1. OVERALL OBJECTIVES

The Oil Palm Annual Research Programme, Volume 1, 1988 defines its broad objectives as follows:

i) yield improvement through further advances in selection and breeding and physiological and biochemical studies;

ii) optimization of yield through improved agronomic practices and evaluation of improved pest control measures;

iii) yield forecasting;

iv) development of improved small-scale methods for processing palm oil and palm kernel oil;

v) collection of primary and secondary data on the Nigerian and world palm oil industry.

To these the objective of the Farming Systems Programme 1988 may be added, as Farming Systems research is considered as a disciplinary research for the purpose of this report.

vi) Generation of agro-economic and crop protection packages for improving palm/foodcrop farming systems in small-holder agriculture in Nigeria.

Although there is some confounding between objectives (e.g., yield improvement) and areas in which research is required to achieve the objective, the intention is clear. It may be seen that the given objectives are already rather specific and actually derived from overall objectives. The latter are normally related to the needs of the country as a whole (shortage of vegetable oils, other foods, foreign exchange) and the problems of its farming communities (shortage of land for the cultivation of food crops), and in accordance with the agricultural policies of the federal and state governments of Nigeria. These overall objectives may perhaps be summarized as follows.

i) Increase the national production of palm oil to a level of self-sufficiency, and eventually to quantities allowing export around the turn of the century.

ii) Develop environmentally sustainable, economically sound, socially just, and politically acceptable improved oil-palm-based farming systems.

iii) Improve the quality of the Nigerian oil palm products and their derivatives, and extend the number of derivatives.

[This part of the report will only deal with the overall objectives i) and ii).]

From these the specific objectives of present and future research may be derived.

2. SPECIFIC OBJECTIVES

The projects covered by this part of the report suggest, with minor changes of the wording, the following specific objectives. They may be short-term (ST), medium-term (MT) or long-term (LT) in character.

3. AGRONOMY, SOILS, AND PHYSIOLOGY

3.1 Project 8: Yield Physiology of Oil Palm (p.43, a, b, c, d)

(ST) Identify vegetative characters that are associated with bunch production. This objective is short-term by nature but may reappear in the programme after attainment of the original targets if suggested by a better understanding of the physiology of the oil palm. The results are of interest for the selection and breeding of improved cultivars, and the identification of cultural practices leading to increased bunch production and/or better possibilities for intercropping.

(ST) Identify chemical markers for nursery seedlings, with a view to distinguishing the three formae and genotypes. This objective is mainly of interest for selection and breeding work.

(ST) Identify cellular biochemical characteristics for high- and low-yielding oil palm genotypes. This is again a short-term objective and mainly of interest for selection and breeding.

Research on the agronomic aspects of yield physiology has made a modest start. More emphasis should be given to the analysis of the carbon budget of the oil palm and its maintenance respiration, as affected by cultural practices and cultivars. The recent work of C.J. Breure, at Wageningen, on "Factors Associated with the Allocation of Carbohydrates to Bunch Dry Matter Production in Oil Palm (E. guineensis Jacq.)" should prove useful as a reference in these studies.

3.2 Project 10: Weed Control in the Oil Palm

(ST) Define the biology and ecology of the noxious weeds in oil palm plantations.

It is evident that the biology and ecology of noxious weeds must be known before efficient means of control can be developed.

(SL) Develop weed control measures for oil palm nurseries and plantations.

This objective is long-term in character, as the most efficient and economic weed control measures will depend on the cropping system and will change as new weed control measures (biological, chemical, mechanical, and manual) become available. It covers all objectives (2-6), which are partially research activities, in pages 51 and 52 of the 1988 programme.

Weed research on frequency of slashing and screening of herbicides is relevant, although purely empirical. More attention is required for the study of the biology of the major weeds and screening for better cover crops.

3.3 Projects 11 and 12: Nutritional Requirements of the Oil Palm

Some of the objectives listed for this project are research activities required to attain the targets of an objective. (Oil Palm Programme 1988, page 59, nos. 1 and 5). In addition, some of the objectives are of such a general nature (nos. 3 and 5) that their specific utility for oil palm research may be questioned. This leaves the following relevant specific objectives.

(MT) Establish improved critical leaf and soil deficiency levels for oil palm.

Critical leaf and soil deficiency levels for oil palm in Nigeria were established in the '60s by NIFOR scientists. The present objective aims at further refinement, which is especially necessary for the planting material originating from the second breeding cycle.

(ST) Identify the visual symptoms of nutritional deficiencies.

The major single nutrient deficiencies in the oil palm are well documented by the results of sand culture experiments done by scientists in Nigeria, Zaire, and Malaysia in the '50s and '60s. The symptoms of some deficiencies (e.g., Cl, Cu, Mn, Zn, and Mo), although suggested by the results of leaf and soil analysis, are not yet known from direct evidence.

The study of the effect of multiple deficiencies on visual symptoms (e.g., N+P, K+Mg, etc.) is likely to contribute to further precision of the criteria for visual identification of deficiencies.

(LT) Establish nutritional requirements of oil palms on the major Nigerian soil types.

This objective is long-term in character by nature, in view of the length of the economic life of the oil palm, the continuous efforts to develop higher-yielding cultivars, and the development of new land areas (e.g., in the Niger Delta) for oil palm cultivation.

Research on mineral nutrition which is based on field experiments on the different soil types under various rainfall patterns and on leaf analysis is well-advanced. More emphasis should be given to the role of S, Cl, and trace elements and to the study of the nutrient fluxes on the major soil types under typical rainfall patterns.

3.4 Project 13. Miscellaneous Field Practices

The rationale of this project is that several cultural practices in oil palm cultivation either lack a scientific basis or require re-evaluation because they may have lost their significance under the present conditions. Examples are leaf pruning, palm cleaning, assisted pollination, removal before anthesis of young inflorescences of young plantation palms (disbudding, wrongly named 'castration'), and the now obsolete germination, pre-nursery, and field-nursery techniques.

As it is almost impossible to define one or two specific objectives for this project, subdivision into separate projects for well-defined cultural practices would seem to be more appropriate. The following objectives would seem to justify the present activities under this heading.

Sub-project 13a. Removal of young inflorescences (disbudding)

Objective (MT): Assessment of the effect of removal of young inflorescences on growth and development.

Sub-project 13b. Assisted pollination

Objective (MT): Assessment of the effect of assisted pollination on growth and development.

The only ongoing research activity under these sub-projects is a combined debudding/pollination experiment, commenced in 1979, planned to be completed in 1987, but likely to be continued until 1990 with a view to obtaining more yield data for the assessment of the effects. No 1987 progress report is available on this experiment. Both practices have been widely employed in Southeast Asia and Papua New Guinea. Recent experience has cast doubts with regards to the benefits of disbudding, while it has been shown that the need for assisted pollination in Southeast Asia and Papua New Guinea can be removed by the introduction of a West African pollinator insect, Elaedobius kamerunikus (Syed, Law and Corley, 1982). It seems unlikely that the effect will be different in Nigeria, as the pollination insect is indigenous to the country.

A recent earlier activity, which can be classified under project 13, is a leaf-pruning experiment, according to the 22nd Annual Report of NIFOR (1985) concluded in the course of 1985. It is not mentioned in the list of completed projects during the last three years (1985-87). The results confirm earlier findings that leaf pruning should be restricted to removal of dead leaves and leaves which must be cut to harvest a ripe fruit bunch.

Little or no further activities would seem to be required under this project, as all standard treatments of individual palms in the field are well-founded by experimental evidence and documented.

3.5 Project 14. Soil-Water Relations and Yield Forecasting in the Oil Palm

This project deals with different subjects and should be divided in two. This will enable a better definition of the overall objective of each project, e.g.

Sub-project 14a. Soil moisture requirements

Objective (ST): Assessment of the effects of water stress on oil palms.

Increasing experimental evidence has become available during recent years on the benefits of irrigation in oil palm cultivation in West Africa. From this it is apparent that knowledge of the consumptive water use of palms, the occurrence of periods of positive and negative water stress, and the dependence of the availability of soil water on soil type and climate are of paramount importance for the assessment of the productivity of oil palm under various conditions of soil and climate. Work on the soil moisture requirements of oil palm at NIFOR commenced in 1981. In the meantime, four experiments were completed:

1) a water balance study on acid sands in southern Nigeria;

2) the response of oil palm seedlings to irrigation regimes on four 'acid-sands' soil series;

3) effect of soil moisture stress at different stages of growth on subsequent growth, water relations, and yield of oil palm seedlings;

4) effect of fertilizer levels and irrigation regimes on the growth, yield, and water relations of the oil palm (first phase).

The results led to the following important conclusions:

- Very high water deficits occur in the soils of the Nigerian oil palm belt, resulting in low yields.

- Growth rate, water use, and dry-matter production vary with soil series as a result of differences in the availability of soil moisture and plant nutrients.

- Continuous moisture stress over three weeks causes an irreparable reduction in seedling growth.

- Irrigation of oil palms on the acid sand soils of southern Nigeria improves yield and the response to fertilization.

The ongoing research activities under this sub-project follow equally from four specific objectives (slightly simplified):

(ST) Determination of the soil moisture relationships in oil palm plantations on the benchmark soils of the Oil Palm Belt.

(ST) Determination of the water consumptive use in oil palm plantations on the benchmark soils of the Oil Palm Belt.

(MT) Assessment of the value of moisture conservation methods for mature oil palms.

(LT) Assessment of the value of palm oil mill effluent for irrigation, fertilizing, and moisture conservation in oil palm plantations.

The corresponding ongoing activities under these objectives are, in the same order:

1) A study of the soil moisture distribution and water uptake rates and patterns. It is not clear why this study, commenced in 1983, should be long-term in character. Studies of this type can be fairly accurately planned and phased. After analysis of the results of a first phase of a maximum of five years it should be decided whether a second phase is necessary.

2) A study of the water consumptive use in oil palm plantations, based on calculated and measured values of the potential evapotranspiration (PET) of young and adult palms and the relation between PET and bunch productions in different ecological zones of the oil palm belt. This study commenced in 1987 and is expected to be completed in 1989.

   Records should be extended to include an estimation of the annual dry-matter production (by non-destructive means) of both palms and interline cover, and growth parameters such as leaf area index (LAI), leaf area duration (LAD), and sex ratio.

3) An experiment designed to evaluate moisture conservation by mulching with various materials which are readily available. This experiment, commenced in 1983, must be continued until 1993, with a view to obtaining sufficient yield data. Records should be extended as suggested for 2).

4) An experiment of medium duration, designed to determine the effect of irrigation with palm oil mill effluent on the physical and chemical properties of the soil, and the mulching effect caused by its residue remaining on top of the soil. As the results of this multidisciplinary experiment will be of paramount interest for the future management of oil palm plantations, the extensive range of records to be kept is fully justified and should even be extended as suggested for 2). After completion of a first phase of 10 years (1996) and evaluation of the results, the experiment should be continued as long as possible, with a view to assessing the cumulative effects of irrigation with effluent on the parameters of soil fertility. The pattern and rate of change of these parameters may eventually be used to estimate the ecologically allowable quantities and frequencies of effluent application. It should also be borne in mind that large-scale disposal of effluent in a plantation will require major preparatory measures before planting or important investments in equipment for sprinkler irrigation.

Since this problem is of great interest to the estates, NIFOR may wish to explore the possibility of replicating the experiment with one of the estates.

Sub-project 14b. Yield forecasting

Objective (ST): Development of models simulating the relationship between soil and climatic parameters, and bunch yield.

Two studies have been planned under this objective. The first is in course.

1) Study of the effects of sunshine, rainfall, temperature, potential evapotranspiration, and soil moisture in oil palm production, with a view to developing models for the prediction of the production of fruit bunches. The numerous previous efforts in the leading oil-palm-growing regions to predict bunch production have never been entirely satisfactory, for several reasons, such as:

- arbitrary assessment of the parameters for light, temperature, and water;
- ignorance of the partition of assimilates between vegetative dry matter, generative dry matter, and maintenance respiration;
- ignorance of the physiology of sex differentiation and inflorescence abortion.

In most oil-palm-growing regions the effect of one or two factors affecting bunch production were found to be predominant, but they rarely explain more than 75% of the variations in bunch production. Major restrictions for this type of studies until recently were the tedious and vast manual calculations. Computers have lessened this drawback, but for the development of simulation models highly specialized staff is required.

The commencement of the second study was planned for 1986, but since the old NIFOR computer is outdated and has frequently broken down, this study has to wait for a better machine.

2) Time Series Modelling

This new activity, planned for implementation in 1988, is an excellent exercise. It should be borne in mind, however, that it will require excellent computer facilities and staff qualified in mathematics and plant physiology, with experience in the development of plant growth models.

A forthcoming publication by Van Kraalingen, D.W.G., Breure, C.J., and Spitters, C.J.T., entitled 'Simulation of Oil Palm Growth and Yield', is recommended for recent information on the magnitude of the problems involved. This would protect the proponents from wasting time on outdated methods of data processing. For the time being the Mission recommends restricting these activities to the creation of a computerized databank of the records. The database should include in addition to those listed in page 88, data such as

leaf area and total annual dry-matter production (trunk, roots, leaves, male inflorescences, bunches). Expert advice from scientists familiar with this matter should be helpful.

3.6 Project 15. Advisory Services on Site Selection, Manurial Requirements, and Disease and Pest Control

This multidisplinary project substantiates the dissemination of the proven knowledge acquired by NIFOR scientists and others on the physical requirements of oil palm cultivation. Its activities are continuous by nature.

Objective (LT): Dissemination of proven knowledge on oil palm soils, fertilizing, and crop protection for the benefit of the growers.

The objective would seem to be incomplete, as it does not cover the technologies of oil palm propagation, plantation management, and harvesting. Since this project has to do with advisory services and extension, not research per se, the creation of the project is a little out of place. The Mission prefers that the subject and function be treated under the appropriate headings of advisory services and extension. Accordingly, we propose the following distinction - advisory services for estates and extension for small growers.

Since estates are large, commercial entities, NIFOR's services to them should be handled on a revenue-generation basis. NIFOR should recover the full cost for services actually rendered, plus a reasonable fee to augment the resources of the institute. Thus advisory services should fall under the supervision of the proposed deputy director for services, plantations, and production (see section on management).

To avoid confusion and to achieve better coordination of activities directed to smallholders, it is suggested that all extension activities be coursed through the Extension and Training Programme.

4. CROP PROTECTION

4.1 Project 16. Epidemiology and Control of Vascular Wilt Disease of the Oil Palm

As suggested by its name, the project includes two rather different sub-projects.

16a. Epidemiology

This sub-project has the following objective (MT): identification of the environmental factors affecting the incidence of vascular wilt.

It is rather disappointing to note that control of vascular wilt disease caused by the soil-born fungus *Fusarium oxysporum* is still a major problem, more than 40 years after its identification by Professor Wardlaw in Nigeria and Zaire. In practice, the incidence of the disease would seem to be more dependent on environmental conditions than on the specific tolerance of the oil palm progeny. Previous vegetation, water stress, and K-deficiency were already associated with a higher incidence

of vascular wilt in the fifties. During the period 1978-1984 a field experiment was done to evaluate the importance of some ecological factors, such as soil moisture, pH, organic matter amendments, and weeds. Unfortunately, the Report on Completed Projects is very vague on the results. Four unspecified common weed plants were found to act as symptomless carriers of the pathogen. Pending a full report, however, the scientific and practical value of this experiment is negligible.

16b. Control

Objective (LT): Identification of vascular-wilt-tolerant progenies.

Resistance to vascular wilt seems to be extremely rare. Tolerance is known, but the screening method developed by Prendergast in the late forties has apparently not yielded a reliable prediction of the field tolerance to vascular wilt. A new method, developed at Manchester, is claimed to be more discriminating.

The following activities are under way in this sub-project.

1) Screening of oil palm progenies for their reaction to vascular wilt disease and selection of tolerant material for commercial seed production.

   This activity, using the Prendergast screening method, commenced in 1972 and is planned to be completed in 1992. The results obtained to date suggest that some 46% of 768 progenies tested are vascular wilt tolerant, but there seems to be no control of the method by comparing the field tolerance of both discarded and selected progenies.

2) Evaluation of various techniques for screening oil palm progenies for their reaction to vascular wilt disease caused by *Fusarium oxysporum*.

   This experiment will commence in 1988 and is planned to be completed in 1990. It is designed to compare the Prendergast and Manchester techniques. The Mission is of the opinion that the discrimination of the progenies by these techniques should be compared with their field tolerance.

4.2 Project 17. Investigations into the Mycoflora Associated with Oil Palm Seeds

The objective of this project can be formulated as follows:

(ST) Identification of pathogenic seed-borne fungi. Pathogenic seed-borne fungi are a potential menace to oil palm propagation. In addition, distribution of infected seed may contribute to the dissemination in soils which were hitherto free of these fungi.

From the five experiments under this project, three have been completed and two will be implemented in 1988. All were/are of short duration.

1) Isolation and identification of fungi in oil palm seeds (1984-1985).

The number of fungi isolated amounted to 26, including 10 new records. Most of these are likely to be accidental contaminations and quite harmless, but seven are known or suspected to be potentially harmful.

2) Pathogenicity of seed-borne fungi on oil palm seedlings.

All three Fusarium spp, viz. F. oxysporum, F. solani, and F. equiseti tested in this experiment were found to be pathogenic.

3) Biochemical changes in oil palm kernels by seed-borne fungi (1987).

All seven fungi tested caused a biochemical deterioration of the palm kernel meal and oil.

4) Quarantine measures in relation to seed-borne Fusarium oxysporum f.sp. elaeidis (1988-1989).

This experiment is expected to provide information on the effect of heat treatment on the occurrence of the fungus and the viability of the seed.

5) Testing of seed-dressing fungicides for the control of seed-borne Fusarium oxysporum (1988-1989).

This experiment is expected to provide information on the recovery of the fungus and the viability of the seed after treatment.

The experiments under this project form a logical sequence. Although the prevention of damage by seed-borne fungi has already been studied elsewhere, e.g., in Ivory Coast, they may serve some useful purpose for Nigerian conditions. Before starting new experiments, the results obtained to date at NIFOR should be fully analyzed and compared with those in other African countries.

4.3 Project 18. Biological Control of Oil Palm Diseases and Pests

Biological control of pests and diseases is an attractive alternative to chemical control. The readily available means are still limited, however, so that screening of insecticides and fungicides and the identification of suitable cultural measures should not be neglected. In the eastern states of Nigeria, the leaf miner, Coelaenomenodora elaeidis has become a serious pest. Other pests such as Oryctes spp. remain as a potential menace to the industry.

Objective (LT): Development of biological control methods for oil palm pests and diseases. Activities required under this project include the study of the epidemiology and the identification of parasites, predators and lethal micro-organisms, the propagation of these natural enemies, and the effect of releasing them on the pest or disease and the side-effects on the biotic environment. The following experiments are under way or planned under this project:

1) Distribution and population of Coelaenomenodera elaeidis. This study started in 1987 with observations in small holdings and plantations in the Eastern States (Cross River, Imo, Rivers and Anambra), Bendel and Ondo. It should not be a continuous activity, but limited to about 4 years. After thorough analysis of the results, decisions can be taken with regard to the necessity of follow-up and continuation.

2) Identification of natural enemies for the control of Coelaenomenodera elaeidis (1987-1991). This study commenced in 1987 and can be done simultaneously with (1). Up to the present no parasites or predators have been identified.

3) Biological control of Rhizoctonia lamellifera and Pythium splendens (1987-1991).

   These fungi are still believed to be the causal organisms of seedling blast in Nigeria, although a mycoplasma transmitted by an insect (Recilia mica) has been identified as the cause of blast in Ivory Coast. It is evident that this possibility should also be checked by NIFOR for Nigerian conditions. A number of microbial antagonists of R. lamellifera and P. splendens have been identified.

4) Biological control of Cercospora elaeidis (1987-1991). No results have been reported to date.

4.4 Project 19. Occurrence, Activities, and Control of Termites

Termite species may cause considerable damage to seedlings in the nursery and recently planted field palms. Research leading eventually to control of these insects can be expected to be completed within five to ten years.

Objective (ST): Development of Termite Control Methods

1) Assessment of the activities of termites in different oil palm growing areas, with particular reference to soil type. Although the experiment was completed in 1987, according to the 1988 Research Programme, no results are given in the 1987 Progress Report.

2) Control of termites in the oil palm nursery (1986-1987). It is not clear whether this experiment actually commenced in 1986 and terminated in 1987, as no results are mentioned in the 1987 Progress Report.

5. FARMING SYSTEMS PROGRAMME

Although farming systems is a programme in the present NIFOR structure, it will be dealt with as a multidisciplinary unit of the same order as that of the research divisions. The overall objective of farming systems research within the Oil Palm Programme could be formulated as follows:

Development of environmentally stable, economically sound, and socially acceptable oil-palm-based farming systems.

Small farmers in the oil palm belt constitute the major target group of farming systems research. Large-scale oil palm growers normally practice monocropping, with rarely more than three years of intercropping after field planting. This practice has been known to have no lasting harmful effects on the future productivity of the palms, provided excessive leaf pruning of the young palms and nutritional deficiencies are prevented. Monocropping is not acceptable for small farmers with limited land resources, as the palms planted at optimum densities for bunch production will render the land unsuitable for intercropping after closing of the leaf canopy, about four years after planting. An acceptable alternative would be an oil-palm-based cropping system permitting permanent or almost permanent intercropping with food crops. This would be an improvement over the present bush fallow system practiced in the semi-wild palm groves, which are periodically rejuvenated as a consequence of this system.

The bunch production of semi-wild palm groves is low and the oil content of the bunches is at least one-third lower than that of tenera-type plantation palms. Moreover, the cropping system tends to degenerate as a consequence of the shortening of the fallow periods, caused by the ever-increasing need for more land for the production of food crops. This results in incomplete natural regeneration of the semi-wild palm grove, which may eventually disappear almost completely and degenerate into an anthropogenous savannah dominated by coarse grasses.

Apart from irrigated rice, sustainable permanent cropping systems with annual and bi-annual crops were unknown until recently. IITA scientists have now developed what appears to be a stable alternative to the traditional shifting cultivation or fallow systems, a system named alley cropping. In alley cropping, soil fertility is maintained by pruning hedges bordering four-meter-wide alleys, between which the crops are grown. Depending on soil, climate, and crop, additional fertilization may be required to correct nutritional deficiencies for optimum results.

This cropping system can be combined with widely spaced avenues of high-yielding tenera-type palms, obtained from elite NIFOR seed. The highest yields per palm are obtained at low planting densities, as contrasted to the highest yields per ha obtained with triangular spacings and high densities of 140-150 palms per ha. From old spacing experiments at NIFOR it may be concluded that the maximum yield per palm is obtained with triangular spacings of about 12m (80 palms/ha) (SLY and CHAPAS, 1963). The same authors found that the spacing in the row must be near to normal (e.g., 9m), because narrower spacings in the row will impede normal growth and development. To optimize conditions for permanent intercropping, the rows must be much wider apart than 10.39m corresponding with a 12m triangular spacing. This is a subject requiring further research. It may already be concluded, however, that densities as low as about 80 palms per ha, with sufficient spacing in the row, are likely to give about 60% of the yields per ha obtainable from pure stands planted at optimum density. Depending on his/her needs and preferences, the farmer can choose such density of palms below about 80 per ha, as will provide him/her sufficient space to grow food and cash crops.

It is evident that this means gradual replacement of the palms in semi-wild groves by high-yielding NIFOR tenera. For optimum results, the semi-wild palms must be removed before the improved palms are planted.

When planted under the canopy of the semi-wild palms, the improved palms will never develop their full potential for high bunch yields. Replacement of each hectare of semi-wild palm groves by widely spaced (<80/ha) improved palms will increase the oil yield per ha from 180 to 700-1200 kg. Replacing 50% of the semi-wild palm groves would eventually increase the national palm oil production by at least 600,000 tonnes.

The present programme includes the following projects related to oil palm cultivation.

5.1 Project 1: On-station Research: Oil Palm/Food Crop Intercropping Systems

The numbering of the activities under this project is somewhat confusing, as activities by several research divisions may refer to the same field experiment. These will be grouped per field experiment in the following review.

Objective (MT). Assessment of intercropping in oil palms planted at normal sole-crop density.

Although the possibilities of intercropping young oil palms during about three years after field planting are well known from the results of NIFOR research in the fifties, the consequences for soil fertility, the sanitary risks, and the economics of this practice have not been sufficiently studied. This justifies the following activities under this project.

(1, 5, 7, 10, 12) Intercropping of oil palm with cassava and maize (1984-90).

This experiment is used for studies by Agronomy, Soil Science/Plant Nutrition, Plant Pathology, Entomology, and Economics divisions. Observations on growth and production should be continued until 1994.

(2, 6, 8, 13) Density studies of cassava and maize mixtures in oil palm (1984-1990).

This experiment is used for studies by Agronomy, Plant Pathology, Entomology and Economics. Oil palm density is not a differential factor. The effects of various maize and cassava density combinations on growth and production of the oil palms should be continued until 1994.

(3-9-11) Role of leguminous cover crops on the growth of oil palm (1984-1990).

This joint experiment of Agronomy, Soil Science/Plant Nutrition, Plant Pathology, and Entomology divisions may lead to a better understanding of the role of Pueraria as a cover crop. Observations should be continued until 1994 for optimum information.

(14, 16) Effect of live mulches on the yield and incidence of pests and diseases in an oil-palm-based intercropping system.

This experiment is part of a Ph.D. study. It is very unlikely that an experiment of this unbalanced design (13 only partly related treatments, 3 replications) will yield significant results. It should be replaced by a properly designed experiment or altogether abandoned.

(15) Weed Control measures in a cropping system involving oil palm, cassava, and maize (1988-)

This rather complicated experiment of Agronomy, Entomology, and Plant Pathology divisions was designed to compare the benefits of the use of various herbicides with manual weeding. The split-plot treatments are different and sometimes unequal in number (mostly 2, but once 1 and once 3). A statistical analysis seems almost impossible, and a thorough revision of the design is recommended. Perhaps a design of 3 Latin squares, each comparing the four possible combinations of one of the three crops, e.g., (Oil Palm = OP, Maize = M, Cassava = C):

(1) OP, OP + M, OP + C, OP + M + C

(2) M, M + OP, M + C, M + OP + C)

(3) C, C + OP, C + M, C + OP + M

with split-plots (+ or - the herbicide used for the first crop of each square) would be more convenient.

5.2 Project 2: On-station Trial on Alley Cropping with Oil Palm

This is the most important project of the programme resulting from cooperation between NIFOR and IITA, and the participation of three agronomists, including one IITA scientist, a soil science/plant nutrition specialist, an economist, and a statistician. The first experiment will be implemented under this programme in 1988.

1) Feasibility of associating oil palms with Leucaena and Cassia hedgerows in a system where continuous arable cropping with maize + cassava is practiced.

This simple but well-designed experiment with a clear objective is likely to yield useful information on the ecologic and economic feasibility of a permanent mixed-cropping system of widely spaced (20 x 8 m, 62.5/ha) oil palms and maize + cassava for the humid and sub-humid tropical lowlands of Nigeria. Data should be recorded during at least 10 years from its establishment, and probably longer, for an accurate assessment of the nutrient fluxes in the system.

This experiment should be supplemented with:

i) a NPKMg experiment on a mixed-cropping system of oil palm with maize + cassava, with and without leguminous hedgerows.

ii) an oil palm spacings/densities experiment assessing growth, development, and bunch yield of the palms and the dry-matter production of a permanent intercrop (e.g., a perennial fodder crop such as Pennisetum purpureum).

Treatments could be limited to three avenue distances (e.g., 24-20-16m) and the three distances within the avenue (e.g., 8-9-10 m) yielding nine densities (52.1, 46.3, 41.7, 62.5, 55.5, 50.0, 78.1, 69.4, 62.5).

iii) an experiment comparing the dry-matter productions of Pennisetum purpureum and maize + cassava, both with and without oil palm avenues (20 x 8 m), and with and without leguminous hedgerows.

The results of these three experiments will permit determination of the ecologic and economic optimum combinations of oil palms and intercrops.

5.3 Project 4: On-farm Studies

Objective: Assess the value of new oil-palm-based cropping systems under the conditions of the small farmers.

The rationale of these experiments is that close involvement of the farmer in the execution of an experiment may help to raise his interest in the new technology, and at the same time provide the responsible scientists with direct information on unforeseen impediments for its introduction and on possible improvements or simplifications. NIFOR will participate in this project with the same subject-matter specialists as mentioned under project 1, and additional participation of the Deputy Chief Agricultural Research Officer of ADP.

The following experiments will be established in 1988.

1) Feasibility of associating oil palms with Leucaena and Cassia hedgerows in a system where continuous arable cropping is practiced.

The main treatments are similar to those of Project 1, exp. 1, with the exception that the farmers are free to choose their arable crops, but in general they plant maize and cassava. Ten on-farm experiments of this type have been implemented in Oyo State since 1986.

2) Effect of compound fertilizer rates on the yields of yam/maize/cassava crop mixtures under farmers' conditions.

3) Evaluation of the productivity of cassava varieties intercropped with maize.

These experiments (2) and 3), although interesting, bear no direct relationship with the work of NIFOR and should be taken over by the federal research institutes responsible for research on root crops and cereals.

ANNEX IV - END-USE PROGRAMME

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Annex IV

END-USE PROGRAMME

1. BACKGROUND INFORMATION

The main traditional food oils in Nigeria are palm oil and groundnut oil. Today minor amounts of cottonseed oil and soya bean oil are also produced. While palm oil is produced in the southern coastal areas, groundnuts are grown in the north.

The housewife in the village uses palm oil in the unrefined state, usually produced by primitive methods from the fruit. This oil contains all the natural red colour and has a high content of free fatty acids of 8-18%. Groundnut oil, which is much more expensive, is preferred for cooking certain dishes.

Urbanization has led to an increased demand for refined oils and an as yet relatively small demand for table margarine and other processed fats.

Demand for all oils has outstripped domestic production, and since 1980 there have been sizeable imports of oils. These have taken the form of refined palm olein, soya bean oil, and minor quantities of other oils. Imported palm olein, in particular, has been readily accepted as a direct replacement for the traditional groundnut oil.

In addition, significant quantities of inedible tallow have been imported for soap manufacture.

At the same time, the traditional export of palm kernels and also of palm kernel oil has continued.

2. PRODUCTION OF OILS AND FATS

Various sources of quantitative information on production are collected together in Tables I and II.

Table I: Palm Oil Production (x 1000 tonnes)

	1983	1984	1985	1986
FAO		700	730	760
C.B.N.	500	550	615	650
Oil World		260	297	340
M.E.U.				535

C.B.N. = Central Bank of Nigeria 1986 Annual Report

M.E.U. = Monitoring and Evaluation Unit, Benin City, of Federal Dept. of Agriculture

Discussion of Table I: The discrepancies in these figures may be explained as follows:

The MEU estimate is based on the yield total for the known areas of semi-wild groves, estates, and smallholders, calculated at 70% exploitation of the potential. This is probably a realistic figure.

"Oil World" usually obtains its data from industrial sources, and in the present instance the figure relates quite well to the potential yield from estates and smallholders, as calculated by MEU (332,000 tonnes at 100%). The FAO figures are based on land area and expected yield, and therefore represent a theoretical maximum rather than actual production.

Table II: Palm Kernel Production (x 1000 tonnes)

	1983	1984	1985	1986
FAO		340	360	355
C.B.N.		340	360	350
Oil World		176	227	210
M.E.U.				226*

* at 70% exploitation

Discussion of Table II: These figures are subject to the same considerations as those in Table I.

The production of other oil seeds is reported by the Central Bank of Nigeria as in Table III.

Table III: Production of Other Oil Seeds

	1983	1984	1985
Groundnuts	396	591	621
Cottonseed	120	108	114
Soya bean	42	43	60

Discussion of Table III: It is not known what proportion of these seeds are extracted for oil. However, according to FAO Data, domestic production of "other vegetable oils" was 100,000 tonnes in 1984 and 117,000 tonnes in 1985.

3. IMPORTS OF OILS AND FATS

Statistics from various sources on major imports are listed in Table IV.

Table IV: Imports of Oils and Fats (tonnes)

Source		(1)	(2)	(2)	(3)
Code		1985	1984	1985	1984
221000	Oilseeds*	46,198			
421900	Vegetable Oils	77,372			
422000	Other Fixed Vegetable Oils	30,542			
431000	Processed Animal & Veg. Oils	579			
411000	Animal Oils & Fats	47,480			
	Palm Oil		83,000	73,000	135,000(est.)
	Other Vegetable Oils		50,000	51,000	

* Mainly soya beans

Source (1) Federal Office of Statistics, Lagos
(2) FAO Year Book 1985
(3) Ataga - Paper presented at International Conference on Oil Palm, Port Harcourt 9/11/86

Discussion of Table IV: Although the International code contains a number specific to palm oil, no imports are recorded under that number. However, the main sources of imports under 422000 are Malaysia and Singapore and the figure therefore presumably represents mainly palm oil products.

The main source of "other vegetable oils 421900" is the USA, and this entry is probably mainly soya bean oil, but also some 5,000 tonnes of palm oil products (from Singapore and Malaysia). It seems likely that some of the palm oil products imported are reported under another classification. The entry under 411000 is probably all inedible tallow imported for toilet soap manufacture.

We were informed by trade sources that refined palm olein was the main import.

One other item of interest in the 1985 trade statistics was noted. Crude glycerol in the amount of 2706 tonnes was exported at a value of 1.34 million Naira, while 857,000 litres (approx 680 tonnes) of the pure product was imported at a cost of 2.15 million Naira.

4. EXPORTS

The Federal Office of Statistics records the following for 1985:

Palm Kernels	32,448 tonnes
Palm Kernel Oil	6,624 tonnes
Palm Kernel Cake	13,534 tonnes

5. GENERAL OBSERVATION AND RECOMMENDATIONS

Although the available statistics are not up to date or comprehensive, it is clear that there is a substantial deficit in edible oil supplies. This was confirmed in our discussions with user industries and our observations at oil mills, which have no difficulties in selling their product, irrespective of quality.

There is no reason to doubt estimates that, if no action is taken, the deficit (190,000 tonnes in 1988) will increase to 221,000 tonnes in 1990 and 315,000 tonnes in 1995.

It is therefore recommended that the End-use Research Programme should place priority on projects which:

a) maximize the use of domestic resources;

b) effect substitution for imports, especially those requiring hard currency;

c) give rise to the best cost benefit;

d) are expected to produce results for application within three, or at most, five years.

In addition, preference should be given to projects dealing with food applications and soap, which together represent more than 90% of the uses of oils and fats.

6. SPECIFIC COMMENTS ON NIFOR END-USE RESEARCH PROGRAMME 1987

The 1987 research programme contained 11 projects on various aspects of end use. Little progress had been made with this programme, mainly due to lack of equipment, but also in some cases due to inexperience in the specialized techniques required. The projects will be discussed individually.

i) Fractionation of Oils and Fats

In view of the shortage of groundnut oil and the ready uptake of refined palm olein when this was available, this project meets the criteria set out above and should get high priority. Emphasis in the experiments should be given to dry fractionation and, in particular, to a careful determination of the design parameters required for crystallization and filtration. Experience in Malaysia and elsewhere has provided ample evidence that solvent fractionation is not a useful or economic industrial technique for palm oil, except when highly specialized confectionary fats are being produced.

ii) Modification of Oils and Fats

A project on this topic is necessary and should be integrated with the needs of other projects in the end-use programme. In the first place it is recommended that work should concentrate on:

a) putting together and operating an experimental glassware refinery (five-litre scale);

b) interesterification, using chemical catalyst;

c) hydrogenation.

The proposal at present includes a plan to study enzyme-catalyzed transesterification. This should be given low priority, since it cannot be expected to give practical results within the required timescale. It may be observed that enzyme-catalyzed transesterification has not been commercialized anywhere at the present time.

iii) Studies on the Hydrolysis of Fats and Oils

Fat splitting is the first step towards various oleochemicals. The proposal is aimed at identifying a source of an active lipase, and establishing conditions for the enzyme hydrolysis of fats on an industrial scale, for the production of fatty acids and partial glyceroles.

This project is unlikely to produce an applicable technology within a reasonable timescale. At first sight, enzyme-catalyzed processes are appealing because of simplicity and their low energy requirements. In practice, however, the major practical problems are in the large-scale production and purification of the enzyme. The project should be given low priority.

iv) Novel Sources of Carbohydrates, Fats, and Proteins

Three unrelated work areas are proposed:

a) utilization of *Arecastrum romanozoffianum*;

b) preparation of wax esters from vegetable oils;

c) Synthesis of fatty alcohol sulfates;

Arecastrum is an American native which is not being cultivated in Nigeria. Research on its utilization seems to be irrelevant at the present stage. Items (b) and (c) are more appropriately considered in the overall context of an oleochemicals research programme.

v) Chemical and Biological Assessment of Fungal Biomass Grown on Oil Palm Slurry

It is understood that laboratory-scale work has resulted in a dried biomass with enhanced protein content which has been successfully used in poultry feed.

The project should be scaled up for feeding trials in collaboration with a feed meal manufacturer.

vi) Biogas Production from Palm Oil Mill Effluent

This project and the previous one are appropriately considered in the context of an overall programme on mill effluent treatment.

vii) Design and Fabrication of Prototype Machinery

The engineering group potentially fulfills a vital role in developing small-scale processing and in the translation and transfer of research findings into industrial technology. The small-scale oil mill is an example of an effective project that has been transferred to the industry as a viable entity.

It is visualized that future activity will be required in a number of areas:

a) improvement in the mini mill, e.g., steam boiler to replace open fires;

b) extension of kernel processing, e.g., fibre/nut separation, size sorter for nuts;

c) design of plant for drying protein-enriched feed component (from project 5);

d) design of fractionation equipment.

The project proposal contains as a major item the design and fabrication of a complete refinery. It is predictable that an increase in refining capacity will be required, as the production of palm oil increases, and as the consumer demand moves more from red palm oil to processed products. The most economical and appropriate system for palm oil refining is the physical or steam refining system. This technology has been fully developed in Western Europe and the United States. In these countries the emphasis has been mainly on high-throughput equipment of 300-1000 tons/day capacity because of the economies of scale.

There is, therefore, a gap in the market for small-scale commercial refineries of 1-2 tons/hour capacity. This is probably the size required in Nigeria and may well be useful elsewhere.

However, it is recommended that this part of the project be given low priority at present and that when it is activated an experienced refinery consultant should be invited to advise on the design. This would significantly shorten the time required to accomplish the objective.

viii) Preparation of Margarines

This is an appropriate project, to be integrated with projects 1 and 2.

ix) Preparation of Soap

This is an important project, and should be focussed on (a) the utilization of palm stearin, (b) the improvement of the village-level soap-making process, and (c) the recovery of glycerol, potentially a valuable byproduct. (The export and import data noted for glycerol suggest that the purchase of a small glycerol purification unit would soon repay its cost and become a profitable venture.)

x) Preparation of Creams and Lotions

This project is best considered in the context of the overall oleochemicals programme.

xi) Coconut-Shell Charcoal

It is desirable to include in the proposal some basic figures for:

a) the availability of coconut shell, including feasibility of collection;

b) the demand for charcoal in Nigeria and the types required.

Potentially, this project could save imports. However, the work plan does not at present include anything on the activation process required.

7. CONCLUSIONS ON PRESENT END-USE PROGRAMME

Most of the present project proposals are in appropriate areas. As they stand, however, the proposals are defective in a number of respects. Important work areas are not covered, and in some cases the emphasis is not placed on the most feasible approach.

It is therefore recommended that further work be done to prepare a more systematic and comprehensive set of project proposals.

8. PREPARATION OF PROPOSALS

The following considerations provide a suitable basis for the procedure:

1) The End-use programme in NIFOR is new, and is aimed at sectors of the industry not extensively serviced by the Institute in the past. At the outset, therefore, the individual research officers involved in the programme should acquaint themselves with the appropriate sector of industry. The information required includes:-

What is the structure of the industries?

What are the major companies, the medium-sized and small-companies?

What are their main products?

What volumes are produced?

What ingredients or raw materials derived from fats are used and how much?

What technical, quality, and supply problems have they experienced?

What suggestions for activities in NIFOR do they have?

What is their opinion on existing research proposals?

What are the possibilities for future collaboration with the Institute?

2) The End-use programme is conveniently divided into "Project Areas". It is suggested that the following areas are appropriate initially:

1) oils and fats process technology, refining, and modification;

2) oils and fats process technology for end uses;

3) quality improvement for palm oil and palm kernel oil

4) food technology of oils and fats;

5) effluent treatment;

6) oleochemicals, including soap.

It is expected that other project areas would be added later, for example on end uses of other palms within the Institute's remit.

It is suggested that each project area could be assigned to an officer with appropriate qualification, and he or she could then be given the specific training required. However, end-use research is necessarily multidisciplinary, and various levels of collaboration will be required in individual projects.

9. SUGGESTED PROPOSALS (in their order of priority)

In each of the project areas a number of separate projects can be specified, which cannot possibly be all carried out at once. The following is a list of project titles under each of the above areas, in a suggested order of priorities.

1) Oils and Fats Process Technology

1.1 Title: Five-litre-scale refinery
Objectives:
to assemble a five-litre-scale glassware refinery from standard laboratory glassware;
to acquire experience in operation and determine the process parameters for refining palm oil and palm kernel oil of different qualities.

1.2 Laboratory-scale "dry" fractionation of palm oil.
Objectives:
to determine crystallizing conditions and filtration conditions for obtaining palm olein and palm stearin of commercial quality.

1.3 Assembly and operation of pilot-scale (say 50 kg batch) fractionation
(Possibly the crystalliser and its controls could be designed and made in NIFOR and the filter purchased.)

1.4 Interesterification of palm oil and its fractions with other oils (on five-litre scale)

1.5 Hydrogenation (on one-litre scale)

2) Oils and Fats Process Technology for End Uses

2.1 Formulation and texturization of bakery shortenings (five-litre scale)

2.2 Formulation and texturization of margarines (five-litre scale).

Note:
This type of project requires the development of an analytical "package" to determine the physico-chemical characteristics of the products on the market and match them with the experimental formulae, and applications package to measure their performance in food products, such as cakes, biscuits, or local specialities.

3) Quality Improvement of Crude Palm Oil and Palm Kernel Oil

3.1 Quality survey of palm oil from mills of various sizes

3.2 Quality survey of palm kernel supplies and of palm kernel oil.

Note:
Palm oil is effectively produced for two markets - the industrial market, which produces refined fats and the "village-type" market, which uses red palm oil. The quality parameters of the two types are quite different, and "village-type" red palm oil is unsuitable for the refinery.

As the quantity of palm oil increases and the demand for refined palm oil increases, it will be necessary to ensure that the quality required by the food industry is available in sufficient quantity. The same applies to palm kernels and palm kernel oil.

These survey projects will lead naturally to investigation of sources of low-quality oils and to technical liaison work to upgrade the quality.

4) Food Technology of Oils and Fats

4.1 To develop standardized procedures for laboratory-prepared foods which will measure the performance characteristics of experimental fats.

Note: Initially, cakes, biscuits, fried food, and a popular Nigerian food using fat would be appropriate.

4.2 Food uses of palm-kernel oil

Note:
Currently, despite the shortage of edible oils, quantities of palm kernels and/or palm-kernel oil are still being exported, while we found considerable quantities of kernels being wasted in most of the mills visited. Apart from its potential use in margarine formulations (project 2.2) and for interesterification (project 1.4), palm kernel oil and its derived products (fractions and hydrogenated) are especially useful in confectionary manufacture. Liaison with the food industry will indicate the most profitable direction to pursue.

5) Effluent Treatment

5.1 To scale up the enriched mill effluent project and carry out large-scale trials

Note: An existing project has resulted in a protein-enriched animal feed component on a laboratory scale. This project should produce a sufficient amount for thorough feeding trials in collaboration with an animal feed company (poultry feed).

5.2 Engineering aspects of manufacturing scale for enriched mill effluent involving fermentation, separation, dehydration.

5.3 To establish knowledge of a suitable treatment process to enable mill effluent to be discharged without pollution, i.e., to reduce biological oxygen demand to a defined low level.

Note: Experience elsewhere has been that as the industry grows and mills become larger, they cause unacceptable pollution, which is eventually controlled by legislation. NIFOR should be in a position to recommend on the design and operation of suitable treatment. The knowledge already acquired elsewhere should be the starting point.

5.4 To experiment with effluent treatment using thermophilic bacteria

Note: Appropriate strains of thermophilic bacteria affect the anaerobic stage of treatment quicker and with less technical problems. The conditions of operation and control have to be defined.

5.5 Design of effluent treatment process in which biogas is recovered and used

6) Oleochemicals, Including Soap

6.1 To establish and document technology and formulae for palm-based soap at various levels of scale and sophistication.

Note: Soap requirements in Nigeria are upwards of 100,000 tons. Manufacture ranges from sophisticated international brands of toilet soap to "home-made" soaps using waste fat and wood ash. NIFOR should develop experience for technical guidance and design at various levels of technology. Large quantities of tallow are being imported for soap.

6.2 A quantitative survey of the uses of oleochemicals in Nigeria

Note: Oleochemicals have many uses in diverse industries. Many products are imported in relatively small quantities. NIFOR could not hope to develop technology in more than a few selected areas.

This survey would 1) identify possible areas and 2) establish the specifications of input fatty acids in the major applications. As a result, NIFOR can determine whether palm oil or palm kernel oil could meet these specifications and thus save imports, and whether research projects are required.

Some possible areas for local manufacture could be identified, e.g., "stearic" acid for the rubber industry, metal soaps for greases and surface coatings.

10. TRAINING FOR END-USE RESEARCH

1) Practical Training

As indicated earlier, the end-use field covers a wide range of technologies. It would therefore be appropriate to arrange specialized training for each of the officers mainly involved in the programme. This training would preferably be in an industrial setting and not in academia. The following possibilities are suggested:

a) The multinationals in Nigeria. In particular:
Levers - refinery operations
Paterson-Zochonis - soap manufacture

b) B.F.M.I.R.A. (Food Industries Research Association) at Leatherhead, England.
Analytical techniques for end-use
Confectioners technology

c) British Baking Research Association, Chorleywood, England.
Applications of fats in baked products
Test-baking procedures for performance of fats

d) Attachment to an industrial laboratory in U.K. or USA. In the writers' experience, P.L. Trading Co., (Peerless Refinery U.K.) has proved helpful in the past.

Approaches could be made through the British Council or by informal contact.

2) Technical Meetings

Participation in appropriate national and international conferences is a valuable element in the development of research staff. The informal contacts made at such conferences can be developed by correspondence and can become useful channels for exchange of information and advice.

A NOTE ON PREPARING PROJECT PROPOSALS

Major Elements. The proposal is best prepared by the research officer who would be responsible for the project. Each proposal should contain the following:

a) A title.

b) A clear objective. The objective should be very carefully specified. It is very doubtful whether it is ever appropriate to have more than one objective in a project (see discussion below).

c) A description of the background. This should contain relevant literature references. In many projects it is appropriate to carry out a formal literature review before preparing the proposal.

d) A work plan indicating the approach intended, with some detail. The work plan should preferably be broken down into activities and indicate the time span required for each activity.

e) An estimate of resources required in terms of manpower and of special equipment or expendable items. It is especially important to express quantitatively the expected demand of the project on resources elsewhere in the Institute, e.g., analytical services, engineering workshop, or external to the Institute.

f) An analysis of the expected benefit of the project. Wherever possible this should be quantified in money terms, e.g., "to establish product technology for a market of X thousand tonnes, saving Y million Naira in imports".

Statement of Objective in a Project. The objective should be specific, even quantitative if possible. It should be finite and expressed so that progress towards it can be evaluated at each review.

It is worth discussing, as an example, the objectives set down for Project 1 of the 1987 End-use programme.

Title - Fractionation of Oils and Fats

Objectives:

(1) to provide suitable methods for producing liquid vegetable oils (palm olein) from palm oil;

(2) to produce fractions of palm stearin with different properties;

(3) to identify the uses to which the various fractions could be put.

Objective (1), as written, is already amply met by reading the extensive literature on laboratory and commercial procedures. However, this technology has not been established in Nigeria. A more suitable

objective would be: to prepare kilogram quantities of palm olein and stearin under various controlled conditions.

It will be seen that Objective 2 is now redundant, since the production of olein also inevitably results in the production of stearin.

Objective 3 belongs to a different proposal, which should be written on the utilization of fractions. While experience in Nigeria shows that there will be no difficulties in marketing olein, the commercial viability of fractionation in Nigeria depends on finding sufficient profitable outlets for the stearin produced at the same time. The technology for this needs to be worked out.

Finally, the conditions for fractionation determined in the course of reaching the new objective (1) will be necessary base data if it is decided to design and fabricate fractionation equipment.

A Technical Advisory Committee. It is especially important for the End-use Programme to develop a suitable forum for the discussion of the "portfolio" of project proposals which will result from the process outlined above. This forum would preferably contain representation of senior technical personnel from the user industries, some members of the institute management, representation from appropriate disciplines at the university, and from the responsible ministry or ministries.

The forum could be a technical advisory committee to the Director, or a decision-making body on the end-use programme. Essentially, the forum would examine and critically evaluate each project proposal, discuss it with the originators and recommend on pursuit and priorities of projects.

Progress Reviews. Quite apart from the formal annual reporting procedures, each project should be reviewed informally by all the workforce involved in the project, including technicians. Such reviews can be assisted by the presence of one or two senior colleagues who are not directly involved in the work, but can offer advice based on their experience.

These reviews should include discussion of the next phase of research, and consideration of new ideas or avenues of approach that may occur. Major reorientation of a project may require formal ratification or alteration of the proposal.

A NOTE ON THE NIFOR MINI MILL

Basic Information

The information obtained on the NIFOR mill is summarized below.

1) The mill package consists of:

a) fruit bunch cookers; bunches were cut up before cooking;

b) bunch-stripper, manual operated;

c) digester - motorized;

d) hydraulic press - imported;

e) clarification unit. The expressed oil slurry from d) is placed in a heated tank with water. The oil layer is overflowed into a second tank, where it is dried by waste heat from the flue.

Units a) and e) are heated by wood fires.

2) The mini mill installed at NIFOR in normal operation requires a labor force of 10 men. One-quarter ton/hr of fruit is processed, but up to ½ ton/hr could be handled with additional FFB cookers.

No data on production efficiency or oil quality were available, since such measurements are not being made. However, we were informed that extraction efficiency was about 87%, and the free fatty acid content of the oil was below 4%.

3) Some 30 mini mills have been made, many of which are presumed to be in commercial operation.

4) Production of mills is continuing, according to orders received, at about 10 per year.

5) The price at 50,000 Naira is cheaper than that offered by commercial fabricators. The view was expressed that this was appropriate, since NIFOR is a Government body.

6) The weak element in the mill appears to be the hydraulic system, whose seals become defective after about two years of operation, resulting in incomplete expression of oil.

Conclusions and Recommendations

The mini mill is an appropriate package for the situation in Nigeria, where there are localities in which fruit is wasted because there is no access to a processing facility.

The steady demand for mills is an indication that they are meeting this need, and that the mills are profitable in operation. Our rough calculations, based on production figures from a commercial operation, confirm their profitability. There is, however, a need to extend and improve the engineering.

The following topics require attention:

1) Processes for the treatment of the fibre/nut mass from the press. At every mill visited by the team there was a total or partial waste of kernels. Efficient recovery of kernels would make a significant contribution to the deficit in edible oils or to the export trade.

There is a need for a small-scale system for separating the fibre from the nuts. A design is in hand, but the prototype is not expected to be ready before late 1988.

There is a need for nut sorting equipment. Most, if not all, mills are processing a mixture of tenera and dura fruit with kernels of widely ranging sizes. In consequence, the nut crackers cannot be adjusted to operate efficiently.

There is also a need for a small-scale kernel/shell separating system and a kernel dryer. The quality of kernel oil obtained in the extraction plants is often unsuitable for food use or for export, and effective drying of kernels will make a significant contribution to improved quality.

There is no need in the foreseeable future for small-scale kernel crushers, since the existing five large extraction plants are operating below capacity for lack of kernels.

A screw press for kernels is currently under construction in NIFOR, but it is most unlikely to function. The worldwide experience in processing kernels is that because of their hardness, they require extensive pretreatment, which usually includes four steps, i.e., hammer mill, fluted roll mill, cooker, and flaking roll mill. The NIFOR design proposes to omit all these steps. We believe it is a waste of effort.

2) Improvements in present design.

a) Design of a low-pressure boiler to replace the present wood furnaces for cooking of FFB and for heating. The system will be more fuel efficient, with reduced labor and running costs.

b) Press design - NIFOR is working on a small-scale screw press, but it seems probable that the difficulties of an effective design have been underestimated. The processing of mixed dura and tenera fruit leads to very heavy wear on the screws. (This is the weakest point in the commercial mills.) It is recommended that, as an alternative, a hydraulic press should be designed for local manufacture, incorporating modern concepts of seal design.

3) The engineers' work programme includes a project on the performance evaluation of the NIFOR mills in commercial use. This monitoring is important to enable weaknesses to be pinpointed, and advice on efficient operation and maintenance to be given. However, the engineers have not been able to travel for lack of transport. It should be given priority.

Consideration should be given to widening the concept of this project to include visits to the large-scale mills also. Quality and efficiency data in these mills is scanty. A significant contribution to the industry (and to oil production) can be anticipated if NIFOR can introduce and monitor efficiency and quality measurement.

Furthermore, all the mills suffer from spare parts problems. It is proposed that NIFOR could take the initiative in starting a mill managers' and engineers' "forum", which would meet occasionally to discuss mutual problems, and to keep in touch through a periodic news sheet. Such informal contacts within the industry can achieve significant improvements and enable the Institute to keep in touch with the needs.

4) It was surprising to us that no operating or quality data was available on the mini mill being operated at NIFOR. It would be expected that a prime objective of this operation would be as a demonstration unit to show commercial feasibility and quality to potential investors.

The lack of quality data is inexplicable in view of the fact that the engineering complex includes an adequate laboratory facility and that the NIFOR Oil Mill Company's functioning quality laboratory is on the same site.

Oil quality from the mini mills will become a crucial factor in the future, if they hope to supply the refining industries.

5) A general recommendation is that the policy objectives of the manufacturing operations should be critically re-examined. Why is the mini mill being operated and for how long is it intended to continue? From the point of view of the research project, a limited operation of the prototype is all that is required.

This re-examination is perhaps even more important in the case of the production of mini mills, which is quite a large undertaking. In our view, NIFOR should confine its fabricating activities to prototypes and their improvement. Once a functional design has been evolved, the Institute should seek to commercialize it through licence fees, sale of drawings, and consultancy. It is probable that this would be a more profitable method of exploitation. It would leave the staff free of production responsibility and able to proceed faster with new design projects.

It is recognized that the ability to earn income independent of the annual Government subvention is a basic necessity for NIFOR in present circumstances. This being so, it is obviously important to optimize the revenues. This would probably be best effected by employing a professional manager who is not involved in the research programme.

A NOTE ON THE PALM WINE BOTTLING UNIT

The operation of the NIFOR system for palm wine is as follows:

- Palm wine is obtained by tapping the flower stem of either the raphia or the oil palm.

- Tapping is carried out twice a day.

- The product of the morning tappings is collected in the afternoon (day 1). The product of the afternoon tappings is collected the next morning (day 2).

- The two tappings are bulked together and bottled during day 2. After closure with a crown cork, the whole bottles are pasteurized in water in a temperature-controlled vat, electrically heated.

- Bottles are packed 10 to a cardboard case. A pack of raphia wine sells at 8 Naira. A pack of Palm wine sells at 10 Naira.

- The wine is claimed to contain 8% sugar and 2% alcohol.

- Production capacity is 500 x 10 bottles per day and is about 50% utilized.

- The bottles used are second-hand beer bottles which are washed manually. The unit has its own electricity generator which is in working order. The sole equipment need identified was a bottle washer.

Assessment. The NIFOR process is a common-sense "package" of small-scale technology that works. The process has two important advantages over the village-produced palm wine:

1) Provided the operating schedule outlined above is adhered to, the alcohol content and flavor will be reasonably standardized, although the process is entirely empirical.

2) The bottled product has a shelf life of at least one month at ambient temperature.

It is probable that the product has considerable marketing potential, especially in the larger cities in the palm oil area, where consumers would find access to village-made palm wine difficult. There may also be a potential in the non-palm-growing areas of Nigeria and even in export. However, this potential would require larger-scale manufacture and the development of distribution networks.

It is undoubtedly desirable to have a mechanical bottle washer; the manual washing is the least-tidy part of the present operation. However, it should be borne in mind that a washing machine will have a relatively high demand on hot water and detergents and could significantly increase operating costs.

There seems to be no reason why the department should not purchase a bottle washer out of its profits. An alternative possibility would be to commission the research engineering group to design a bottle washer, which could be included in the wine bottling "kit". However, the increase in capital and running costs will be significant.

Annex V

INDICATIVE LIST OF EQUIPMENT

Qualification. The following list of equipment should not be taken as prescriptive but merely indicative of the equipment requirements of the Institute. This list was based on the submissions of the different units at NIFOR and took into account the Mission's understanding of what NIFOR's work programme might be in the next ten years.

Since acquisition costs and subsequent maintenance costs are extremely prohibitive, the Mission sought to minimize duplication as much as possible. The division laboratories were to be equipped only with standard, minimum, and very often used equipment. As much as possible, expensive and occasionally used apparatus will be placed in the central laboratory, where everybody can have access to it.

The Mission did not have the benefit of extensive discussions with the staff on their needs for specific equipment. The deliberations on the utility of equipment were conducted by the Mission members among themselves in the isolation of The Hague. Some of the equipment features and prices were obtained by telephone from suppliers in Europe. Freight, taxes, and installation costs were not taken into account in the price listings.

The Mission recommends that, at the appropriate time, management appoint an Institute Equipment Committee to deliberate more exhaustively on the equipment requirements of the Institute. For some of the more sophisticated and expensive pieces of equipment, it might be a good idea to hold in abeyance the decision on actual equipment models until the scientists requesting them have the opportunity to consult other colleagues and/or visit elsewhere and observe actual use of the equipment.

End-use Laboratory

	U.S.$
*Gas chromatograph	23,000
*Bruker NMR for solid content	20,000
*7 waterbaths for solid fat (3 refrigerated)	11,600
Fermenter	39,000
Rancimat stability tester	16,600
Vacuum pumps + vacuum ovens	9,000
2 x fume cupboards	6,000
2 x ovens	1,000
Sandbath	500
Incubator	1,300
Refrigerator	1,000
Freezer	2,000
2 x balances	6,000
Bench-top centrifuge	4,600
2 x hot plates with stirrer	500
pH meter	550
Autoclave	5,800
Inoculation chamber	2,300
Refractometer	2,000
Oxygen meter	600
2 x rotary evaporators	900
Homogeniser	900
Waterstill	1,000
*5-liter glassware refinery and ancillary equipment	11,000
Soap-making equipment	19,000
Chilled roller for margarine	30,000
Parr hydrogeneration vessel	3,500
Dilatometers	1,000
Blender	500
CO_2 meter	1,200
Shaker	1,200
Thin-layer chromatography equipment	1,400
High-speed mixer (Silverson)	1,200
Lovibond tintometer	1,300
Haake Viscometer	1,600
2 x Yamato Recirculating water pumps	1,400
Various glassware	23,000
Simon reel oven for baking	7,000
Hobart mixer + attachments	600
Balance for food technology	2,000
	263,000

*Priority items in emergency fund

Physiology Laboratories

		U.S.$
360	Vacuum pump	2,400
361	Water pump	1,000
363	Psychrometer	2,500
364	Camera lucida	2,500
365	Bath for photosynthesis	2,500
366	Warburg apparatus	3,000
367	Pyrometer	2,700
370	Freeze dryer	2,000
371	Photometer	2,500
375	Thermographs (x 2)	1,000
380	p^H meter	550
381	Incubator	3,500
383	Balance	3,000
385	Deeptreeze	2,000
387	Shaker	2,500
388	Autoclave	5,000
390	Hotplate	500
392	Refrigerator	1,000
393-4	Manometer, etc.	1,300
398	Water still	1,000
		42,450

Weed Control and Entomology

		No.	U.S.$
23	Boom sprayer	3	11,500
24	Cooper sprayer	5	2,500
25	Birky Applicator	5	1,250
26	Cosmos Applicator	5	250
308	Canon sprayer	5	1,200
309-11	Knapsack sprayer	15	3,200
312	Fog sprayer	5	2,000
313	Incubators	5	6,000
314	Ovens	3	4,600
315	Trunk injection gun	2	500
316	Light trap	10	2,500
312	Stereomicroscopes	3	14,000
318	Suction trap	10	1,200
319-21	Balances	2	5,600
322	Dissection equipment	3	750
			57,050

Central Analytical Laboratory

	U.S.$
U.V. Vis. Spectrophotometer	8,250
Kjeldahl outfit	3,850
Flame photometer	10,450
Sealing machine for plastic bags	2,400
p^H meter	550
Water still	1,000
4 large ovens, forced-air draft	15,000
2 incubators, forced-air draft	7,000
Refrigerator	1,000
Freezer	2,000
Milling machines x 4	8,000
High-speed centrifuge	11,000
Shaker	2,500
Leaf area meter	4,500
2 x hot plates + stirrer	500
Muffle furnace	2,200
Orbital shaker	1,000
Blender	1,000
Automatic pipette	300
Deioniser	3,000
Diluter	600
Conductivity meter	750
Light comparator	1,000
Atomic absorption spectrophotometer, including installation costs	49,000
Autoanalyser and accesories (includes training)	55,000
Waterbath	1,200
Thermostat	2,000
2 vacuum pumps	4,800
Grinding machine	3,000
Deioniser	4,000
Specific ion electrodes	2,500
Standard sieves	1,000
Bench-top centrifuge	4,700
Refrigerated high-speed centrifuge	27,500
Olympus microscope with polariser and photographic equipment	7,500
Simple laboratory microscope	2,500
Gas chromatograph	22,000
Thin-layer chromatography	5,000
Latroscan analytical system	10,000
Soxhlet extraction equipment	2,500
4 x fume cupboards	12,000
Infrared spectrophotometer with accesories	27,500
2 x Yamato water pumps for filtration and rotary evaporators	1,400
4 x balances	13,200
	346,150

Pathology Laboratory

		U.S.$
328	Stereomicroscope	5,000
327	Sterilisers	7,000
329	p^H meter	550
330	Sterile bench	2,700
331	Incubators	2,600
333	Microtome	500
334	Refrigerators	1,000
335,8,9	Wax embedding equipment	3,000
340	Autoclave	5,800
341	Rotary evaporator	500
342	Thermostat bath	1,200
343	Blender	500
344	Vacuum pump	2,400
349	Fermentation system	6,000
350	Colony counter	500
351	Camera lucida	1,300
354	Particle sampler	900
		41,450

Extension Service

	Naira	U.S.$
Offset printing	234,000	
Composing	12,000	
Guillotine	10,000	
Paper sorting	15,000	
Light table	1,500	
Refrigerator	3,400	
Drying cabinet	10,000	
Folding machine	66,000	
Sewing for binding	45,000	
Perforating	20,000	
Punch	15,000	
Typewriter	10,000	
Photographic - tinfoil	800	
Copy stand	2,500	
Copy camera	8,000	
Timer	1,200	
Color-print processing	31,000	
Slide Copier	5,000	
35mm camera + lenses + equipment	7,000	
Equipment-Video	56,000	
Studio equipment	58,000	
Recording equipment, projector	40,000	
Poster+Display making equipment	69,000	
	720,400	167,460
Small items and consumables		31,000
		U.S.$ 198,460

Workshops

		Naira	U.S.$
39	Lathes (2)	72,000	
40	Drilling I	100,000	
41	Milling	100,000	
42	Drills (2)	10,000	
43	Riveting	1,500	
44	Gouging	1,500	
45	Sheet cutting	5,000	
46	Disc cutting	5,000	
47	Bar cutting	2,000	
52	Guillotine	10,000	
54	Arc welding	20,000	
55	Spot welding	5,000	
56	Aluminium welding	1,500	
57-59	Reamer, roller, bender	5,000	
61	Crane	2,000	
62	Gantry	2,000	
63	Fork lift	3,000	
64	Sprayers	1,000	
65	Wood lathe	5,000	
66	Sand papering	1,000	
68	Wood planing	20,000	
69	Wood cutting	10,000	
70-72	Irrigation equipment	6,000	
73-75	Surveying equipment	12,500	
79-82	Drawing board & equipment	14,000	
83,4	Temp. measurement	5,500	
89-92	Flow measurement	3,000	
117	Thermostat controls	5,000	
118	Flange former	10,000	
121	Oxyacetylene cutter	5,000	
462	Block moulding	20,000	
463	Concrete mixer	5,000	
466	Powered hacksaw	5,000	
468	Saw bench	10,000	
470-71	Motor Workshop equipment	10,000	
473-477	Pipefitters equipment	56,000	
	Air compressor	14,000	
		563,500	U.S.$ 131,000

Met Stations

488	Wind recorders	3,850
489	Solar Radiation Integrator	700
490	Sunshine recorders	900
491	Thermohydrographs	500
492	Recording thermometer	250
493	Rain gauges	500
		6,700

Electronic/Instrument Workshops

		Naira	U.S.$
478-9	Multitesters	8,000	
480	Oscilloscope	4,800	
481-2	Signal generators	11,000	
483,486	Electrical components/spares	45,000	
487	Instrument lathe & stools	25,000	
453	Winding machine	59,000	
456	Printed-circuit machine	27,000	
458	Glassblowing equipment	6,000	
460	Micro-volt meter	2,000	
461	Thermo circulator	2,000	
		189,800	44,100

Statistics/office equipment

		Naira	U.S.$
494-497	Calculators/counters	5,000	
498-9	Sampling equipment	3,000	
500-502	Office equipment	5,000	
519-522	General office equipment photocopiers, typewriters, etc.	145,000	
		158,000	36,700