IITA
Medium-Term Plan
1989-1993

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International Institute of Tropical Agriculture
Ibadan, Nigeria

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1. BACKGROUND

As IITA approached its twentieth anniversary, it became evident that the nature and pace of its progress and the rapidly changing African scene made strategic planning an urgent and imperative task. IITA's present and projected resources would be insufficient to sustain the past research agenda and to move in urgent new directions. Sharper program focus, new and more effective modes of collaboration, and more effective strategies were needed to deal with the related issues of malnutrition, poverty and sustainability in tropical Africa.

IITA therefore launched a strategic planning study in 1986, that is summarized in a separate volume: IITA Strategic Plan 1989-2000. The study was a lengthy, multiphase process due to the scope of IITA's mandate and the complexity of the African environment. The phases of the planning process involved a strategic diagnosis of IITA's environment (the ecological, economic and institutional setting), a formulation of program objectives and a vision of IITA's future role, the setting of program strategies and priorities to realize these objectives, and the translation of these into strategic plans for the future. The present phase is the implementation of the strategy represented in this Medium-Term Plan.

The major themes in the preparation of the Medium-Term Plan were focus, integration, and cooperation:

- **focus** on the most important clients, geographic regions, agroecological zones, commodities and researchable issues to be addressed by IITA;
- **integration** of all IITA activities in order to achieve its goal of increasing sustainable food production; and
- **cooperation** and partnership with African national agricultural research systems (NARS), international institutes of the Consultative Group of International Agricultural Research (CGIAR), and those many other organizations which share its mission.

The strategic planning study did not produce easy solutions to the critical issues, but it did mobilize the best talents in the developed countries and in Africa to assist IITA in making informed judgments on the delicate balances that would make best use of limited resources:

(a) The balance in the IITA research program between the urgency of increasing food production today and the long-term research required to develop sustainable production systems.

(b) The balance between downstream, adaptive research in collaboration with national systems and the need for strategic upstream, more basic research on the technical problems that block research progress.

(c) The balance within the commodity improvement programs between concentration on a few key staples and the large number of crops that play critical roles in the farming systems of the tropical regions.

(d) The balance between research at IITA and outreach activities that strengthen the capacity of national systems to do their own research.

IITA's Medium-Term Plan, 1989-1993, presented in this volume, is the implementation or action phase of the long-term Strategic Plan. The strategies and priorities described in the Strategic Plan have been translated in this Medium-Term Plan into (a) the detailed program thrusts, staffing requirements, and financial budgets for the five-year period, 1989-1993; and (b) modes of collaboration with African NARS, international agricultural research centers (IARCs) and other organizations necessary for effective implementation. The Medium-Term Plan was approved by the IITA Board of Trustees at its semi-annual meeting during May 1988 and by the CGIAR Technical Advisory Committee (TAC) at its Forty-sixth Meeting during June 1988.

2. PROGRAM OBJECTIVES

IITA conducts international agricultural research and outreach activities in partnership with NARS, in order to contribute to sustainable and increasing food production in the humid and subhumid tropics and thereby to improve the well-being of low-income people. IITA has a long and complex formal mandate, from which its Board of Trustees has distilled four operational program objectives:

(a) To develop systems for the management and conservation of natural resources for sustainable agriculture in the humid and subhumid tropical zones. There is global concern that Africa's rapidly growing population is placing increasing pressure on basic natural resources and threatening the viability of traditional farming systems.

(b) To increase the performance of selected food crops that can be integrated into improved and sustainable production systems. This is the central thrust of the CGIAR system, the approach that initiated the "green revolution" in rice and wheat. It remains valid for tropical Africa, although the problems are more complex and the rate of achievement not as spectacular. IITA is currently conducting varietal improvement research on three primary and three secondary food crops.

(c) To strengthen national agricultural research capacities in developing countries in order to accelerate the generation and utilization of improved technologies by means of training, information and other outreach activities. The objective is to enable our partners in national systems increasingly to meet their own technology requirements.

(d) To improve quality characteristics and postharvest technologies in order to realize the more complete utilization of food crops within IITA's mandate. For a number of IITA commodities, particularly roots and tubers, the lack of efficient technology for storage, processing, and conversion to commercial products is a serious barrier to their increased use for both food and feed.

These objectives and the operating strategies described in chapter 3 are the foundation for a new sense of scientific purpose and collaboration at IITA. The Strategic Plan provides a basic philosophy and vision of the future in order to guide and enhance the policies and actions of the present. Central to this philosophy are three major themes: focus, integration, and cooperation. They guide IITA as it implements organizational changes to improve its capability to realize its goals with maximum economy and effectiveness. The objective is an IITA with a high degree of scientific creativity; with organizational cohesiveness based on a common philosophy and shared values; with a decentralized, lean operating structure; with an agroecological and systems orientation to assure that IITA understands its ultimate clients; with effective working relations with national agricultural research organizations; and with resources clearly focused on the most critical problems.

3. PROGRAM STRATEGIES

In this chapter, four program strategies are discussed that have been adopted by IITA to ensure greater focus in the use of its limited resources.

3.1 Primary emphasis on West and Central Africa

In order to increase program focus, IITA will place primary emphasis on improving the farming systems of the lowland humid and subhumid tropics of West and Central Africa. West and Central Africa account for the greater part of these lowland environments in Africa. This geographic focus is consistent with the international objectives of IITA. Research findings in Africa will be shared through germplasm exchange, publications and training with tropical zones in other continents.

In the strategic planning study, a research agenda for this region was developed without regard to the organization that might implement it. The questions were asked: How can international agricultural research contribute to the development of West and Central Africa? What are the researchable issues? What will be the socioeconomic value of improved technologies?

Having completed the strategic study, IITA is entering the implementation stage, but it clearly cannot do the job alone. It is working closely with partners, both in sister centers and in national systems, to improve existing modes of collaboration and to develop new ones that will best serve the interests of Africa.

IITA is a link in a chain that stretches from the basic research laboratories of the developed countries through national agricultural research and extension agencies to the ultimate target, the African farmer. It depends on fraternal international centers with global mandates because they have a comparative advantage in some areas of strategic upstream research and because of the diversity and quality of their germplasm.

On the other hand, IITA's comparative advantage lies in 20 years of experience with farming systems in West and Central Africa, an enormous, complex region with over 40 percent of the population of sub-Saharan Africa. IITA has infrastructure, program momentum, and long-established, strong links with the national systems of the region. At present, IITA has 50 scientists outside Nigeria working in 12 African countries. It is thus in an excellent position to facilitate intercenter cooperation and the evolution of a coherent CGIAR program to strengthen African national systems.

IITA has collaborative relationships with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Rice Research Institute (IRRI), Centro Internacional de Agricultura Tropical (CIAT), West Africa Rice Development Association (WARDA), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), Centro Internacional de la Papa (CIP), International Centre for Insect Physiology and Ecology (ICIPE), International Livestock Center for Africa (ILCA), International Network for the Improvement of Banana and Plantain (INIBAP), International Service for National Agricultural Research (ISNAR),

International Council for Research in Agro-Forestry (ICRAF), Asian Vegetable Research and Development Center (AVRDC), International Board for Plant Genetic Resources (IBPGR), International Food Policy Research Institute (IFPRI) and other international centers. Many of those relationships are described in later sections of this Plan.

3.2 Focus on the African smallholder or family farmer

The second IITA program strategy is to focus on the African smallholder or family farmer. Small farms, usually under 3 hectares, remain the basic food production unit in West and Central Africa. They employ about 75 percent of the people of the region. This means that farmers – both men and women – must be the center of concern. The aim increasingly will be to raise the productivity of farmers rather than to maximize yields from their land. Industrial or urban development cannot absorb all potential rural migrants. Most farm families have no employment alternatives to agriculture. Increasing their productivity and income is an efficient means of producing more food; it is also a moral imperative that cannot be ignored.

Among the smallholders whom IITA recognizes as beneficiaries of its research, there is a range of ability to provide those external inputs which, albeit at low levels, are necessary for sustained agricultural production. At one extreme are resource-poor farmers largely ignored by conventional research, while at the other are those smallholders who already use purchased inputs to produce a marketable surplus and who, by increasing commercialization of their operations, can become the driving force for change in Africa.

Compounded with present and future access to resources are the issues of sustainability and equity which have been raised by TAC in its report on sustainable agricultural production*. IITA recognizes the distinction between less-endowed and well-endowed regions, and that in future it will be the farmers of well-endowed regions who are likely to benefit soonest and most from the increased use of external inputs to produce and market surplus food. While acknowledging the importance of this more favored group, IITA's research strategy is explicit in allocating significant resources for work relevant to the problem of farmers in less-endowed regions.

Against this background IITA recognizes three phases in the development of technology for the African smallholder or family farmer.

First, the subsistence pattern of the lives of resource-poor farmers must be transformed by technologies which stabilize output (i.e., reduce unpredictable variation) in order to decrease risking the productivity of inputs, either internal (labor) or external. Such a stability requires (a) varieties resistant to diseases and insect pests and tolerant of adverse environmental factors; (b) biological approaches that reduce dependence on chemicals and that work with nature to solve farmers' problems; and (c) management practices that save labor and raise productivity.

The ability of resource-poor farmers to sustain low levels of crop production with few, if any, purchased inputs has largely depended upon the restorative value of natural fallow. The point has been forcefully made elsewhere that increasingly dense human populations must inevitably bring pressure to bear upon the land, which will decrease the

* Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research. 1988. Sustainable agricultural production: implications for international agricultural research. AGR/TAC:IAR/87/22Rev.2 (FAO doc. no. W/S7091). Rome: TAC secretariat, FAO.

duration and restorative value of such fallows. Finding practical ways to sustain and even to increase productivity and production by resource-poor farmers under these circumstances is the central theme of IITA's mission.

The second phase is to develop management practices that optimize the productivity of inputs so as to provide increases in output while sustaining the resource base. For resource-poor farmers, optimizing the use of labor through fallow management systems such as alley farming, or through the improvement of natural fallows, will be adequate to sustain the enhanced output resulting from first-phase technologies which stabilize production.

The third phase of technology development for smallholders is to continue to increase output while sustaining the resource base by optimizing the productivity of an increasing volume of external inputs.

While the focus of IITA research is clearly on the smallholder or family farmer, much of the technology generated by IITA is scale neutral, and is of equal value to large and small farms. Improved varieties of maize, rice, cassava, cowpea and soybean have already been adopted by large commercial enterprises in West Africa. Land clearing and soil and crop management practices, and machines and tools appropriate for large-scale, mechanized production in the forest/savanna transition zone, have been developed or selected at IITA during the conduct of a long-term land and soil management experiment at the Ibadan headquarters, and during the course of 20 years of routine farm management. Furthermore, IITA has experience in bulk seed handling, processing and storage, and with a wide range of agricultural chemicals appropriate for commercial agriculture. The experience and knowledge gained from that work has been of great value to the many enterprises which seek IITA advice.

Nevertheless, IITA recognizes a continuing need for technologies which are appropriate to sustain large-scale, mechanized agriculture in the lowland, humid tropics. For example, research on land clearing and soil and crop management has demonstrated that several existing technologies used by large commercial farms do not permit sustained production. Those can be modified utilizing IITA's understanding of the processes involved in productivity and sustainability.

3.3 Agroecological orientation

The third program strategy is to establish small research substations or satellites in the key ecological zones of West and Central Africa. Decentralization of research is a logical stage in the evolution of IITA. In the first stage of its history, it was apparent that commodity research could make the greatest impact by developing germplasm resistant to major diseases for use by national systems. With access to genetically diverse germplasm and sophisticated research support, the commodity scientists could do this work most effectively at IITA headquarters.

Moreover, they were notably successful in breeding resistance to major pathogens – cassava bacterial blight and African mosaic disease, diseases of maize such as lowland rust and blight and the streak virus, rice blast, and numerous cowpea diseases. These successes now permit a significant decentralization of research from Ibadan headquarters to the zones where the commodities studied are important food crops.

The key zones in West and Central Africa are the humid forest, the narrow forest/savanna transition where IITA is situated, the moist savanna, and the inland valley ecosystem which is to be found in all three of these zones. Table 3.1 (overleaf) shows the importance of IITA commodities in these zones.

The forest and transition zones together represent over 50 percent of the land area within the countries of West and Central Africa. They are characterized by high rainfall, ranging from around 1,400 mm to over 4,000 mm annually, with from 6 to more than 9 humid months when rainfall exceeds evapotranspiration. Half or more of the forest areas is covered by acidic ultisols and oxisols with low inherent fertility and long fallow requirements. While the original forest cover helps to mitigate the effects of intense rainfall and to maintain a stable recycling of nutrients, widespread cultivation removes nutrients and exposes the soil to the effects of rain, heat and sunlight. This can lead to rapid loss of soil productivity through leaching, acidification, erosion and structural deterioration. The forest zone of West Africa contains close to half its total population on less than 40 percent of the region's area, and thus has the highest population densities of the region.

The farming systems in most forest zones have remained productive because smallholders have a wide range of strategies to maintain and restore soil productivity – including various shifting cultivation and bush fallow rotations, complex cropping patterns and sequences, mixtures of tree crops and annuals, and intensive compound gardening. These function to replicate the protective and fertility-restoring effects of the original forest cover. Nonetheless, serious degradation has already occurred in a number of areas, and in many others the ability of current practices to maintain productivity is threatened, either by population pressures in the high-density areas or by labor shortages in the low-density areas. To meet this challenge, IITA's research will emphasize technologies which stabilize output in order to decrease risking the productivity of inputs, and management practices (e.g., alley farming) will be developed that optimize the productivity of inputs while sustaining the resource base.

The moist or Guinea savanna zone of coastal West Africa includes almost 45

Table 3.1 The importance of mandated commodities by agroecological zone

	Humid forest	Transition	Savanna moist	Savanna dry	Inland valleys
Cassava	XXX	XXX	XX	X	X
Maize	X	XX	XXX	X	X
Rice[a]					XXX
Cowpea		X	X	XXX	X
Soybean[b]					
Plaintain	XX	X			
Yam	XX	XXX	XX		
Crop systems (basis of working groups)[d]	cassava	cassava/ maize	maize	sorghum/ millet[c]	rice

Notes

The number of crosses indicates the relative importance of IITA's mandated commodities in each agroecological zone.

a IITA works on rice only in the inland valley ecosystem which occurs in all zones.

b Soybeans are not a significant component of any West or Central Africa farming system at this time. Nonetheless, research into their potential will be undertaken in the transition and moist savanna zones, and the inland valleys.

c IITA cowpea breeders collaborate with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in this crop system.

d The crop-based systems working groups are described in chapter 4 of this volume.

percent of the area, but only 30 percent of the population of the region. It is an area of considerable agricultural potential, particularly for arable crops. In this well-endowed region IITA's objective will be to stimulate continued increase of output while sustaining the resource base by optimizing the productivity of an increasing volume of external inputs. Intense solar radiation during the growing season, warm day temperatures, and relatively low night temperatures favor high biomass potential. However, the soils of most of the moist savanna zone require careful management to sustain production.

Rice ecosystems are not restricted to a major zone. The most important classification criterion is the water regime, since technology requirements and production constraints differ markedly in a moisture continuum from flooded inland valleys to dry uplands. Within the inland valleys there are hydromorphic areas characterized by the presence of an underground water table which fluctuates in level during the year from 60 cm below the surface to above ground. These soils can often be continuously cropped with rice in the rainy season, followed by other crops whose root systems exploit the underground water in the dry season. While technically they are rainfed uplands, they

are treated as a separate category because the availability of soil moisture associates them more closely with lowland areas, in terms of their rice production potential and technology needs.

These inland valleys are for the most part underutilized. They have been estimated to comprise collectively some 85 million hectares. Many reasons are given for this lack of development – including health hazards, scarcity of labor and of investment resources needed for improvement, and an absence of population pressure on the land. It is also believed that cropping systems well adapted to this ecosystem have not been available to farmers.

IITA plans to locate one research station in the humid forest zone, primarily for work on cassava and resource management, two others in the savanna for work on maize and cowpeas, and a fourth in an inland valley for rice research. An exception to the regional and agroecological focus will be the extension of cassava research to a substation for the mid-altitudes of East and Southern Africa in collaboration with the Southern African Centre for Cooperation in Agricultural Research (SACCAR). These research stations will be staffed with small teams of scientists who will be able to set research objectives based upon close study of the farming systems in the zone in which they are living. With strong support from Ibadan headquarters, they will increase IITA's ability to help national programs in the region.

3.4 Farming systems orientation

The fourth program strategy is to inculcate a farming systems orientation throughout IITA. This will assure that the technology generated will be productive in the real world of the African farmer. Interdisciplinary cooperation is needed to integrate research on improved varieties with work on management practices. Too often in the past, crop improvement scientists have worked independently from one another and from scientists involved in farming systems research.

After considering various organizational alternatives for promoting multidisciplinary collaboration, the simple innovation of interprogram crop-based systems working groups was adopted. The commodities that serve as the base for these working groups are shown in table 3.1. This new mechanism, described in chapter 4, is leading to a profound reorientation in the way that IITA scientists think about their research.

4. INTEGRATION OF THE RESEARCH PROGRAM

The purpose of this section is to explain how IITA's apparently diverse research activities are integrated to achieve the overarching objective: to develop sustainable food production systems that are appropriate for and acceptable to the smallholder family farms of tropical Africa.

Agroecological diversity in Africa was a major factor in the development of IITA's Strategic Plan, and subsequently of this Medium-Term Plan. It provided a natural framework for the assessment of the present and future economic significance of commodities; of commodity relevance indicators and research productivity*; and of researchable issues related to sustainable production systems. The importance which IITA attaches to this diversity is reflected in the agroecological focus of the plans for research (chapter 6), and of the strategic decision to decentralize to substations in key ecological zones (chapter 3).

Furthermore, it provides an orientation for the integration of IITA's three major activities or thrusts: resource management research, commodity improvement, and crop management research. This integration of research by agroecological zone is illustrated in table 4.1 which shows IITA's strategic vision of how its resources should be allocated by the end of the Plan period in 1993.

4.1 A framework for resource management research

Natural resource management research involves the search for sustainable production systems. This task, fundamental to African agricultural development, is an enormously complex and long-term undertaking, a problem unlikely to be solved until the twenty-first century. Increasingly dense human populations which practice increasingly intensive land use have caused the bush fallows of traditional shifting cultivation systems to be significantly shortened in many areas, resulting in sharply declining soil productivity. The process has especially acute consequences in the humid forest zones of Africa, where the deeply weathered, acidic soils lose fertility rapidly under repeated cultivation. Here there is an irreducible need for fallow periods to restore productivity. Some of the most densely populated areas in Africa are in this humid zone.

Resource management research involves three conceptual stages which are based on IITA experience in the forest/savanna transition zone at Ibadan:

(a) Measurement of the physical, chemical and biological elements of the natural resource base, and of the socio-economic implications of its exploitation.

(b) Analysis of the determinants of stability and degradation of the resource base by studying the dynamic interactions of these elements. This includes, for example, studies of transport and

* Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research. 1985. TAC review of CGIAR priorities and future strategies. AGR/TAC:IAR/85/18 (FAO doc. no. W/R5796). Rome: TAC secretariat, FAO.

storage of water and nutrients; of soil erosion; and of fertility as measured by the physical, chemical and biological properties of the soil and their effects on biomass production.

(c) Designing resource management systems. The principles identified in the analysis of the determinants of stability and degradation are used in modifying resource management practices, or in designing new ones which are capable of stabilizing or increasing output while avoiding degradation of the resource base.

The traditional smallholder system for resource management has involved alternating crops with fallow under natural vegetation. The vegetative cover stops wind erosion and virtually eliminates water erosion. The multilayered network of roots and the buildup of organic matter reduces erosion and leaching by slowing downward movement and intercepting and recycling the major portion of the potentially leachable components. The deeper roots of the trees absorb minerals that are not available to the shallow roots of annual crops and deposit them in and on the surface soil through leaf litter. This not only establishes a greater reservoir of available nutrients upon which the crops can draw, but enlarges the volume of soil in which weathering steadily makes more of the total minerals available for biological processes. Finally, shade, surface mulch and root competition combine to eliminate the light-demanding weeds that normally occur in cultivated fields. However, population

Table 4.1 Summary table of "essential" senior scientist-years by major research activity and agroecological zone, 1993

Research activity	Humid forest	Transition	Savanna moist	Savanna dry	Inland valley	Mid-altitude	Total
Number of senior scientist-years							
Commodity improvement	9.5	5.5	9.3	3.5	2.0	1.2	31.0
Resource management	9.0	6.7	3.3	0	3.5	0	22.5
Crop management	7.2	4.7	3.6	0	3.0	0	18.5
Total	25.7	16.9	16.2	3.5	8.5	1.2	72.0
Percentage of senior scientist-years							
Commodity improvement	13.2	7.6	12.9	4.9	2.8	1.7	43.0
Resource management	12.5	9.3	4.6	–	4.9	–	31.2
Crop management	10.0	6.5	5.0	–	4.2	–	25.7
Total	35.7	23.4	22.5	4.9	11.9	1.7	100.0

pressures continue to increase, land has been left fallow for shorter periods and, as subsequent soil rejuvenation has become inadequate in many cases, crop productivity has declined.

This situation can be improved by resource management systems that maintain or increase the organic matter content of the soil and replace the nutrient elements removed by crops, or by erosion or leaching. One such cropping system is alley farming developed through research at IITA's Ibadan headquarters mainly for the forest/savanna transition zone. The basic principles, the research method, and some of the specific components of this new resource management technology are applicable in the moist savanna and humid forest zones (section 6.2).

Recommendations arising from resource management research generally call for changes in the cultural practices currently in use by African smallholders. The socioeconomic viability of new technologies or changes to existing practices needs to be determined on these farms. This is done, along with testing improved commodity components, by IITA's crop-based systems working groups.

4.2 Commodity improvement research

IITA presently has four commodity improvement programs, whose research is integrated at three levels of activity:

(a) Within IITA, by the participation of commodity scientists in the on-farm research of the crop-based systems working groups. By this means they obtain first-hand experience of the smallholders' environment and problems as they work in teams with resource management scientists, agronomists and agricultural economists.

(b) Within the West and Central African region, by IITA's work in partnership with the scientists of national commodity improvement programs, which goes beyond the exchange and testing of improved germplasm. IITA's commodity scientists have frequent opportunities to exchange views with and to learn from their counterparts in national programs through visits and monitoring tours, at occasional workshops and conferences, and through participation in regional commodity improvement networks.

(c) Within the context of the CGIAR, by collaboration with other IARCs whose global concerns are relevant to IITA's commodity improvement objectives. Such collaboration brings to Africa the benefits of germplasm held by IARCs, and of their basic research.

4.3 Farming systems research

During the strategic planning process at IITA, the organizational structure of research was revised so that IITA currently has three major thrusts, all of them integrated through their focus on the major agroecological zones of the region, and through their work in partnership with the scientists of African national research systems.

These thrusts are:

(a) To study the natural resource base, and to refine existing and devise new resource management technologies in the context of the smallholder. IITA calls this resource management research.

(b) To breed improved crop varieties that stabilize and increase the smallholders' productivity. This is called commodity improvement research.

(c) To synthesize the products of these two thrusts into sustainable and productive cropping systems compatible with the resources and objectives of the smallholder. This is called crop management research.

On-farm research by agronomists, economists and other scientists in collaboration with the scientists of national programs has always been a part of IITA's program. While this has included testing improved varieties, as well as other innovations, it has proved difficult to integrate these on-farm studies with the work of the commodity improvement scientists. There has been insufficient feedback from on-farm research to the commodity improvement programs; and it had also at times been difficult to integrate the shorter-term research on crop improvement with resource management research done by soil and other physical scientists. To conduct multidisciplinary farming systems research, there was need for an organizational mechanism to achieve the essential linkages and feedback between resource management and commodity improvement research.

Multidisciplinary working groups have been established for cassava-based, maize-based, and rice-based farming systems, named after the predominant IITA mandated crops in the forest and moist savanna zones and the inland valley ecosystem. This integration by agroecological zone is shown in table 3.1. Each group includes a full-time agronomist and agricultural economist as well as breeders for the system's major and secondary crops (e.g. grain legumes). A soil scientist, weed scientist, entomologist, pathologist and a postharvest technologist are also regular group members, depending on the particular issues being explored. Different group members participate to varying degrees in each of the main projects and activities defined by the group, some of which are described (for the cassava-based working group) in the appendix.

The general goals of each group are to examine the constraints and potentials of these crop-based systems and to devise appropriate research agendas for farming systems improvement. They have three functions:

(a) A service function involving on-farm screening, testing, and evaluation of technologies generated by experiment station research.

(b) An adaptive research function involving the adjustment or adaptation of existing technology to a particular set of environmental conditions, either agroecological or socio-economic, through on-farm research.

(c) A feedback function providing relevant information from farm-level

characterization, diagnosis, and/or adaptive research to scientists developing resource management technologies or breeding improved varieties at research stations.

The three working groups conduct diagnostic surveys and further base data collection to identify key production constraints, determine the distribution and impact of improved crop varieties, analyze the agricultural potential of the region(s), and identify the main opportunities for improvement. Because commodity improvement scientists participate actively in each group, their farming systems orientation is strengthened, and their enhanced knowledge of the ultimate client improves their ability to define appropriate breeding objectives. Furthermore, the working groups offer excellent opportunities for cooperation with the scientists of national programs.

Although IITA cannot focus on all the variations of ecological conditions and farming systems even in its primary area of focus, it can work with national programs to develop methodologies for cropping systems research and can produce prototype systems. National program scientists can then refine and adapt them for use in their own countries. Moreover, the contributions of national scientists are extremely important in assuring that the methodologies and prototype systems coincide effectively with the resources and capacities of existing institutions. The working groups have initiated contacts with national programs already well known to IITA, and such collaboration is expected to comprise a significant part of their research agenda.

In summary, IITA has established a research framework that will promote the integration of three major activities: (a) resource management research, (b) commodity improvement, and (c) farming systems research to achieve a common objective – to develop sustainable food production systems that are appropriate for and acceptable to the smallholder family farms of tropical Arica. Central to this framework is the integrative function of the crop-based systems working group which ensures linkages and feedback between resource management and commodity scientists as they work together with economists in the study and improvement of smallholder production systems. Furthermore, several initiatives have been taken to strengthen existing linkages with the scientists of Africa's national research systems, for it is through them that IITA reacts to the needs of its ultimate clients in a continent so diverse as Africa. Chief among these initiatives are the IITA research liaison scientists and country teams, the visiting scientists from African national programs, and the increased emphasis on postgraduate research training for the future leaders of national systems.

5. PROGRAM PRIORITIES: RESEARCH AND INTERNATIONAL COOPERATION

5.1 Resource management research

A. AGROECOLOGICAL PRIORITIES

IITA has accumulated data and information from almost two decades of research on the non-acid soils of the subhumid forest/savanna transition zone, where its headquarters are located. The first priority in this Medium-Term Plan is the synthesis of technologies developed there into systems to be tested on-farm by IITA crop-based systems working groups and collaborating national scientists.

IITA will also launch an integrated resource management research program for the acid soil environment at its new substation in the forest zone. Drawing upon experience at Ibadan, the scientists should progress more rapidly through the phases of base data analysis and technology development to the on-farm testing of new systems. Special emphasis will be placed here on alley farming which is believed to be the most promising sustainable system to emerge from IITA's research on resource management.

B. BALANCE BETWEEN RESEARCH ON RESOURCE MANAGEMENT AND COMMODITY IMPROVEMENT

In setting priorities for the future, IITA has had to decide the appropriate allocation of funds between research on resource management and on commodity improvement, recognizing that they must be linked at the level of IITA's research on farming systems. This linkage is achieved by their integration in the research of the crop-based systems working groups. Such linkage is imperative because there are significant differences between research on resource management and research on commodity improvement.

There are differences in research complexity and time horizon. The CGIAR Impact Study estimated that an international center should be able to develop and test a new crop variety within 6 to 15 years. There are no models, however, for creating resource-management innovations.

There are differences in extension potential. New varieties are relatively simple to integrate into existing farming systems. Resource-management innovations require changes in existing practices which usually yield benefits only after some time. Thus, it is more difficult for family farmers with limited resources to adopt them.

There are also differences in focus within the agroecological zones of the humid and subhumid tropics. The two areas with the highest potential for producing marketable surpluses in the short run are believed to be the forest/savanna transition zone and the moist savanna of West Africa. The most profound problem, and one that IITA is uniquely positioned to handle, is the need for sustainable and productive systems to support the population that will be living in the more-humid zones

during the twenty-first century.

There is no conceptually correct or optimal balance between the resource management research and the commodity improvement components of IITA's program. But both opportunities and needs were considered in reaching a policy decision to increase gradually the relative level of funding for resource management as a percentage of the total research budget. This will permit IITA to expand research in the less-favored forest environment where soil degradation is increasing poverty and, in a vicious circle, poverty is accelerating soil degradation. Although this research may have limited impact in the short term, IITA considers itself responsible as trustee for this mandate in the CGIAR system to assist the generations which must cultivate those lands in the future.

5.2 Commodity improvement research

A basic premise of the strategic planning exercise was that the scope of IITA commodity research should be reduced in order to bring available resources more effectively to bear on the critical problems. It was necessary to make critical choices concerning IITA's future commodity improvement research agenda. There were three special aspects of the analytical process:

(a) Thorough economic studies of the present and future significance of potential commodities were conducted, and the constraints to increased production were studied in the context of farming systems and key agroecological zones. The relative significance of the production of these commodities in the region is shown in table 5.1, although these data should be interpreted in the context of the full analysis set forth in the Strategic Plan volume.

(b) There were extensive consultations with many Africans concerning the commodity agenda. IITA is in close contact with the national systems because of the many African scientists on its staff and the presence of IITA scientists working in many African countries.

(c) IITA defined its comparative advantage in each case vis-a-vis other institutions. If another institution could conduct the research as well as IITA, it was encouraged to share the responsibility for IITA's notoriously complex mandate.

The IITA Board of Trustees established the following strategies for

Table 5.1 Indices of the importance of mandated crops in West and Central Africa, 1982-1984

Crop	Net food production[a]		Population for which the crop is a staple food (millions)[b]
	energy	protein	
Cassava	100	100	125
Maize	39	112	105
Rice	15	35	60
Cowpeas	6	52	–
Yams	47	94	60
Sweet potato	7	16	10
Plantain[c]	14	16	40

Source
Calculated from FAO production data, food balance sheets and food composition tables, for the period 1982-1984.

Notes
a Index of net production (gross production less seed and losses) with net production of cassava defined as 100.0.
b Millions of people whose average consumption of the crop is 200 or more kilocalories per day.
c Does not include cooking bananas.

commodity improvement research:

(a) IITA should have three major commodity improvement programs – cassava, maize, and cowpeas. Each program should have highly focused research agendas that are described in section 6.3 of this volume. In addition, IITA will continue small but sharply defined improvement programs for three commodities of special importance in the tropics – yams, plantains, and soybeans.

(b) IITA terminated research on cocoyams and has transferred its global mandate for sweet potato improvement to CIP. IITA scientists have been successful in improving sweet potato varieties for Africa. African scientists, inside and outside IITA, wanted IITA to continue this work because sweet potatoes are a crop with great potential in Africa. The decision was made, nevertheless, because CIP is able to devote more resources to sweet potatoes and this is in the interest of the CGIAR system and of the African farmer. CIP and IITA will work closely together in outreach activities with national systems for roots and tubers in Africa.

(c) Rice improvement research will be phased out because of the recent revitalization of WARDA. The IITA Rice Research Program has a momentum growing out of 15 years of experience in breeding rice for major African agroecological zones, training African scientists and technicians, and close collaboration with national systems in the region.

After a thorough study during 1986-1987 of the present and future significance of rice in Africa, it was decided to maximize the impact of the rice improvement program by focusing limited resources on a single ecosystem, the inland valleys. This ecosystem seemed to be particularly appropriate for IITA because research has indicated the potential for greatly increasing food production, while at the same time increasing the sustainability of the farming system through improved water management. Farmers in the inland valleys not only grow rice, but many other crops as well, and frequently have to make choices about the allocation of their scarce resources (especially labor) to maximize their returns. The rice-based farming systems group can tap the expertise of scientists in all the relevant programs. Thus, IITA can strive to improve the farming system as a whole.

An important reason for focus on the inland valleys was to complement WARDA's research, which previously had not involved this ecosystem. Since WARDA has been reorganized, IITA has changed its strategy so as to assist WARDA to build a strong rice program for West Africa. IITA will reduce its rice improvement program as WARDA becomes increasingly operational, and it will collaborate with WARDA in farming systems research on the inland valley ecosystem. During the transition, TAC has advised IITA to continue the rice improvement program in order to support WARDA, while meeting the needs of a vast potential area of sub-Saharan Africa. Furthermore, IITA will discuss with IRRI and WARDA the rice research needs of Africa which lie outside the WARDA geographic mandate. The three institutes will make their recommendations to TAC.

PRIORITIES FOR THE COMMODITY IMPROVEMENT PROGRAMS

Commodity improvement research is described in greater detail in the next chapter on program plans, which elaborates on each budget line item in table A-1, "Essential program requirements, 1988-1993" of the annex to this volume.

Cassava improvement
IITA has a continental mandate for cassava in Africa, and it has been successful in developing improved varieties and breeding populations that are high-yielding, resistant to two devastating diseases and low in cyanide. In the strategy for the future, highest priority will be given to breeding cassava for local adaptation to diverse environments and cropping systems, with increased emphasis on the humid forest zone where a research substation will be established. IITA will begin work on the crop in East Africa or Southern Africa and in the more arid zones of Africa in cooperation with CIAT. IITA is also increasing research on postharvest technology and utilization of cassava. The processing of cassava, largely by women, requires more labor than does production of the tubers. With appropriate processing, cassava has a great potential as a source of cheap food for urban populations.

Maize improvement
IITA will continue a full-scale commodity improvement program for maize because of its importance as a source of food and feed, because of its high labor productivity, and because of the potential for rapid impact. TAC approved funding in 1988 to establish a maize research station in the West African moist savanna, an area where maize is replacing sorghum and where production is expected to grow most rapidly. A major research objective there will be breeding resistance to *Striga*, a parasitic weed that attacks several traditional crops in this zone. Breeding objectives for the humid forest zone include resistance to stem borers and pathogens such as downy mildew and ear/stalk rots. Agreement has been reached with CIMMYT for collaboration on maize improvement for Africa.

Cowpea improvement
The third major commodity, and one for which IITA has global responsibility, is the cowpea. The future strategy is to focus more sharply on tropical Africa. IITA is shifting from breeding varieties suitable for sole crop production to those adapted for the cereal intercropping systems of the savanna where at least 80 per cent of African cowpeas are produced. The overriding biological constraint to cowpea grain production in African farming systems is the damage caused by post-flowering insect pests. Resistance breeding at IITA will involve collaborative upstream research with advanced institutes in the developed countries.

Other commodities
In addition to major research on these three commodities, IITA will continue small, focused improvement programs on three additional commodities: soybeans, yams and plantains. In all these cases, IITA has received strong and high-level requests for this research from leaders of African national programs.

IITA breeders removed two serious obstacles to soybean production in Africa: poor seed longevity and the need for artificial inoculation with rhizobial bacteria. This gives the resource-poor farmer the means to produce a high-protein, nitrogen-fixing food crop with no more inputs than are used to produce traditional food legumes. The principal constraint to increased production is the low level of present demand. IITA will support a single breeder to sustain our capability to expand the program rapidly if the level of demand increases.

Established methods of commodity improvement are not readily applicable to the two remaining commodities: yams and plantains. It is expected that IITA's capability in cell and tissue culture and cytogenetics will provide comparative

advantage in improving these two crops, as well as cassava, for the humid tropics. IITA expects over the next several years to employ a cell and tissue culture scientist and a cytogeneticist for this purpose.

In the case of plantains, the critical issue is the appearance in West and Central Africa of black sigatoka disease. There are also alarming reports of its presence among starchy bananas in East Africa. IITA will initiate a breeding program with first priority on resistance to black Sigatoka. This work will be carried out in close collaboration with INIBAP.

5.3 International cooperation

Although the research described earlier is conducted in close collaboration with scientists of national programs, IITA has additional specific mechanisms for promoting partnerships with NARS: training, resident scientist teams, and information services. The goal is to strengthen the capability of national systems to use and generate agricultural technology to satisfy their own national needs.

IITA is acutely aware that the technology it generates is of little value in the absence of effective mechanisms to share it with national programs in West and Central Africa. There is a special problem, however, in West Africa, as stated in the World Bank review of West African agricultural research:*

> ... Most countries are too small to finance their respective national research on a scale needed to meet their total requirements. Small countries cannot individually and independently support research on their agricultural activities at levels required for sustained progress. Of the 24 countries of the region, six have populations of less than 1.0 million each, eight lie between 1.0 and 5.0 million, seven are between 5.0 and 10 million and only three are above 10 million. Further, ecological [variations] subdivide most countries into several zones of crop and agricultural enterprise adaptation. Thus the units of agro-ecological adaptation within each country are quite small, with resultant small units of affordable investment in agricultural research.

IITA places high priority on understanding the needs of national programs of all sizes and stages of development. IITA scientists have consulted with national systems throughout the region and invited leaders to IITA for special meetings to discuss alternative modes of collaboration. There is agreement that it is essential to distinguish national systems' requirements at different stages of institutional development. Table 5.2 (overleaf) presents a model illustrating how IITA mechanisms for collaboration with NARS should develop as the national systems grow in strength. This conceptual framework does not imply linear progress from stage to stage nor any moral judgment. It merely emphasizes that IITA must be prepared for a dynamic relationship with each national system that will be continuously evolving and changing over time.

With greater knowledge of the requirements of national systems, IITA intends to adopt a more active association with them. IITA has the largest portfolio of special projects in the CGIAR system, most of which have funded international cooperation activities. This has enabled IITA to engage in a wide range of collaborative activities that extend technologies to specific agroecologies and help strengthen national systems throughout Africa. Most of the training activities at IITA, for example, have been supported by special project funding with impressive results. Since 1972, IITA has trained over 5,000 Africans, mostly technicians in group

* World Bank. West Africa Projects Department. 1987. West Africa agricultural research review (World Bank 1985-86), p. 4. Washington, D.C.: World Bank.

Table 5.2 IITA – NARS collaboration by stage of NARS development

Stage of development	Commodity improvement		Crop and resource
Stage I:	IITA	NARS	
Early	- Adaptive breeding of finished varieties for NARS	- Multi-locational testing of IITA varieties	Joint IITA – NARS participation in the description
Stage II:	IITA	NARS	IITA
Medium	- Applied breeding of parental lines for NARS	- Line selection; national variety development and testing	- Share component technologies and methodologies for combining into improved systems
Stage III:	IITA	NARS	IITA
Mature	- Maintenance breeding - Pre-breeding research (biotechnology)	- Major breeding program for national agroecological zones	- Long term, strategic, basic research on crop and resource management problems, including methodologies

courses, but 7 percent of that total has been scientists receiving research training for postgraduate degrees. IITA scientists collaborate with IITA alumni who are rapidly moving into key positions of responsibility in African national systems. While their accomplishments have been substantial, the rapid expansion of such programs, has strained management's capability to maintain the standards of an international institute and the diversity of projects has blurred program focus.

During implementation of the Medium-Term Plan, IITA will develop partnerships with NARS that are closely linked to the strategic needs at their respective stages of development. This will lead to a reduction in the total volume of such activities but an enhanced focus that will particularly benefit the least-developed national systems. Over the Plan period, there will be a gradual reduction in activities considered desirable, while essential activities will increase.

The Plan provides for research liaison scientists to study the requirements of individual NARS and to link them to IITA and other sources of technology. They will facilitate communication, identify training needs, determine effective locations forresident scientist teams, and generally ensure that IITA is

management research	Mechanisms for collaboration	
	IITA	NARS
of existing systems and constraints analysis	- Resident scientist team - Training of technicians and MSc candidates	- Counterparts to resident scientist team - Training of selected technicians and graduates
NARS	IITA	NARS
- Testing commodities and component technologies in national agroecological zones	- Resident scientist team phases out - IITA research liaison scientist provides linkage - Training of PhDs and trainers starts	- MScs return from training and assume responsibility - PhD candidates selected - In-country technical training is prepared
NARS	IITA	NARS
- Adaptive on-station and on-farm research - Testing new farming systems - Participation in regional activities (networks, NARS-to-NARS exchanges)	- IITA research liaison scientist continues linkage - NARS visiting scientist - IITA trains trainers and provides training materials	- PhDs assume leadership - Technical training conducted for national and regional requirements

moving toward a constructive partnership with the NARS of the region.

The three principal mechanisms for promoting such partnerships — training, resident scientist teams, and information — are discussed below.

A. TRAINING

In addition to research, training is an integral part of IITA work. In the long run, training may be the most enduring IITA contribution to the solution of Africa's food problems, and it warrants the highest priority. Like the other IARCs, IITA has a unique comparative advantage in training because of its intimate involvement in applied agricultural research. In wider terms, Professor A.H. Bunting (a former chairman of the IITA Board of Trustees) has generalized that "through its special advantages of continuity and cooperation, the international agricultural research system is building up living linkages in a worldwide invisible college, based on continuing personal relationships, which has no parallel anywhere else."

Various studies suggest that an enormous number of people professionally trained in African agriculture will be required: 5,000 people by the year 2000 for West Africa alone. Clearly, IITA can meet no more than a small proportion of Africa's requirements for trained people.

IITA's capacity is constrained both by financial resources and by the accommodation available on the Ibadan campus, which is already fully utilized. Therefore, it is necessary to establish clear priorities based on an understanding of IITA's strengths and the needs of national systems at different stages of development. Four priorities have been established for the Plan.

(a) IITA will devote more core resources to training in order to have more control over the basic decisions on training priorities. In the past, training courses have been financed largely through the support of bilateral donors to individual course participants. This has sometimes made it difficult for IITA to make full use of its insight and judgments concerning training decisions.

(b) IITA will shift emphasis on campus at Ibadan from group training to individual research training, especially of Africans at the PhD and postdoctoral level. There is an important need to apply IITA's substantial research resources to the training of advanced researchers who will be able to address African problems in and through African national institutions.

(c) IITA will continue its current efforts to decentralize group training to national institutions in response to their requests to support more "in-country" training. IITA will help to determine what courses to develop, plan curricula, prepare training materials and train nationals how to teach the courses, i.e., train the trainers.

(d) IITA will seek effective means to increase the proportion of women participants at all levels. The record of the past four years shows that only 6.8 percent of African trainees at IITA were women. Given the important role women play in African agriculture, this record is simply unacceptable. IITA has an affirmative action program to identify and encourage women to apply for on-campus training opportunities.

B. RESIDENT SCIENTIST TEAMS

IITA currently has 46 scientists working in teams to provide assistance to NARS by strengthening their institutional capacity to conduct research. These scientists are classified in the Plan as desirable but not essential.

Although IITA performance in these projects is considered successful, IITA intends to phase down these commitments and replace them with a small group of experienced scientists to continue this as an essential service to NARS. IITA has a responsibility to assist in the process of building such NARS capacity to the extent that it has a comparative advantage and that such activity does not weaken its vitality as a research institute. These scientists will be assigned in teams of 2 or 3, if feasible in association with scientists from other centers, to NARS at an early stage of their development. (See table 5.2.)

High selectivity will be required to locate such scientists strategically to countries where the maximum benefits are possible. IITA's liaison scientists will help in identifying countries where there is a demand for such assistance and the strong institutional commitment needed to make it successful.

C. INFORMATION

Information activities will be an increasingly active mechanism for collaboration with national systems. Major essential activities will be library services, publications, development of data bases, public information, and video technology application. Desirable additions are a scientific literature service to NARS, training for scientific editing and technical publishing, and an extension of the library.

6. PROGRAM PLANS: MANPOWER AND BUDGETARY REQUIREMENTS

This section presents a detailed discussion of each line item in the summary budget of table A-1 in the annex to this volume: "Essential program requirements, 1988-1993".

6.1 Resource management research

Resource management research is discussed by (a) key agroecological zones of the region in terms of three major activities: measurement of the resource base, analysis of the determinants of stability and degradation, and devising of resource management technologies, and (b) TAC-defined activities.

Over-all resource requirements
Resource management research at IITA for the duration of the Plan has an essential requirement of 13.5 scientist-years in 1989, increasing to 21.5 in 1993. An agroforester from ICRAF is expected to participate in the research for the humid forest zone beginning in 1989. In addition, the Plan envisages 4 desirable scientist-years in 1989, decreasing to 2 in 1993. The allocation of these scientists to agroecological zones and to TAC activities for 1988 (base year for planning purposes) through 1993 is shown in table A-4 of the annex: "Senior scientist-years ('essential' and 'desirable') in the research program by TAC activity, 1988-1993"; and for 1988 and 1993 in table 6.1: "Senior scientist-years ('essential' and 'desirable') for resource and crop management research, by TAC activity and ecological zone, 1988 and 1993".

A. ESSENTIAL RESEARCH FOR THE HUMID FOREST ZONE
A new substation will be established in 1989 in the humid forest zone. Work at this substation will involve a combination of resource management research to develop sustainable farming systems, and commodity research, emphasizing tree and root crop interactions. Initial emphasis will be on the measurement of the resource base, on research aimed at a better understanding of resource and fallow management systems, and on the related physical and biological parameters, particularly those which influence nutrient leaching, acidification and low fertility. Appropriate adaptations of alley farming may provide the key technological innovation that allows increased labor and crop productivity, shorter and more productive fallows, and increased availability of the forest resources that are needed for the maintenance of farming and livelihood systems.

1. Research agenda for the humid forest zone

- Survey of farmers' resource management strategies and fallow systems to (a) determine how these have changed in response to population pressures and (b) identify major plant species in natural fallow systems.

- Ecological studies to evaluate the effects of fallow management systems on the composition and persistence of the weed flora.
- Studies to quantify soil chemical parameters affecting productivity with emphasis on organic matter, soil acidification, and nutrient leaching and recycling.
- Studies of soil fauna influencing organic matter, nitrogen production and cycling, and phosphorous uptake.
- Screening woody species and herbaceous plants for use in fallows and alley systems.
- Development of fallow management practices, including alley farming systems.

2. Resource requirements for the humid forest zone

The essential requirements are:

- Measurement of the resource base; 1.5 scientist years for the duration of the Plan.
- Analysis of the determinants of stability and degradation; 2.5 scientist years in 1989, increasing to 3.5 in 1990.
- Devising new resource management technologies; 2 scientist years beginning in 1992.

The essential scientific disciplines for resource management research in the humid forest zone over the five years of this Plan are:

Discipline	88	89	90	91	92	93
Resource economist	1	1	1	1	1	1
Soil physicist	1	1	1	1	1	1
Agronomist (alley farming)		1	1	1	1	1
Soil chemist		1	1	1	1	1
Soil biologist			1	1	1	1
Ecologist (weeds)					1	1
Agroforester					1	1
ICRAF agroforester		1	1	1	1	1

A desirable addition is to continue work started in 1983 at a rainforest location south of Benin City, Nigeria. It is an extension into the humid forest zone of a long-term 40-hectare experiment on land clearing and soil management which started in the forest/savanna transition zone at Ibadan in 1978. Its objective is to obtain the scientific information needed to formulate guidelines to manage land resources for economically viable and sustained productivity, and to ascertain the food production potentials and limitations of the rainforest.

3. Output for the humid forest zone

All of these outputs should be realized by the end of the Plan period.

(a) Increased knowledge of the resource base of traditional fallow systems.

(b) Knowledge of the processes influencing the rapid decline in soil fertility, including those which influence organic matter, nutrient recycling and soil acidification.

(c) A prototype alley farming system designed with: (i) appropriate agroforest species adapted to the acid soils, with high biomass production and prunings which degrade slowly on the soil surface, and (ii) appropriate cultural modification of the alleys for root crops.

Table 6.1 Senior scientist-years ("essential" and "desirable") for resource and crop management research, by TAC activity and ecological zone, 1988[a] and 1993

TAC activity	Year	Ecological zone: humid forest	forest/ savanna transition	moist[b] savanna	inland valley	Total
Resource management research						
Resource management research[c]	1988	2.0	4.5	1.0	1.0	8.5
		(1.0)				(1.0)
	1993	7.0	5.0	2.0	1.5	15.5
		(1.0)				(1.0)
Water management research	1988					
	1993				1.0	1.0
Machinery research	1988					
	1993	0.5	0.5			1.0
Agroclimatology	1988	0.3	0.3	0.3	0.1	1.0
	1993	0.3	0.3	0.3	0.1	1.0
		(0.3)	(0.3)	(0.3)	(0.1)	(1.0)
Plant nutrition	1988	0.3	0.3	0.2	0.2	1.0
(analytical services)	1993	0.3	0.3	0.2	0.2	1.0
Statistical services	1988	0.3	0.3	0.2	0.2	1.0
	1993	0.3	0.3	0.2	0.2	1.0
Coordination of networks	1988	(0.5)	(0.5)			(1.0)
	1993	0.5	0.5			1.0
TOTAL	1988	2.9	5.4	1.7	1.5	11.5
resource management research		(1.5)	(0.5)			(2.0)
	1993	8.9	6.9	2.7	3.0	21.5
		(1.3)	(0.3)	(0.3)	(0.1)	(2.0)
Crop management research						
Crop system research	1988	2.0	3.0	1.0	3.5	9.5
	1993	2.0	2.5	1.5	2.5	8.5
Plant protection research	1988	2.0	1.0	1.0		4.0
(biological control)		(1.0)	(1.0)			(2.0)
	1993	2.0	1.0	1.0		4.0
		(1.0)	(1.0)			(2.0)
Utilization research	1988	1.0	1.0			2.0
			(1.0)			(1.0)
	1993	0.5	0.5			1.0
			(1.0)			(1.0)
Nutrition/consumption studies	1988	1.0	0.8	0.2		2.0
	1993	0.4	0.4	0.2		1.0
Market demand studies	1988	0.5	0.5			1.0
	1993					
TOTAL	1988	6.5	6.3	2.2	3.5	18.5
crop management research		(1.0)	(2.0)			(3.0)
	1993	4.9	4.4	2.7	2.5	14.5
		(1.0)	(2.0)			(3.0)
GRAND TOTAL	1988	9.4	11.7	3.9	5.0	30.0
resource and crop		(2.5)	(2.5)			(5.0)
management research	1993	13.8	11.3	5.4	5.5	36.0
		(2.3)	(2.3)	(0.3)	(0.1)	(5.0)

Notes Figures in parentheses are desirable additions.

a The year 1988 is included here as a base year for comparative purposes, and is not within the Medium-Term Plan period.

b Includes cowpea research in drier savanna.

c A recommended TAC activity.

B. ESSENTIAL RESEARCH FOR THE FOREST/SAVANNA TRANSITION ZONE

As a first priority, work will continue at Ibadan to improve resource management systems based on the accumulated knowledge of the determinants of stability and from extensive on-farm testing of alley farming and mulch system management.

Research will also continue on the processes which determine stability and degradation in order to provide quantifiable measures of sustainability for use in crop system research. It is anticipated that the principles used to establish a measure of sustainability in the forest/savanna transition zone will be relevant as well for the humid forest and moist savanna regions of sub-Saharan Africa.

1. Research agenda for the forest/savanna zone

- Studies on the changes in soil and crop productivity and nutrient dynamics as affected by various fallow management systems.
- Long-term studies of nutrient management and cycling in alley farming systems on degraded and non-degraded alfisols.
- Soil microbiological studies on nitrogen cycling and related biological processes in fallow management systems.
- Studies of crop competition in alley farms and traditional mixed cropping systems to determine the optimum arrangement of alley and crop species.
- Studies to determine the effective control of weeds, particularly *Imperata cylindrica*, through the selection and management of fallow species.
- Development and testing of new fallow management systems and appropriate fallow species.
- Studies on the establishment of different alley species.
- Development of energy-saving tools appropriate for fallow management systems.

2. Resource requirements for the forest/savanna transition zone

The essential requirements for the Plan period are 4 scientist-years in 1989, increasing to 5 by 1991 to continue to develop and improve resource management systems at Ibadan; and for an additional 0.5 scientist-year for research on development of simple tools and machines in 1993. The addition of 1 scientist-year for the coordination of an alley farming network supported jointly by IITA, ILCA and ICRAF is desirable in 1989 and becomes essential in 1991.

The essential scientific disciplines for resource management research in the forest/savanna transition zone, all located at Ibadan over the five years of this Plan are:

Discipline	88	89	90	91	92	93
Soil chemist	0.5					
Soil physicist	0.5	0.5	0.5	0.5	0.5	0.5
Economist	1	1	1	1	1	1
Agronomist (alley farming)	1	1	1	1	1	1
Ecologist (weeds)	1	1	1	1	1	1
Microbiologist	0.5	0.5	0.5	0.5	0.5	0.5
Alley farming network coordinator				1	1	1
Crop physiologist				1	1	1
Agricultural engineer						0.5

3. Output from research in the forest/ savanna transition zone

Resource management systems for on-farm testing by crop-based systems working groups (crop management research) and by NARS includes:

(a) Improvements to alley farming systems in response to feedback from on-farm tests and the alley farming network: (i) improved stand establishment of the alley through choice of species and appropriate cultural methods, (ii) enhanced weed control through canopy management and through allelopathic effects of the alley species, and (iii) changes in the husbandry of the alley, in the configuration of the food crops, and in the judicious use of external inputs of fertilizers.

(b) Annual mulch cover crop systems with: (i) species that regenerate effectively to produce adequate biomass and nitrogen (symbiotic fixation), (ii) cultural methods which allow for planting through the mulch, and (iii) adequate control of the cover species to minimize competition with the basic food crops for light, water and nutrients.

(c) Improved knowledge of the relationships between properties of the resource base and their quantification, leading to indices of "sustainability" for use in crop system research.

C. ESSENTIAL RESEARCH FOR THE MOIST SAVANNA ZONE

Some of the baseline research and the resource management technologies developed for the forest/savanna transition zone are applicable in many areas of the moist savanna. There are, however, differences in relative priorities of some of the resource issues because of differences in environmental factors and in farming systems. In particular, soil fertility, soil compaction, and the need of biomass for feed and fuel are likely to be of relatively greater importance as resource issues. The loss in productivity, by the invasion of grass and other weeds, is also a high-priority issue in many savanna areas.

1. Research agenda for the moist zone

- Long-term studies on external nutrient management in different fallow management and crop rotation systems.
- Screening woody species and herbaceous plants for use in alley farming systems.
- Studies of crop competition to determine the optimal arrangement of alley and crop species for biomass production and its allocation for food, feed, fuel and organic matter.
- Studies to determine the effective control of weeds (including *Striga*) through fallowmanagement and other appropriate measures, including herbicides.
- Development of energy-saving tools for tillage, planting and harvesting.

2. Resource requirements for the moist savanna zone

The essential requirement is for 1 scientist-year at the beginning of the Plan and the addition of 1 scientist year in 1991, both to be based at the new maize substation in the moist savanna (see the discussion of maize improvement). There is also the addition of 0.5 scientist-year in 1993 to develop labor-saving technologies.

The essential scientific disciplines for resource management research in the moist savanna zone, all located at the maize substation over the five years of this Plan are:

Discipline	88	89	90	91	92	93
Fertility agronomist	1	1	1	1	1	1
Weed scientist				1	1	1
Agricultural engineer						0.5

3. Output from the moist savanna zone

(a) A prototype alley farming system with emphasis on: (i) nitrogen fixation to reduce the dependence on external inputs of nitrogen which may reduce soil pH; (ii) allocation of biomass for feed and fuel; (iii) ability to cycle fossil phosphorus to the surface layers; and (iv) the control of grassy weeds through manipulation of the canopy.

(b) An improved maize-cropping system based on rotation and mixtures of cereals, legumes, and cover crops to enhance internal nitrogen supply.

D. ESSENTIAL RESEARCH FOR THE INLAND VALLEY ECOSYSTEM

Since this specific ecosystem is found scattered over the three major zones (forest, transition, savanna), and that in these, any one farmer will allocate resources between rice and upland crops, the research to measure the resource base is included in that already discussed for the zones. As a priority, work will continue on resource management technologies involving minimum water control, ridging, fertility management, weed control and planting methods of rice, and the adaptation of other crops (including cassava, yam, cowpea, soybean and maize) for the system.

It is recognized that the most sustainable and productive rice-growing systems include some form of water management. As a long-range goal, the benefits that derive from optimal water management should be possible for African rice growers in the inland valleys. Although the essential research program addresses the development of technologies for the lower, suboptimal levels of water management that currently prevail, a desirable activity will be the determination of the most efficient paths for water control development and to identify the rice-based system technology that will be most appropriate for different developmental stages.

1. Research agenda for the inland valley ecosystem

- Studies on water uptake and water use efficiency of non-rice crops.
- Studies of the effects on weed competition of rapid rice leaf-area development, achieved either through transplanting or through genetic variation in early growth and tiller production (the latter particularly associated with *O. glaberrima*).
- Studies of the effects of fluctuations in the water table on soil chemical properties and on nutrient management.
- Studies of small-scale water management systems.

2. Resource requirements for the inland valley ecosystem

The essential requirement is for 1 soil chemist and 0.5 soil physicist for the duration of the Plan to measure the determinants of stability and degradation.

An hydrologist for water management studies is a desirable addition in 1989 and 1990, becoming essential from 1991.

3. Output from research for the inland valley ecosystem

(a) A resource management technology based on minimum water control and on soil management practices for (i) effective weed control, (ii) alleviation of the effects of toxic chemicals on rice (e.g. iron), and (iii) optimal stand establishment, nitrogen fixation and root explora-

tion by non-rice crops.

(b) An understanding of the effects of fluxes in the water table on soil properties (physical and nutrient), and on efficient use of applied nutrients.

E. RESEARCH FOR ALL ZONES

Essential requirements to support the resource management research in all zones are:

(a) An analytical chemist for routine analysis of soil, plant and water samples, and to develop rapid methods to screen for quality and nutritional factors.

(b) A statistician to design and analyze experiments and surveys, and to research appropriate experimental designs.

(c) An agroclimatologist. In collaboration with other centers, international organizations and NARS, IITA plans to continue to assemble environmental information for regions of Africa in standardized and machine-readable form. Also information on the weather during the growing season at particular experiment locations, and of variation in weather conditions between years and sites is essential to explain yield variation, and ultimately to develop equations which relate biomass accumulation (yield) to time and to the time courses of radiation receipt, temperature and water balance. Such models are necessary to predict, from individual site and year information, the stability and production of the system for a broader target area.

1. Resource requirements for all zones

The essential requirements are 3 scientist-years at Ibadan for the duration of the Plan. An IFPRI macroeconomist will be located at IITA from 1989 (see section 6.11).

Discipline	88	89	90	91	92	93
Analytical chemist	1	1	1	1	1	1
Statistician	1	1	1	1	1	1
Agro-climatologist	1	1	1	1	1	1

A desirable addition is a geographer from 1989 onward to participate with the agroclimatologist in the agroecological research described above.

2. Output from research

(a) Services to the research programs.

(b) During the Medium-Term Plan period, a data base of edapho-climatic conditions and crop distribution from which experimental sites can be chosen for relevance and potential production.

(c) In the long term, crop or system models which predict biomass output from environmental data.

6.2 Crop management research

Crop management research is the activity by which IITA meets the need to understand and serve its ultimate clients on the one hand, and by which it works in partnership with national agricultural research systems to test and validate the products of all its research programs on the other. Thus it is both a unifying activity which focuses the whole institute sharply on the family farmer, and the mechanism which ensures that its research is responsive to the needs of national programs and that its products are readily available to them.

Over-all resource requirements
Excluding the inputs of scientists from the commodity improvement and resource management programs to the systems-based working groups, the overall essential requirement for crop management research is 17.5 scientist-years in 1989, declining to 14.5 in 1993 with the completion of the IITA/CIAT agroeconomic study of cassava in Africa. Desirable additions are 3 scientist-years for the duration of the planning period. These data are summarized in Table 6.1 where scientist-years in 1988 (the base year for planning purposes) are shown for each relevant TAC activity, and for each ecological zone. Table A-4 in the annex to this document presents data for 1988 through 1993 by TAC activity for each crop-based system and for biological control as a component of integrated pest management for all systems.

A. CROP-BASED SYSTEMS WORKING GROUPS
To conduct crop management research IITA has recently established the three systems-based working groups whose goals and functions were referred to in section 4 of this Plan.

The essential and common activity of all three working groups (cassava, maize and rice) is crop systems research emphasizing on-farm activities. Their main objective is to test and adapt improved cropping systems which integrate component technologies from the commodity improvement programs with the resource system technologies devised through resource management research. This work is planned with inputs from appropriate members of each group, but is conducted by the full-time staff of each working group. Other objectives are to characterize the agroecological and socioeconomic environment of the cropping areas; to strengthen the farming systems orientation of commodity improvement scientists, and to enhance their knowledge and understanding of the target family farmers and so improve their ability to define appropriate breeding objectives; and to identify long- and short-term issues to be addressed by more applied strategic research on-station. This latter work is planned by the working group, but is conducted by the appropriate research program.

The outputs of the working groups are of two distinct kinds; those which are related essentially to the feedback function, and which are intended to ensure the relevance of on-station research; and those which relate to the service and adaptive research functions, whose outputs are intended to have impact on farms, but primarily through IITA's partnerships with NARS.

The working groups became operational in 1987. In the annex to this volume is a brief description of the current activities of the cassava-based

systems working group which illustrates how the working groups in general are implementing the objectives set for them.

Alley farming

Common to each of the crop-based systems working groups (described immediately below) is the development of farming systems which are sustainable, environmentally sound, and productive with a range of external inputs from the low levels available to subsistence farmers to those higher levels used by more advanced farm families. The alley cropping concept developed at IITA encompasses these needs. It involves growing arable crops between hedgerows of woody shrub and tree species, preferably legumes, which are periodically pruned to prevent shading of the companion crop(s), and to provide mulch cover for them. Incorporation of small ruminant production by ILCA into the alley cropping system, utilizing supplementary browse produced from the hedgerows on a cut-and-carry basis, led to the development of the "alley farming" concept, so named because of the incorporation of livestock in the system.

Alley farming is a very promising agroforestry approach because it is close to actual farm practices; it functions satisfactorily with low inputs; and may operate without much modification of traditional multicropping systems. It is also flexible. The management of the hedgerows can be modified in terms of the number of tree rows, tree species, and frequency and pattern of cutting to partition the output as desired among green manure at various seasons, continuous fodder, erosion and weed control, mulch, fuelwood, stakes (for example, for yams), food, small construction materials, or a combination of these diverse options. It can be combined with mechanization and soil fertilization if desired. All three crop-based systems working groups are engaged in efforts to test and refine this important new technology in different agroecological zones.

A key issue regarding the alley farming concept is its acceptance by farmers. Working from its base at IITA, Ibadan, the Humid Zone Program of ILCA has evaluated alley farming from the perspective of small ruminant production in on-farm trials and pilot projects since 1981. By 1986 ILCA was monitoring the performance of 100 farmers who had adopted alley farms, or who had at least put them to the test on their own farms under their own management, some 60 km north of Ibadan in the forest/savanna transition zone.

In reporting this work, Atta-Krah and Francis note that a major component of it has been to assess the farmers' own evaluation of the technology in terms of its relevance, workability and acceptability. They go on to say:

> Although farmers are familiar with the management of trees in the context of the bush fallow system, the adoption of alley farming implies a number of innovations in farming practice. These include the planting and establishment of trees within arable farms, their management for mulch and fodder production, cut and carry feeding of animals, and the alteration of land use and rotation patterns. Moreover, the issue is not simply one of managerial innovation and

* Atta-Krah, A.N. and P.A. Francis. 1987. The role of on-farm trials in the evaluation of composite technologies: the case of alley farming in southern Nigeria. Agricultural Systems 23:133-152.

the acquisition of new skills. In the adoption of a new system, attitudinal, sociological and institutional factors (such as the distribution of the benefits derived from the technology among household members or the implications of land tenure systems), may also intrude. A further implication of the relative novelty of the system is the need to evolve and institutionalize effective extension strategies for the technology.

IITA has also evaluated alley farming in on-farm trials in the vicinity of Ibadan, but in the context of crop production. The two IARCs have accumulated sufficient experience in farmer-managed, on-farm research with alley farming (including the important issue of farmer acceptance) to enable them (with ICRAF) to provide effective guidance to an alley farming research network which will be established in 1988, and to set their own research agendas to address the most significant problems. A comprehensive review of alley farming research has been written at IITA, and will be submitted for external publication in the latter part of 1988.

The objectives of the alley farming research network are to (a) promote discussion and research on alley farming and similar improved methodologies, (b) test technologies developed and the use of the concept across diverse environments in tropical Africa, and (c) encourage intercountry and national cooperation to support those objectives.

Within the network most research will be implemented by participating national and international organizations, not by the network as an entity. Some will be conducted by all the countries in the network on projects that are selected, planned and carried out by member scientists within the countries represented. In addition, the network coordinator, consultants and fellow scientists will be available to (a) review proposals for funding from various sources; (b) offer suggestions on planning, experimental designs, and research implementation; and (c) monitor progress and give guidance for the analysis and interpretation of research results.

A comprehensive on-station and on-farm research agenda has been developed by the alley farming network steering committee whose members, as well as IITA, ILCA and ICRAF, come from Benin, Cameroon, Ghana, Malawi, Nigeria, Sierra Leone and Tanzania.

IITA's own alley farming research agenda includes:

(a) Identification of suitable alley tree species and site adaptabiltiy studies for various agroecological conditions, including those with acid soils.

(b) Studies of the soils in alley farms, especially the maintenance of a favorable carbon (organic matter) status, nutrient recycling, the maximization of biologically fixed nitrogen in the system, and improved assessment of other biological activities in the soil.

(c) Evaluation of the performance of a wide range of food crops and their improved cultivars, either as sole or mixed crops in alley farms.

(d) Further refinement of the technology by the interchange of information derived from on-farm and on-station research.

(e) Socioeconomic studies by the resource economist, and by the crop-based systems working groups, with particular reference to the economic aspects of farmer adoption.

Economic research recognizes that alley farming is a system of resource and crop management with multiple components, flexible management options, and multiple outputs and benefits, some which accrue in the future. The eco-

nomic analyses respond to this complexity by simultaneously studying the adoption problem at several levels – field, household, village and region. Methods are tailored accordingly; e.g., village surveys, detailed field-level input-output data collection, diagnostic experiments, and special topical studies. Information from all sources is used to match management and output options with farmers' production environments. In addition, elements of alley farming with particular appeal and components which pose difficulties for the farmer can be identified. Particular attention is devoted to seasonal labor requirements. As an integral part of the resource managment program as a whole, circumstances where alternative resource management techniques or systems are appropriate will also be identified.

Other technology options

(a) Mulches and cover crops. Various forms of mulch farming have also been investigated for use under diverse conditions. These include a number of species of live mulches, which are generally quick-growing leguminous cover crops. These can provide a constant soil cover before, during and after the cropping phase to prevent or retard soil degradation, and, in many cases, to suppress weeds. A number of useful species (not for live mulch) have been identified and selected, and experiments have been carried out to test their compatibility with different cropping systems and their performance under various conditions. Simple hand-drawn equipment for planting crop seeds through the mulch cover has also been developed. Identification of appropriate species for the humid acid zone is continuing. There are also still some drawbacks to *Mucuna pruriens*, the main species currently being used for nonacid areas, and there is need for additional work on identifying other suitable species.

(b) Land clearing development. In the humid and subhumid tropics, land clearing for cultivation requires the removal of trees and shrubs. On small and medium-sized farms, land clearing is done manually. This has a distinct advantage over machine clearing since the area cleared is normally quite small, and the problems of soil compaction and erosion are reduced. The drudgery involved, however, makes some degree of mechanized clearing seem an attractive alternative. In the subhumid tropics, where there are fewer trees, mechanized land clearing is becoming more common on large commercial farms. These techniques can have drastic effects on soil structure and erosion. IITA research has shown that when heavy equipment is used, soil disturbance and subsequent erosion can be kept to a minimum with implements such as the shear blade, which cuts the vegetation at ground level. Minimum or zero tillage with use of cover crops, mulches and herbicides is necessary when the land is cleared in this way.

(c) Tillage methods. Various studies at IITA and elsewhere have shown the advantages of minimum- or no-tillage farming. To be successful, this must be combined with appropriate land clearing and subsequent managment practices including the use of mulches. Weeds are generally controlled with herbicides. This system has decided advantages in conserving soil and water and maintaining lower soil temperature and higher levels of soil organic matter. However, further agronomic and economic analysis is needed to determine the conditions under which it would be most practical for small-scale farmers.

(d) Fertilizers and soil additives. There is clearly growing interest among small-scale farmers in much of Africa in

the use of fertilizers and other chemical additives. In addition to increasing short-term output, these can delay or modify some aspects of soil degradation. However, IITA and other research has shown that because of the greatly reduced buffering capacity of the weathered soils in the humid and subhumid tropical regions, excessive and inappropriate use of nitrogen fertilizers can cause severe acidification and soil toxicity problems. Careful use is critical.

(e) **Improved fallows**. A limited amount of research has been done in developing improved fallow management practices that will be more efficient in restoring soil fertility than unmanaged bush fallows. Some of the species used in alley farming experiments, such as *Leucaena*, can be beneficial in a managed fallow system. Moreover, there are areas in which farmers already plant or select certain fallow species, especially in the humid forest zone. This can provide the basis for further work, although the particular mix of species used may be quite site-specific.

Cassava-based systems

Cassava-based systems research which is focused on key agroecological zones has already identified the need to improve IITA's improved cassava to meet the needs of family farmers. There is a need for a greater range of maturities and plant architectures to fit diverse cropping systems, for better in-ground storage characteristics of the tubers. Research is expected to produce superior clones with these improvements for the major zones where cassava is grown within 5 to 10 years. This should have significant impact, especially in densely populated areas where progressive decline in fertility is already causing a shift to cassava from more favored crops such as yam.

Postharvest processing of cassava is a labor-intensive operation, usually performed by rural women and children. Utilization research is expected to develop improved processing technologies that will raise labor productivity, especially of rural women, as well as technologies that will expand and diversify cassava use through commercial applications.

The disciplines and essential scientist-years for the cassava-based systems working group are:

Discipline	88	89	90	91	92	93
Agro-economic cassava study	4	4	4	1	1	
Economist	1	1	1	1	1	1
Agronomist	1	1	1	1	1	1
Physiologist	1	1	1	1	1	1
Postharvest technologist	1	1	1	1	1	1
Social scientist	1	1	1	1	1	1
Weed scientist				0.5	0.5	0.5

Maize-based systems

Continued improvements of the components of existing maize-based systems, including improved varieties of maize and other crops in the system, fertilizer applications, weed control, sowing dates and plant populations should have substantial medium-term impact, especially in the moist savanna where maize is replacing sorghum, and has potential for rapid expansion. In the medium term of 5 to 10 years, the alley farming concept for maize-based systems in the moist savanna and forest/savanna transition zones will have been improved through the process of continuous feedback from on-farm experiments. It is expected to have substantial impact on the stability and productivity of these systems.

Soybean production is most likely to increase in the moist savanna zone in

association with maize-based systems. Soybean utilization research focused on domestic and village-level use of the crop is a desirable addition requiring 1 scientist-year for the duration of this Plan. The output from this research will be an important stimulant to the expanded use of the crop for direct human consumption.

The disciplines and essential scientist-years for the maize-based systems working group are:

Discipline	88	89	90	91	92	93
Economist	1	1	1	1	1	1
Agronomist	1	1	1	1	1	1
Weed scientist				0.5	0.5	0.5

Rice-based systems in the inland valley ecosystem

In the short term, significant benefits will be derived by farmers from the adoption of improved varieties of rice and the crops associated with it, and from improved cultural practices in the inland valley ecosystem. The rice-based systems working group will collaborate with WARDA and with national research systems to ensure that breeding objectives and agronomic research take account of farmers' constraints.

Within 5 to 10 years, improved soil and water management technologies designed to enhance and sustain the productivity of rice-based cropping systems will have been developed. This work will include a physical description and a classification of the diverse types of inland valley and hydromorphic ecosystems in West and Central Africa, and it will include designs for more productive and sustainable cropping and land use systems.

The disciplines and essential scientist-years for the rice-based systems working group are:

Discipline	88	89	90	91	92	93
Economist	1	1	1	1	1	1
Agronomist	1	1	1	1	1	1
Microbiologist	0.5	0.5	0.5	0.5	0.5	0.5
Rice specialist	1					

Resource requirements for crop-based systems working groups

The essential requirements for systems-based working groups are: for cassava, 5 scientist-years in 1989, increasing to 5.5 in 1993; for maize, 2 scientist-years in 1989, rising to 2.5 in 1993, and a desirable addition of 1 scientist year for soybean utilization research 1989 to 1993; and for rice, 2.5 scientist-years for the duration of the Medium-Term Plan.

B. CEREAL-BASED SYSTEMS IN THE SAVANNA ZONE

IITA cowpea scientists cooperate with ICRISAT in research on the sorghum/millet-based systems of the dry savanna where most of the cowpeas in West and Central Africa are grown. There should be substantial short-term impact from breeding disease resistance in both determinate, leafy cowpeas and indeterminate, photosensitive ones which are locally adapted to the duration of the growing season, and to intercropping with the cereals. In the longer term, impact will follow quickly from success in breeding host-plant resistance to post-flowering insect pests.

C. THE AGRO-ECONOMIC STUDY OF CASSAVA IN AFRICA

It is widely acknowledged that too little is known about the distribution of cassava in Africa, the farming systems in which it is grown, and about the agro-climatic and socioeconomic features of its production and utilization. To obtain comprehensive information of this kind, and which will be useful to all who are concerned with cassava in Africa, IITA

and CIAT will collaborate in a joint agro-economic study of the crop during this five-year planning period.

The essential resource requirements for the cassava study are 4 scientist-years until 1990, decreasing to 1 in 1991 and 1992, when the study will have been completed and the results published.

D. BIOLOGICAL CONTROL AS A COMPONENT OF INTEGRATED PEST MANAGEMENT

The achievements and success of IITA's project for the control of cassava mealybug in Africa has been thoroughly documented in recent in-house and external reviews (e.g., the Winrock report*). While the present program to control cassava pests will continue, with increased emphasis on the green spider mite, the Medium-Term Plan envisages the incorporation of biological control science into the research agenda of IITA as a component of integrated pest management. In this context the objectives of biological control research will be expanded to include the pests of other crops in IITA's mandate, and weeds. The work will be integrated with that of the commodity improvement scientists seeking host-plant resistance, weed scientists and others whose inputs will contribute to integrated pest management at the level of the family farm.

Biological control of cassava mealybugs and green spider mites in Africa has been funded as a "special project" by a consortium of seven donors. The IITA Biological Control Program has four internationally recruited scientists: the project leader, an entomologist and the person who initiated present activity; two experts in the biological control of mealybugs and spider mites; and a scientist devoted to the assessment of the potential of biological control applied to the pests of other crops (presently maize, cowpeas and plantains) and weeds. Supporting staff are concerned with the development of methods to mass-rear pests and beneficial insects, with training in support of African national biological control programs, and with the implementation of the mealybug control campaign throughout the African cassava belt. During 1988 all biological control research, mass-rearing and training will transfer from Ibadan headquarters to new facilities at Cotonou in the People's Republic of Benin.

The Medium-Term Plan envisages a gradual decrease of research and control activity on mealybugs as the present campaign reaches its successful conclusion, probably by the end of 1991. Research, and the implementation of measures to control green spider mites, are expected to continue throughout this five-year planning period, but there will be a gradual change in the nature of IITA's involvement. The implementation of control campaigns will be transferred to other competent organizations, and IITA will concentrate on biological control research and research training. Part of the new facilities in Cotonou will be made available to other organizations (such as the Commonwealth Institute for Biological Control and ICIPE) for research on the pests of crops not within IITA's mandate (including "cash" and plantation crops), and to mass-rear beneficial insects for future control campaigns.

The resource requirement to implement this Plan is 4 scientist-years for essential research on the biological

* Winrock International. 1987. Midterm review: Africa-wide Biological Control Program of the International Institute of Tropical Agriculture. Prepared for the International Fund for Agricultural Development. Morrilton, Arkansas: Winrock International.

control of pests and weeds. They will be based at Cotonou. Biological control research is opportunistic, requiring sound scientific judgment on the feasibility of success for each pest. Also, as demonstrated by the effective control of the cassava mealybug, considerable resources are necessary for research which interfaces with development programs. The four "essential scientists" are judged to provide this capacity realizing that, just as with IITA's experience of the biological control of mealybugs, there will be a need to modify staff needs on an opportunity basis. Four scientists are therefore an appropriate number in view of the importance attached to biological control as a component of integrated pest management. Other components are breeding for host-plant resistance to pests and pathogens, and research on weed and fallow management, mixed cropping systems, and the judicious use of insecticides. Each of the commodity improvement programs has entomologists with whom the biological control scientists will collaborate. These scientists, together with IITA plant pathologists and weed scientists, provide a sufficient "critical mass" to launch an effective integrated pest management research program.

The research of the 4 scientists will complement that of other scientific disciplines at IITA and will be integrated in on-station research, and by their participation in the work of the crop-based systems working groups. Their specific research agenda will include: the study and analysis of the interrelationships between pests, the populations of their natural enemies, and the farming and cropping systems in which they occur, including studies of the effects of cultural practices on the impact of beneficial insects; environment-crop-pest-natural enemy predictive modelling; research on mass-rearing of pests and indigenous (or, when feasible, exotic) natural enemies; and research associated with the release and impact of beneficial insects.

As a focus of crop management research, integrated pest management is an important theme in the work of the crop-based systems working groups in both on-station and on-farm research.

Desirable additions are 2 scientist-years (subject to review in 1991) to continue IITA's commitment to complete the implementation of the Africa-wide campaign for the control of mealybugs and its associated research and training.

6.3 Commodity improvement research

The breeding objectives described in this Plan are those which were identified during the strategic planning process as having high priority for future IITA research, and in its partnership with national agricultural research systems in Africa. A large number of researchable issues were considered for each commodity. In every case an estimate was made of the resource requirements and the probable time needed to achieve the objective. In broad terms, the objectives chosen fall into three groups:

(a) Those which can be achieved in the medium term (5 to 7 years), such as the transfer of traits for which genetic sources and established breeding methods are available;

(b) Those, such as host-plant resistance to insect pests, which may be expected to require a decade or more; and

(c) Maintenance breeding to sustain past achievements in germplasm development.

IITA will address these issues in collaboration with other international agricultural research centers and national research systems. While collaborating closely with CIMMYT, IITA will take the leadership for the improvement of maize in West and Central Africa, and will collaborate with CIAT for the improvement cassava in all of Africa, with AVRDC and International Soybean Program (INTSOY) for research on soybeans, with INIBAP for plantains, and with IBPGR for genetic resources. The mandate for sweet potato improvement has been transferred to CIP. IITA will make available its research support services to CIP for their work on sweet potato improvement in Africa. IITA will assist WARDA to to take responsibility for rice improvement in West Africa, and will collaborate to develop sustainable systems for the inland valley ecosystem.

IITA will also consolidate and strengthen its existing linkages with national commodity improvement programs in West and Central Africa, through the continuing participation of its scientists in training at all levels, in the provision of improved germplasm, and through the new initiatives which are described elsewhere in this Plan document.

Over-all resource requirements

Commodity improvement at IITA for the duration of this five-year Plan has an essential requirement of 29 scientist-years in 1989, rising to 32 in 1993. In addition, the Plan envisages 10 desirable scientist-years in 1989, declining to 6 in 1993. These data are summarized in table 6.2 where scientist-years in 1988 (the base year for planning purposes) and in 1993 (the last year of the five-year Plan) are shown for each relevant TAC activity, for each commodity and for the related support services of biotechnology and virology. Table A-4 in the annex to this Plan document shows the same data for 1988 through 1993.

A. MAIZE

IITA, in collaboration with CIMMYT, will continue a full-scale commodity improvement program on maize because of its importance as a source of food and feed, because of its high labor productivity, and because of the potential for rapid impact.

The primary focus in the IITA Medium-Term Plan for maize improvement is on the lowland moist savanna and humid forest zones of West and

Central Africa. IITA and CIMMYT have agreed that the interests of the countries of this region will be best served by the joint resources of the two centers working in tandem to supply the widest range of germplasm possible for the region.

IITA will therefore assume the leadership for maize germplasm development for West and Central Africa, including breeding maize for the various environments, and the distribution of germplasm through regional testing networks.

A CIMMYT scientist will be located at an IITA maize substation to be established in the moist savanna zone as an adjunct breeder to introduce resistance to major, unique local pests, e.g. streak virus, into CIMMYT's global lowland maize germplasm. This scientist will also help to ensure that CIMMYT's global germplasm is made available to the countries of West and Central Africa by its inclusion in IITA's regional testing network.

IITA's maize scientists will be actively involved in cropping systems research, in training, and in various other activities to strengthen national research systems in the region.

Table 6.2 Senior scientist-years (essential and desirable) for commodity improvement research, by TAC activity and commodity, 1988 and 1993

TAC activity	Year	Commodity							
		cassava	maize	cowpea	yam	plantain	soybean	rice	total
Breeding/	1988	2.0	3.5	2.5	1.0	1.0	1.0	4.0	15.0
improvement		-	-	(4.0)	-	-	-	-	(4.0)
	1993	6.0	4.5	4.5	1.0	3.0	1.0	-	20.0
		-	-	(5.0)	-	-	-	-	(5.0)
Enhancement[a]	1988	2.0	2.0	1.0	-	0.5	-	-	5.5
		(1.0)	-	-	-	-	-	-	(1.0)
	1993	1.5	2.0	2.5	0.5	0.5	-	1.0	7.5
International trials	1988	0.5	0.5	0.5	-	-	-	-	1.5
	1993	0.5	0.5	0.5	-	-	-	-	1.5
Genetic collection	1988	-	-	0.5	0.3	-	-	0.2	1.0
and conservation	1993	-	-	0.5	0.3	-	-	0.2	1.0
Plant protection	1988	-	1.0	1.0	-	-	-	-	2.0
research	1993	1.0	0.5	0.5	-	-	-	-	2.0
Coordination of	1988	(1.0)	(1.0)	(1.0)	-	-	-	-	(3.0)
networks	1993	(2.0)	-	-	-	-	-	-	(2.0)
Total essential	1988	4.5	7.0	5.7	1.3	1.5	1.0	4.2	25.0
	1993	9.0	7.5	8.0	1.8	3.5	1.0	1.2	32.0
Total desirable	1988	(2.0)	(1.0)	(4.0)	-	-	-	-	(7.0)
	1993	(2.0)	-	(4.0)	-	-	-	-	(6.0)

Notes Figures in parentheses are "desirable additions".
a Includes biotechnology.

1. Maize breeding and improvement
The lowland moist savanna, or the Guinea savanna zone, with a growing period ranging from 150 to 240 days, is thought to have the greatest potential for future maize production in West and Central Africa, and it will have the highest priority for IITA's essential maize program. In order to deal adequately with the research priorities of this environment and to produce technological advances that are appropriate to the farming systems of the region, a research substation will have been established there by 1989.

As well as maintaining resistance to foliar diseases and to maize streak virus, the essential program will give high priority to the development of screening methods, followed by breeding for resistance to the parasitic weed *Striga*, and to enhancing adaptation to drought stress. Basic research in collaboration with advanced institutes (including ICRISAT) will be undertaken on the relations between *Striga* and its host, on possible resistance mechanisms, and on means of developing effective resistance screening techniques. Studies of its economic impact are also needed and will be important in the assessment of the viability of farm-level control measures.

IITA's essential maize improvement for the lowland humid forest will be conducted from the Ibadan headquarters. In addition to maintaining resistance to foliar diseases and maize streak virus, the research priorities will be:

(a) Developing screening methods and breeding for resistance to the main stem borers, *Eldana* and *Sesamia*, which cause major losses in late-planted or "second season" maize;

(b) Breeding for resistance to downy mildew, a disease of growing importance which has great destructive potential;

(c) Breeding resistance to ear and stalk rots caused by *Botryodiplodia*, *Fusarium* and *Macrophomina*; and

(d) Research on postharvest insects, chiefly weevils (*Sitophilus* spp.) but also the greater grain borer (*Prostephanus truncatus*) which has recently been introduced from America and poses a major potential threat to maize in Africa. Lower priority is accorded to research on mottle virus and tolerance of acid soils.

Hybrid breeding. IITA's Medium-Term Plan for maize includes as an essential component the development of both open-pollinated varieties and hybrids, on the grounds that the two activities are mutually supportive, and that there is a strong case to give national programs a choice, and the opportunity to develop hybrids if, as in Nigeria, they believe them to be appropriate.

Hybrid breeding will be continued at the Ibadan headquarters, and will be extended to any of the countries of West and Central Africa that request assistance to develop inbred lines and hybrids.

Coordination of networks. IITA has a commitment to provide for the coordinator for the maize research network of the Semi-Arid Food Grains Research and Development (SAFGRAD) project. This will continue as a desirable activity for the duration of the project whose current phase ends in 1990, when IITA's involvement will be reviewed.

2. Resource requirements for maize improvement
In each of the five years of this planning period the essential requirement for maize improvement is 7 scientist-years (excluding the CIMMYT breeder). During the first two years (1989-90) a desirable addition is the coordinator of the SAFGRAD maize research network. The scientific disciplines and locations of the 7 essential maize scientists will be:

Location	Discipline	88	89	90	91	92	93
Ibadan head-quarters	Breeders	4	2	2	2	2	2
	Pathologist	1	1	1	1	1	1
	Entomologist	1	1	1	1	1	1
Moist savanna substation	Breeder		1	1	1	1	1
	Biologist (*Striga*)		1	1	1	1	1
	Coordinator/ agronomist		1	1	1	1	1
	CIMMYT breeder		1	1	1	1	1

3. Output from maize improvement

(a) In the short to medium term, locally adapted populations, inbred lines and cultivars will have been bred with stable resistance to foliar and ear diseases and streak virus, and with grain types and a range of maturities which meet the diverse needs of producers and consumers in the humid forest and moist savanna zones of West and Central Africa.

(b) In the medium term, a better understanding of the biology of *Striga*, stem borers and storage pests will have been acquired, and efficient methods to screen for host-plant resistance to these constraints will have been developed.

(c) IITA will continue to strengthen national programs and networks in West and Central Africa, and will participate in regional maize networks.

(d) In the short term a maize research substation will be established in the West African moist savanna.

B. CASSAVA

IITA has a continental mandate for cassava improvement in Africa. Given the achievements of previous work to breed cassava resistant to bacterial blight and mosaic virus diseases, and the development of methods to multiply improved planting material, the major current needs are to diversify cassava genotypes to meet the needs of diverse environments, farming systems, and farmer and consumer requirements. In particular, there will be greater emphasis on cassava for the farming systems of the humid forest zone, a new initiative to breed cassava for eastern and southern Africa (especially the mid-altitudes), and an extension of cassava breeding to cover the dry savannas of Africa.

To ensure close collaboration with CIAT for the improvement of cassava in Africa, and especially to make full use of cassava germplasm, a CIAT scientist will join the IITA program at Ibadan. Another component of collaboration between IITA and CIAT is the agroeconomic study of cassava in Africa. The study will provide comprehensive information which will be invaluable in the continuous refinement and review of the objectives of cassava improvement by IITA and CIAT.

1. Cassava breeding and improvement

The essential medium-term plan for cassava improvement has the following broad objectives:

(a) The selection of plant types with a range of plant architectures and maturities to fit diverse cropping systems and the varying requirements of farmers in all African environments where the crop is grown. An especially important requirement is the farmers' need to retain the flexibilty of labor use which is provided by the range of maturities and harvest dates in their traditional cassava varieties.

To extend IITA's capability to breed cassava for the humid forest, a cassava breeding substation will be established in that zone in 1989. Later, in 1992 and subject to discussions with SACCAR, two scientists will be placed in eastern or southern Africa to breed cassava with

emphasis on the mid-altitudes, and to work in association with the East and Southern African Root Crops Research Network. The focus of cassava improvement will also be extended to include the semiarid zones, where the crop is important though grown on a relatively small area.

(b) Resistance to mosaic virus, bacterial blight, and anthracnose is routinely incorporated into all IITA's improved cassava clones. With improved access to the Latin American germplasm, greater resources will be applied to the search for host-plant resistances to mealy bugs (*Phenacoccus manihoti*), green spider mites (*Mononychellus* spp.), and (of less importance) grasshoppers (*Zonocerus* spp.).

(c) The selection and enhancement of tuber qualities suitable for the major types of utilization. Tuber quality is assessed in terms of starch quality for incorporation in bread flours, cyanide content, consumer preferences, and skin color. White-skinned tubers will be preferred if they can be processed without peeling.

Special attention will be given to international testing, including the transfer of elite, virus-free clones in vitro. In addition, the use of recurrent selection methods for cassava improvement will be emphasized. Populations grown from true seed will be screened and recurrently selected in a range of well-defined ecosystems.

A number of more specialized areas of basic research that will be conducted by IITA's cell and tissue scientist and cytogeneticist (see the section on biotechnology), or which are appropriate for collaboration with advanced institutes will also be an important component of the essential program. Major topics of interest include studies of the induction of flowering; somatic embryogenesis; production of haploid embryos; screening methodologies to assess tuber quality; the cytogenetics of related wild species; the biology of cassava symbiotic organisms; and cassava starch quality.

2. Resource requirements for cassava improvement

The essential requirement for this Plan is 5 scientist-years in 1989, rising to 8 in 1990 (excluding the CIAT scientist). There is also a requirement for the capital development costs of the humid forest substation (which will be shared by the Resource and Crop Management Program) and the substation in eastern/southern Africa. The locations and disciplines of the essential scientists are:

Location	Discipline	88	89	90	91	92	93
Ibadan head-quarters	Breeders	1.5	1.5	1.5	1.5	1.5	1.5
	Pathologist	0.5	0.5	0.5	0.5	0.5	0.5
	Biochemist	1	1	1	1	1	1
	Coordinator/ agronomist	1	1	1	1	1	1
	CIAT scientist	1	1	1	1	1	1
Forest sub-station	Breeder		1	1	1	1	1
	Agronomist/ physiologist					1	1
E/S African sub-station	Breeder					1	1
	Agronomist/ physiologist					1	

Desirable additions. An entomologist to develop methods to screen for resistance to cassava mealybugs and spider mites is a desirable addition in 1989 and 1990. Subsequently screening for host-plant resistance, including rearing the pests, will be by entomologists of the biological control program. Success in this objective will be an

important complement to the biological control of these pests.

IITA is committed to provide the coordinator of the new, but already successful East and Southern African Root Crops Research Network, with headquarters in Lilongwe, Malawi. This commitment is expected to continue to the end of the Plan period.

A Central and West African root crops research network, whose coordinator will be provided by IITA, is expected to be established during 1988. Central and West African national root crop improvement programs are relatively mature, and well able to participate in productive networking.

3. Output from cassava improvement

(a) In the medium term, locally adapted disease-resistant, high-yielding varieties will be available for diverse cropping systems, with a range of plant architectures and maturities suitable for further refinement and use by national programs.

(b) In the longer term, the present levels of host-plant resistance to mealybugs and spider mites will have been improved.

(c) In the short term, cassava breeding capabilities will be established in the West or Central African humid forest zone, and in eastern or southern Africa where special emphasis will be given to cassava in the mid-altitudes.

(d) African national root crops improvement programs will continue to receive support, and the cassava program will participate in regional root crops research networks.

(e) There will be greater collaboration with CIAT, and more productive use of CIAT germplasm.

C. COWPEAS

IITA includes a major cowpea improvement program in its Strategic and Medium-Term Plans for several reasons:

(a) IITA has its headquarters within the center of origin and genetic diversity of the crop, and within the region which is the world center of production.

(b) While in West Africa cowpeas are chiefly important in the sorghum and pearl millet farming systems of the semiarid zones, their cultivation extends into the lowland humid tropics of Africa and other continents.

(c) IITA has a well-established, strong cowpea improvement program with all the associated links with national program scientists in developing countries worldwide, and with centers of advanced research in the developed countries.

(d) IITA holds the world collection of *Vigna* germplasm on behalf of the CGIAR, and has established strong worldwide links for the conservation and study of these resources.

(e) As a nitrogen-fixing food crop cowpeas are important components of sustainable mixed cropping systems in large parts of West and Central Africa. Research can extend their utilization in such systems.

(f) IITA believes that it is desirable for a CGIAR center to have global responsibility for at least one commodity in order to ensure that it retains its international character.

In the essential Plan for the improvement of cowpeas, IITA will continue to focus on the importance of pest and disease resistance, but there will be a change from the past policy of breeding only varieties for grain production as sole crops using insecticides to control pests. Although the latter has been successful, and will continue at a decreased scale, it is dependent on the cost and availability of insecticides and sprayers, and it is likely that the majority of cowpeas in Africa will continue to be grown by resource-poor smallholders in intercropped mixtures with cereals. In

addition, breeding objectives need to take into account production of the haulms, which are a principal source of animal feed in most of the cowpea growing regions of West Africa. Thus, the major thrust of future research will be to breed varieties that are well-adapted to the cereal farming systems of the African savannas and that meet the dual needs for grain and fodder.

1. Cowpea breeding and improvement
The main breeding objectives of the essential Plan will be: (i) the morphological and physiological adaptation of cowpeas to interplanting with cereals in a range of environments with varying lengths of growing season; (ii) the incorporation of multiple pest and disease resistance into adapted varieties; and (iii) the improvement of drought tolerance in cowpeas, especially for the millet farming system of the semi-arid zone. The scientists will be located in northern Nigeria and at the ICRISAT Sahelian Center, Niamey, Niger.

As progress is made in germplasm enhancement (see below), new desirable traits will be transferred to the cowpeas which IITA has bred for production as sole crops, and for vegetable pod production. The scale of this activity will be much reduced from its past level.

2. Germplasm enhancement
The main limitation to cowpea grain production in Africa is the damage caused by post-flowering insect pests. Three components of IITA's essential Plan to develop host-plant resistance to them are:

(a) Refinement of existing screening methods, and the development of new ones to identify better sources of resistance. This will require that significant resources be allocated to research on the biology and rearing of the pests.

(b) Extensive collection of new germplasm, especially of wild relatives in Africa, and the intensive evaluation of both existing and new collections, and of breeding materials.

(c) Research in IITA's biotechnology unit, and contract basic research for the study of pest biology, wide crosses, resistance mechanisms, and innovative screening methods.

Essential work will also continue at IITA to improve the level of resistance to the cowpea storage weevil, *Callosobruchus maculatus*, and its incorporation in all of IITA's elite breeding lines.

This pre-breeding research will be done at the Ibadan headquarters by one breeder and an entomologist working together with scientists in the biotechnology unit, and in collaboration with scientists at advanced laboratories.

3. Genetic resources conservation
IITA has the CGIAR world mandate to collect and preserve the genetic resources of *Vigna*, and as part of its essential Plan will continue to collect, evaluate and preserve cowpea germplasm, and to make it freely available to scientists world-wide. Over the next five years priority will be given to collecting genetic diversity in the wild relatives of cowpeas in Africa and its use in breeding for host-plant resistance to post-flowering insect pests.

4. Resource requirements for cowpea improvement
In the plan for cowpea improvement the essential requirement is for 5.6 scientist-years in 1989, rising to 7.6 in 1991 with the additions of a physiologist and a pathologist, both to the savanna substation (for which there will be a capital development cost). There are 6 desirable additions for the first two years of the Plan, and 4 thereafter. The locations and scientific disciplines of the essential scientists are:

Location	Discipline	88	89	90	91	92	93
Ibadan head-quarters	Entom-ologists	2	2	2	2	2	2
	Breeder		1	1	1	1	1
	Genetic resources	0.6	0.6	0.6	0.6	0.6	0.6
Savanna sub-station	Breeders	2	2	2	2	2	2
	Physiologist				1	1	1
	Pathologist				1	1	1

Desirable additions. In 1989 and 1990 an agronomist/physiologist is a desirable addition to the savanna substation, after which this position is essential. Four scientists, to be based in Maputo, Mozambique, are required to assist the countries of Southern African Development Coordination Conference (SADCC) for cowpea improvement for the duration of this Plan period. IITA is committed to coordinate the SAFGRAD cowpea research network until 1990, after which a second phase will be considered, and IITA participation will be reviewed. Until 1990 a coordinator for this network is a desirable addition.

5. Output from cowpea improvement

(a) In the medium term, a range of photosensitive, indeterminate cowpeas adapted through their response to photoperiod to a range of season length, with the characteristics of traditional varieties grown in mixtures with sorghum and pearl millet, and with multiple resistance to the major pathogens of the West African savanna.

(b) In the long term, sources of host-plant resistance to post-flowering insect pests will have been identified, and incorporated into otherwise superior genotypes, for cereal intercropping, for grain production from sole crops, and for vegetable pod production.

(c) In the medium term, improved levels of resistance to the cowpea storage weevil, *Callosobruchus maculatus*, will have been identified, and incorporated into elite varieties.

(d) In the medium term, a greatly enlarged collection of genetic diversity in the wild relatives of cowpeas will have been collected, preserved, evaluated and documented. IITA will continue to maintain the world collection of cowpea germplasm, and to distribute it freely to cowpea scientists worldwide.

(e) IITA will continue to support and strengthen national grain legumes improvement programs in Africa, and will participate in cowpea research networks.

D. YAMS

Yams are an especially important staple food in the countries of the "yam zone" of West Africa, where Nigeria produces some three quarters of all yams in Africa. In West and Central Africa as a whole about 60 million people depend upon yams as a staple food (obtaining an average of more than 200 calories per day from them).

IITA will continue a small improvement program in its essential Plan for yams not only because the crop is so important, and is expanding in coastal West Africa, but also because:

(a) IITA is located within the center of origin and genetic diversity of at least two important cultivated species, *Dioscorea rotundata* (the white Guinea yam) and *D. cayenensis* (the yellow Guinea yam), other less important cultivated species, and of a great many wild relatives.

(b) There are opportunities to make major advances in yam improvement through the application of biotechnology. This is an area of research for which IITA has an unquestioned advantage compared with national programs in West and Central Africa to whom the crop is of major importance. Improvement using new methods offers the potential

for more efficient and more widespread cultivation of this crop in the humid forest and moist savanna zones where it is extremely popular among consumers, both urban and rural.

(c) IITA has the CGIAR world mandate, not only for yam improvement, but also for the conservation and study of the genetic resources of *Dioscorea*. IITA already holds a significant collection of yam germplasm, and has made progress to preserve it in vitro at great savings in costs and with greater security than is possible with annual field plantings.

1. Plant breeding and improvement
There are good prospects that basic research in collaboration with advanced research institutes and in IITA's biotechnology unit will lead to breakthroughs which will enhance the productivity of yam breeding. The purpose of this collaboration will be to develop effective breeding methods through research on reproductive biology (especially the induction of flowering), the cytogenetics of *Dioscorea*, somatic embryogenesis, and the production of haploid embryos to overcome the restrictions on breeding imposed by the high and complex levels of polyploidy in the genus.

The main breeding objectives in the essential Plan will include minimizing staking needs through changes in plant type and disease resistance; finding resistance to nematodes and mosaic virus; and breeding plant habits and tuber shapes that facilitate harvest.

2. Genetic resource conservation
In view of the importance of yams in West Africa, and since IITA has the CGIAR world mandate for the crop, IITA will continue to maintain and expand its extensive yam germplasm collection as part of its essential Plan.

3. Resource requirements for yam improvement
The essential Plan for yam improvement requires 1.2 scientist-years throughout the five-year period. These consist of 0.5 scientist-year each for a breeder and pathologist (whose remaining time will be devoted to cassava), and 0.2 scientist-year for genetic resources conservation.

4. Output from yam improvement
(a) In the medium to long term, and through basic research, a better understanding will have been obtained of the reproductive biology and cytogenetics of yams, and of the application of new technologies to their improvement.

(b) In the medium term, progress to breed plant types and disease resistances that minimize the need for staking, and improved tuber shape.

(c) The continuing collection, preservation (in vitro), evaluation and documentation of yam germplasm, and its free distribution in response to requests.

E. PLANTAINS
It has been estimated that about 40 million Africans obtain more than 200 dietary calories per capita per day from plantains. At present, black Sigatoka is the overriding constraint to future plantain production in Africa. The fungal spores are dispersed by wind and water and are thus beyond the control of plant quarantine measures.

1. Plant breeding and improvement
The problem of black Sigatoka will be addressed through two essential short-term research activities as well as a longer strategy. First, collaboration will be established with the Honduras Foundation. The products of the Foundation's breeding program will be screened in West Africa for resistance by importing cultures in vitro. Second, East African cooking bananas will be screened

for resistance to the disease so that a potential alternative to plantains in West and Central Africa is available in the event that the disease devastates plantain production.

As a longer-term solution, IITA will establish a plantain breeding capability with an essential team including an agronomist/breeder, a breeder and a pathologist. As well as resistance to black sigatoka, other breeding objectives will include dwarfism, improved harvest index, and resistance to nematodes.

Plantain research will be conducted at IITA's Onne substation in south-eastern Nigeria. IITA's Plan envisages that the scientists in its biotechnology unit, especially the cell and tissue specialist, will make major inputs to the plantain improvement program. There will also be close collaboration with the INIBAP networks, especially national scientists who participate in the West African Regional Cooperative for Research on Plantain (WARCORP), whose INIBAP coordinator will be located at IITA's plantain research station in Onne.

2. Resource requirements for plantain improvement

The essential requirements to implement IITA's plan for plantain improvement are 3 scientist-years for the five-year Plan period, all located at the humid forest zone substation at Onne in south-east Nigeria.

INIBAP's West African regional coordinator will be located at the IITA humid forest substation at Onne, Nigeria, and will contribute to IITA research on *Musa*.

3. Output from plantain improvement

(a) In the medium term a plantain breeding capability, with first priority given to Sigatoka resistance, will have been established. It will include collaboration with INIBAP (and WARCORP), and links with *Musa* breeders in Latin America.

(b) In the long term, new technologies will be applied to plantain improvement through basic research at IITA and in collaboration with appropriate advanced laboratories.

(c) The collection of *Musa* germplasm will have been enlarged and preserved in field plantings, and in vitro, and will be made available to national programs in Africa.

4. *Musa* breeding for all Africa

IITA believes that a single *Musa* breeding program could serve the needs of Africa provided that appropriate locations are established to test and screen its products. Such a single program would concentrate the breeding resources; and it would be efficient and effective in collecting, using and preserving appropriate germplasm. Linkages with INIBAP for access to world germplasm resources, and to established centers of breeding, would also be most effective with a single center for *Musa* breeding in Africa. Note that in vitro cultures are now transferred between countries in Africa, and between Africa and the rest of the world.

F. SOYBEANS

IITA's plan for soybean improvement is to sustain a capability to respond quickly with an expansion of the program if the desired adoption of the crop by African smallholders takes place on a sufficiently large scale. An essential part of the plan is therefore to retain a single breeder to continue work on the most important problems.

There are at least three reasons why soybeans are presently grown by so few African smallholders. First, with few exceptions, they have not had access to varieties which nodulate freely with the indigenous cowpea/groundnut rhizobia

of Africa's soils. Second, the varieties available to them had their origin in North America, and do not retain viability in warm, humid storage for more than two or three months after harvest. And, thirdly, they have not had the knowledge of processing and cooking methods which are so widely used by millions of people in Asia and for whom the crop is so important.

The first two of these constraints have been removed by research at IITA. In discussions with IITA, the leaders of African national agricultural research programs have consequently expressed the view that the crop will be adopted on small farms. Indeed, there is some evidence of increased interest in soybeans as a food crop, and for the commercial extraction of oil in Nigeria. National program leaders have urged IITA to continue a soybean improvement program in order to be able to respond to new challenges which may be expected to arise when smallholder production does expand.

The soybean improvement program is well established, and has a record of significant achievement. It has gathered the germplasm which is an essential resource for continued work, and has forged close links with national programs throughout Africa. IITA therefore believes that it has a comparative advantage to breed the crop for smallholder production in Africa, and that it should sustain its capacity to do so because of soybeans' significant potential as a source of dietary protein in Africa, and its role as a nitrogen-fixing legume in smallholder mixed cropping systems.

IITA has less comparative advantage for work on the utilization of soybeans. Here there is a need not so much for research, but for the adaptation of known processing and cooking methods to meet the needs and capabilities of African consumers. Soybean utilization studies are therefore a desirable component of this Plan, referred to in the section on crop management (because utilization research is not commodity improvement).

1. Plant breeding and improvement
As an essential activity a small breeding effort will continue, with emphasis on further improvement of elite germplasm for resistance to pod shattering, lodging, and pod bugs.

2. Genetic resources conservation
The genetic resources of soybeans which have been accumulated at IITA are specifically useful to breed the crop for African farming systems. As part of the essential Plan, the collections will be maintained and made freely available to national programs.

3. Resource requirements for soybean improvement
The essential requirement for soybean improvement and genetic resources conservation is 1 scientist-year (a breeder to be located at the Ibadan headquarters) for the duration of the five-year Plan. The desirable addition of a soybean post-harvest technologist to work on household and village-level processing is referred to under maize-based cropping systems in section 6.2.

4. Output from soybean improvement
(a) A capability will be sustained to respond quickly (by allocating more resources to improvement) if soybeans are widely adopted by African smallholders, and significant constraints appear which can be alleviated by breeding.

(b) In the medium to long term, resistance to pod shattering, lodging and pod bugs will be incorporated in elite varieties which nodulate freely with indigenous bacteria, and whose seeds

retain viability in farm stores.

(c) Soybean germplasm appropriate for improvement of the crop in Africa will be maintained, and distributed freely to national programs.

(d) IITA will continue to support African national soybean improvement programs, and to maintain its links with INTSOY and AVRDC.

G. RICE

During the first two years of this five-year Medium-Term Plan IITA will maintain the momentum of its rice improvement for the inland valleys of West and Central Africa, while at the same time gradually transferring its responsibilities for rice improvement to WARDA. Breeding stocks and progenies will also be transferred, and the rice fields at the Ibadan headquarters will be available for use by WARDA. Subsequently, from 1991, IITA will retain only its responsibilities for the collection, study, documentation and preservation of the genetic resources of rice in Africa, and will include germplasm enhancement, or pre-breeding research. Some African wild rice (*O. glaberrima, O. longistaminata* and *O. barthii*) accessions have characteristics important for rice improvement in Africa, particularly for resistance to rice yellow mottle virus and for enhanced early seedling vigor which is associated with an improved ability to compete with weeds and resist drought. Transferring the desirable traits from African species to the high-yielding *O. sativa* background has not been satisfactory due to sterility problems. Approaches through biotechnology will be desirable as part of this pre-breeding research for African rice.

IITA is conscious of the need to support rice production by international agricultural research in those regions of sub-Saharan Africa not in WARDA's mandate. This matter will be discussed with IRRI and WARDA in order to develop appropriate recommendations for presentation to TAC in October 1988.

1. Essential resource requirements for rice improvement

The essential requirement to implement IITA's plan for rice research is 3.2 scientist-years in 1989 and 1990, subsequently decreasing to 1.2 scientist-year for the rest of the Plan period for genetic enhancement and to collect, study and preserve the genetic resources of African rice. All the scientists will be located at Ibadan headquarters. The disciplines and years are:

Location	Discipline	88	89	90	91	92	93
Ibadan head-quarters	Breeders	2	1	1	1	1	1
	Entom-ologist	1	1	1			
	Pathologist	1	1	1			
	Genetic resources	0.2	0.2	0.2	0.2	0.2	0.2

2. Output from rice improvement

(a) IITA will continue to collect, evaluate, document and preserve the genetic resources of rice in Africa. These collections will be duplicated at IRRI and made available by IITA to rice scientists worldwide.

(b) Pre-breeding research beginning in 1991 will be directed to promoting the utilization of the wild relatives of *Oryza glaberrima* in rice improvement.

(c) Responsibility for rice improvement in West Africa will be transferred to WARDA.

H. RESEARCH SUPPORT TO ALL COMMODITIES

1. Biotechnology

Several of the plant breeding objectives having high priority in the Strategic Plan are not easily achieved by conventional breeding. Among these are host-plant

resistance to insect pests, often requiring the transfer of resistance genes from wild to cultivated plants, and black sigatoka disease of plantains. New approaches to crop improvement are also likely to facilitate more rapid advances in the improvement of yams and cassava.

IITA will therefore develop a capability to assess the relevance of recent advances in cell and tissue science and molecular genetics, and apply those which are appropriate to its research, either directly or through collaboration with other organizations. To this end a cytogeneticist with knowledge of molecular genetics, and a scientist familiar with recent developments in cell and tissue research will be appointed to form a "biotechnology unit" in association with IITA's existing virologists and microbiologist.

2. Possible applications to IITA's commodity improvement

Although conventional plant breeding has had, and continues to have great impact on genetic improvement there are obstacles to rapid improvement, particularly in the case of interspecific hybridization when it is often difficult or impossible to transfer pest or disease resistance genes from wild species. In some cases these obstacles can be overcome by relatively simple techniques such as ferilization in flower buds, in vitro fertilization, and embryo rescue. For the vegetatively propagated crops, micropropagation techniques, already widely used at IITA, hold interesting possibilities as a means to increase genetic diversity through somaclonal variation provided that regeneration of new plants is possible. New techniques involving molecular genetics may be applicable to some of the more intractable breeding problems faced at IITA. However, the opportunity for the application of such techniques requires the regeneration of protoplasts. While such techniques have been developed for many crops, there is need for such work on cassava, plantain, yam and cowpea.

Cowpeas. Among the most destructive insect pests of cowpea are the pod borer Maruca, and three kinds of pod-sucking bugs. The wild species Vigna vexillata is apparently resistant to them all, but it has proved impossible to obtain progeny when it is hybridized with cultivars. Collaboration with advanced research institutes in Europe and the United States is already in progress to address this problem. Studies of the histology of embryo development following the cross are expected to provide information that will make in vitro fertilization and embryo rescue possible. Work is also under way to investigate recombinant DNA techniques to transfer desirable traits from wild to cultivated cowpeas. In Italy, protoplast isolation and multiplication techniques have been developed, somatic fusions have been made, and tolerance of cowpeas to abiotic stresses (e.g. aluminium toxicity and drought) is being studied on protoplasts and free cells.

Plantain. IITA is well advanced in the use of micropropagation techniques for plantains. Several somaclonal variations have been produced and regenerated, and there are prospects for collaborative work to increase this variability through the use of mutagenic agents. An appropriate method to seek resistance to black sigatoka will be through somaclonal variation and in vitro screening techniques.

Cassava. Wild species of cassava have been shown to have desirable characteristics for insect resistance and cyanide levels. Incompatibility between the crosses of cultivated and wild species has been encountered. Even among cultivated species, shy-flowering limits the choice of parents for breeding.

Cytogenic studies of cassava and its wild relatives and embryo/ovule culture will be important new initiatives in cassava breeding. The unit will also assess the application of regeneration techniques to develop haploid plants, and the potential for genetic transformation for specific viral diseases.

Yams. Cytogenetic research will have high priority as support to the yam breeding program. Indeed, future progress will depend in part upon a much better understanding of the nature of polyploidy in the genus *Dioscorea*. Research on micropropagation, or the regeneration of plants from callus tissue, is a possible source of variation in those species where sexual seed is presently difficult or impossible to obtain.

Virology. Monoclonal antibodies are currently used for the specific detection of viruses at IITA, and for IITA by collaborators.

Microbiology. IITA has a well-equipped microbiology laboratory where research on nitrogen fixation is in progress. This is an area where more active collaboration with advanced laboratories is desirable.

Resource requirements for biotechnology. To initiate research at IITA, and to coordinate collaboration with advanced laboratories in the general area of biotechnology, the essential Plan requires a scientist familiar with recent developments in the field of cell and tissue research, and a cytogeneticist or molecular geneticist.

The essential requirement is therefore 2 scientist-years throughout the five years of this Plan.

Output from biotechnology research.

(a) A capability for cell and tissue research and cytogenetics in support of commodity improvement and the most appropriate applications of these sciences to IITA's objectives.

(b) Collaborative links with advanced research centers. Among the most important of these will be those which support IITA's research on host-plant resistance to insect pests in maize, cassava and cowpeas; resistance to black sigatoka disease of plantains; and resistance to *Striga*, the parasitic weed of maize.

(c) A program of cell and tissue research with plantains and yams to address the chief improvement objectives in these crops. It is reasonable to expect positive achievements by the end of the five-year planning period.

(d) Studies of the cytogenetics of cassava and yams will have enhanced IITA breeding capabilities for these crops.

3. Virology

IITA currently employs two virologists who conduct research on the distribution, ecology, and pathogenic variation of the viruses causing diseases in mandated crops, and on the etiology of the diseases. Through annual surveys the virologists give commodity scientists current information about the incidence and importance of particular viruses to help develop appropriate resistance breeding strategies. Pure virus isolates are provided to enable breeders to screen germplasm for resistance. New viruses are identified and characterized, antisera are produced, and type virus samples are characterized for reference and comparison.

The essential Plan for virology is to continue this work, both the research on viruses and the diseases they cause, and provide service to the commodity improvement programs.

Resource requirements for virology research. The essential requirement is for 1 scientist-year for the duration of this five-year Plan.

Output from virology research. The virologist will continue to monitor the

occurrence and to study the viruses of mandated crops, to publish this information, and to provide a service to IITA commodity programs, and to African national research programs.

6.4 Post-doctoral fellows and visiting scientists

Plans for post-doctoral fellows and visiting scientists have distinct procedures and objectives.

A. POST-DOCTORAL FELLOWS
IITA provides to outstanding young scientists the opportunity to begin a career in international agricultural research in association with IITA scientists. Fellows are recruited from among new PhD graduates, and are selected on the basis of their scientific excellence and the relevance of their interests to IITA's research program. The number of post-doctoral fellows is planned to rise from 12 to 24 over the five-year period. They serve from one to two years as members of IITA research teams.

B. VISITING SCIENTISTS
IITA offers opportunities to experienced scientists of African national programs who have significant research responsibilities in their home countries to conduct research on topics of mutual importance to the NARS and IITA. The visiting scientist serves as a member of the appropriate IITA research team for a period of up to one year, with the understanding that he or she will subsequently return to his or her national system. This program strengthens IITA's research and it provides an invaluable foundation for future collaboration with NARS. Such assignments are particularly productive for the stronger national programs advancing toward mature status vis-a-vis the CG centers. The Plan provides for a minimum of 2 essential and 3 desirable visiting scientists each year. By the end of the Plan period, many of the NARS in the region will have at least 1 scientist with a year's experience at IITA, thus strengthening these systems and providing a sound basis for more sophisticated partnership.

6.5 Research liaison scientists

The Plan provides for 3 essential research liaison scientists, each to serve a group of NARS by studying their requirements and linking them to IITA and other sources of technology and assistance.

IITA needs a mechanism to understand each NARS and to ensure that its input is consistent with and in response to genuine needs. At IARCs with few commodity programs such as CIMMYT, regional liaison officers for each program perform this function. Since IITA has an integrated program, it is necessary to have an holistic view of IITA's potential for collaboration with individual NARS and a systematic knowledge of their requirements. Each of the 3 research liaison scientists, permanent members of IITA's scientific staff, will be assigned seven or eight countries grouped on the basis of linguistic, ecological and geographic factors.

The research liaison scientists will ensure that IITA understands the institutions, scientists and requirements of the highly diverse NARS of the region and is, thereby, able to design suitable methods of collaboration. The research liaison scientist would coordinate IITA activities in each country, assisting other IITA scientists to focus their efforts on the most critical problems so that the total impact will be greater than the sum of the individual parts. The research liaison scientist would, for example, identify training opportunities, facilitate communication with scientists at IITA and elsewhere, encourage collaborative research projects, and arrange screening and testing of materials. One of the key roles of the research liaison scientists will be to help rationalize and improve the effectiveness of research networks.

Research networking is valuable in the development and validation of new technologies for the region, particularly because of the small size of many African NARS. IITA can play a valuable catalytic role in promoting and managing appropriate networks for the region. Because of its technologies, IITA will be an important, often essential member of the network. However, IITA should devolve the responsibility for managing networks to national institutions, as soon as they have the capacity and willingness to assume it. There has been a proliferation of networks in West and Central Africa that is sometimes confusing to NARS and may be leading to diminishing returns from new networks. The research liaison scientists will study the possibility of harmonizing or rationalizing present networks to be sure they are genuine expressions of the perceived needs of NARS leaders. They will also foster more simple forms of collaboration between national systems.

Expected output. By the end of the Plan period, IITA will have systematically acquired a deeper understanding of all the NARS in West and Central Africa. There will be a research liaison scientist who is the contact point for each one and a dialogue will have been started on appropriate forms of collaboration. It is hoped that other CGIAR centers would wish to be associated with this initiative.

6.6 Training

At present, training receives core resources sufficient only to (a) cover its administrative overhead, (b) hold group courses and (c) make a small number of graduate research grants. The high volume of training noted earlier has been supported by restricted funding. While group courses are clearly desirable – and are so classified in the Plan – they do not necessarily build on IITA's comparative advantage or reinforce its priorities for strengthening NARS of the region. An important objective of the training plan is gradual increase of IITA control over the basic training decisions by shifting funding over the five-year period from the desirable to the essential category.

A. AFRICAN GRADUATE RESEARCH FELLOWSHIPS

IITA will introduce a competitive program of research fellowships for outstanding African students working for their MSc or PhD degrees at universities anywhere in the world. Grantees will conduct research on topics relevant to their countries' needs and relating to IITA's mandate, under the supervision of senior IITA scientists. The objective is to strengthen the leadership of African agricultural research institutions. The minimum number of fellowships considered necessary to accomplish these objectives is 30 per year. This scale is sufficient to provide an intellectual environment in which the fellows profit from their own interaction and to justify the costs of administering the program.

The graduate research fellowship program started in the spring of 1988 with an announcement to universities and other organizations worldwide. In future the IITA liaison and resident scientists will be encouraged to provide nominations of key candidates whose training will enhance the research activities within their region. Selection of graduates registered at any university will take place twice a year, in March and September. This will be done according to vacancies in the program and the availability of IITA scientists in the respective field of research for which the candidates will have submitted a research proposal. Appointment of the fellows will commence from the time they can start their research at IITA. By the middle of 1990 the program will be evaluated for the number and qualifications of the applicants, and the success achieved by the appointed fellows.

IITA's capacity to train graduate fellows is set primarily by its senior scientists' ability and willingness to provide effective supervision of fellows' research. IITA scientists have expressed desire to supervise, on average, about two graduate students each, but the availability of accommodation on campus limits expansion to this extent. The Plan provides for stabilization of total fellowship awards at 70, with the essential awards rising to 30. (See the following table). Special attention is being given to increasing the number of women candidates.

Trainees	88	89	90	91	92	93
Essential	8	15	20	25	30	30
Desirable	50	45	40	40	40	40

B. GROUP TRAINING COURSES

IITA currently conducts a wide variety of group training courses on its campus: commodity research and field experimentation courses (so-called "production courses"), skill enhancement courses,

and specialized courses such as those on seed technology or weed management. The intensity of training has been somewhat reduced in 1988 in order to provide time to study course priorities and to design them to serve IITA goals best.

IITA will during this period begin training trainers so as increasingly to decentralize training to the country level. This will permit an increase in the numbers trained per target country, reduce costs and enhance the relevance of training for national programs.

IITA will develop criteria to guide the selection of countries for in-country training (or regions for in-region training), and reallocate staff time from activities in Nigeria in order to enhance human resource development in extension, technical support and production techniques in NARS. IITA will encourage in-country courses by providing training outlines and materials, by inviting national trainers to participate in its courses, and by providing IITA scientists and trainers as resource persons. The goal is to strengthen the national organizations' capacity to satisfy their own requirements.

In order to decentralize group course training effectively from IITA to selected national systems, it is planned to focus on 8 essential courses to be conducted at IITA. (See the following table.) They will have a duration of between 3 and 10 weeks. These courses will provide the training forum for up to 10 national scientists or trainers. An evaluation will be held at IITA after each course which will help determine whether to hold subsequent courses annually or biennially. IITA will request nominations from national systems, with the support of the IITA research liaison scientists, of persons who will play an active role in training at the national level. They in turn will develop, assisted by IITA's training staff, courses at country level for which they will have been trained. The essential courses will include:

- Root and tuber research and technology transfer.
- Cowpea and soybean research and technology transfer.
- Maize research and technology transfer.
- Plantain research and technology transfer.
- Sustainable food crop systems.
- Food crop utilization and nutrition.
- On-farm adaptive research.
- Advanced soil and plant analysis.

Courses	88	89	89	91	92	93
On campus						
Essential	8	8	8	8	8	8
Desirable	6	5	4	4	4	4
Off campus						
Essential	5	5	5	5	5	5
Desirable		1	2	3	4	5
Total	19	19	19	20	21	22

A course such as that on postharvest technology, provided and sponsored twice by FAO, will be reconsidered in view of the emphasis which IITA will give to this research activity. There seems to be ample evidence that the national systems have a great demand for postharvest technology training, and therefore the need to provide such a course and identify it as essential. One will be organized in 1990 and thereafter every two years.

Other desirable courses on subjects such as seed technology and farm management will be held if there is a demand and donors wish to sponsor them. There will be no more than four such courses per year after 1989.

Decentralization to in-country courses

will be to those countries which have national systems in an advanced stage of development, and which need increases in qualified technical support. A number of countries will be identified and liaison scientists will assess the demand for the development of capabilities to hold training courses. The IITA Training Program will then be in a position to determine the assistance to be offered, be it in the form of training materials, resource persons, trainers or limited funding.

IITA will continue to plan and conduct group training courses in close collaboration with CGIAR centers and other organizations. In 1987, IITA participated in training activities with CIAT, ILCA, FAO, the United Nations Children's Fund (UNICEF) and the University of Guelph. During the Plan period, this type of collaboration will be intensified.

C. DEVELOPMENT OF TRAINING MANUALS

IITA's ability to produce excellent training materials is inadequate. Effective implementation of the training plan requires the planning and design of new training materials.

IITA needs improved training materials of four types:

1. For presentation of information. Material is required in support of lectures, in which audio-visual aids increase the attention of trainees, and make the subject matter easier to understand and accept; such materials include models, slides, films, flip charts, and related aids.

2. For reference, refresher, and self-study. These include publications, books, manuals, charts and maps, all of which may help users in following procedures, making diagnoses, or preparing their own materials.

3. For self-instruction. These consist of auto-tutorial modules made up of slides, sound tapes, and associated manuals.

4. To encourage trainee participation and involvement in the learning process. These materials needed include self-correcting examinations, exercises, and simulations which provide trainees and staff with information and insight on trainees' knowledge and skills.

New training materials will make instruction at IITA more efficient and relieve senior staff from repetitive teaching tasks, thus making them available for more interaction with graduate fellows. In addition, the materials will be used to support and supplement in-country training programs. Such aids will not replace interaction with scientists or with the crops in the field.

Resource requirements for training. In the training plan, the essential requirements are a program director, a group course coordinator and a training materials specialist; that is, 3.0 senior staff years from 1989 through 1993.

Desirable additions for the duration of the Plan period are a training officer for the Biological Control Program who will be located in Cotonou; and a second training materials specialist at the Ibadan headquarters, who will ensure the production of all training materials needed for in-country courses.

Expected output. The primary result of the training plan will be an increase in the quality and relevance rather than the volume of activities. Over the Plan period, the graduate research fellowship program will have given the opportunity to over 100 young African men and women to do their graduate research at IITA or one of its substations in partial fulfilment of their MSc or PhD requirements. Training materials both audio and visual, as well as autotutorials, will be available for each of the essential

courses mentioned earlier. Materials derived from these and adapted to the needs of the national systems will also be prepared. Several hundred men and women from countries in the early and medium stage of development will have acquired new or improved skills in the various technologies that will have been made available through courses over the five-year period. Many men and women will have acquired sufficient training skills so that the countries of West and Central Africa will have developed capabilities to hold crop production courses for their technical and extension staff.

6.7 Information

A. FUNCTIONS

Information includes the following functions:

1. Publishing and disseminating IITA research findings to scientists, policymakers, national research programs, development and extension personnel, and others concerned with the agriculture of the lowland subhumid and humid tropics.

2. Maintaining a library with a comprehensive collection of pertinent literature on tropical agriculture to serve Institute scientists, trainees, and other scientists in the region.

3. Providing support for conferences, symposia, and workshops and coordinating an active seminar program at IITA headquarters.

4. Providing French interpretation and translation services to support IITA communication and training efforts.

In the Medium-Term Plan, information activities will be a more active mechanism for cooperation with African national agricultural research programs.

B. ESSENTIAL ACTIVITIES

1. Library services. The development of the integrated computerized library system will continue. A "core library scheme" will be initiated for IITA substations as well as for resident scientist teams. The scheme involves acquisition of relatively small but carefully selected lists of journals, books, and abstracting services for deposit at sub-stations, NARS (where country teams are based), and possibly elsewhere.

2. Publications. The publications program will be pursued vigorously taking advantage of new technologies such as desktop publishing. After nearly 20 years of research, IITA has accumulated a large amount of research data, some of which have been published only in annual reports. Such information will be summarized in a series of technical monographs produced in close collaboration with the appropriate scientists. Extension-support publications based on IITA research findings and designed to upgrade the technical knowledge of NARS extension officers will be produced. Moreover, the production of training materials carefully written and planned for use in specific courses will receive high priority as a mechanism for facilitating the decentralization of training courses.

3. Database development. IITA already has a well-developed library database and mailing list based on a sophisticated software package. These will be upgraded, and new databases will be developed on (i) IITA's research projects, (ii) West and Central Africa NARS utilizing ISNAR's system, and (iii) African women involved in agriculture.

4. Public information activities. In line with the decision of the center directors and the CG secretariat, IITA will engage in more activities designed to increase public awareness of its work and the work of the system in the region, as well as in donor countries. These activities will include, as appropriate, field days, media relations, open house, briefings and presentations to special groups, and participation in agricultural shows.

5. Video technology. Video technology will be used increasingly in IITA public awareness activities and, as appropriate, for training purposes.

6. Translation/interpretation services. To be effective in West and Central Africa, information services must

be bilingual in English and French. In the Medium-Term Plan, translation efforts will be increased to ensure that most of the IITA publications are available in both languages.

C. DESIRABLE ACTIVITIES

Additional activities considered desirable are:

1. Scientific literature service to NARS. A major weakness in most of the NARS of West and Central Africa is the paucity of current agricultural and scientific information. Utilizing its considerable library resources, IITA could provide a regular literature service to NARS.

2. Workshops and training courses on scientific editing and technical publishing. Many NARS are incapable of documenting and disseminating the results of their work because they lack trained scientific editors and others knowledgeable in publishing. An annual training course on scientific editing and publishing would be a major help to NARS.

3. Library extension. After 20 years, the library building has become inadequate. The last program review of IITA commented on the need for an extension to the library. This extension would cost approximately $500,000, and it is included in desirable capital additions.

6.8 Resident scientist teams

IITA currently has 46 scientists providing assistance to African national agricultural research programs with the goals of conducting adaptive research with national scientists and of strengthening their institutional capacity to sustain such research. These scientists, hired on short-term assignments under special project funding, are concentrated primarily in two large institution-building projects. They are classified in the Plan as desirable. Although IITA's performance in these projects is considered successful and other institutions cannot provide the same services at comparable quality, IITA intends to phase down these commitments and replace them with a limited and more cost-effective alternative.

The Plan provides for a small group of experienced scientists to continue this as an essential service to NARS, on an exceptional basis, for the duration of the Plan. It is not normally appropriate for an IARC to provide such assistance to national institutions. It is justified as a transition mechanism in a region where 60 percent of the countries spend under $3 million each year on agricultural research. IITA technology is of little value for countries lacking the capacity for effective collaboration. IITA has a responsibility to assist in the process of building such capacity to the extent that it has a comparative advantage and that such activity does not weaken its vitality as a research institute.

IITA was encouraged by initial TAC support of the concept of the resident scientist team, and in response to TAC's request has provided several arguments in support of it; viz., (a) the teams will address the specific CGIAR request to IARCs operating in Africa for adaptive research; (b) the universal support of this IITA initiative by the directors of national agricultural research systems; (c) the need for mature, permanent members of the IITA scientific staff to carry out this role; (d) the need for a "critical mass" of 2 or 3 scientists in each team; and (e) a total of 6 essential scientists is modest to address the needs of the 24 African countries in the West and Central African region.

IITA has a comparative advantage in strengthening NARS capacity to conduct adaptive research. (Over the past decade, IITA has had over 300 scientist-years assigned to working with NARS of the region.) It has had marked successes, like helping to build the national cassava program of Zaire, and much has been learned in the process. The use of resident scientist teams to strengthen NARS capability for adaptive research has been discussed with ISNAR which strongly supports this as a useful complement to its role in improving the management of reseach systems.

Resource requirements. The Plan provides for 2 essential resident scientists in 1989, rising to 6 by 1991. Six resident scientists in the essential category are the maximum which can be incorporated in the Plan without distorting the over-all balance among the research programs. They will be mature scientists, not a special cadre formed for this purpose, but permanent members of the IITA scientific staff. The number is deliberately set at this low level to avoid distortion of IITA's principal mission.

Resident scientist teams will be based in selected national systems, which fall into two broad categories:

(a) Those in early stages of development in which there is an urgent need to

strengthen the capability to solve specific problems for which IITA has developed appropriate technologies requiring adaptive research in ecological zones of the country.

(b) Those which have moved or are moving to the medium stage of development. These may be national system with which IITA has a history of cooperation, and which can serve as a relay in the dissemination of technologies to weaker neighboring national systems. The team may be involved in helping the national system to solve research problems of an applied nature.

The resident scientist teams will work under the over-all leadership of the director of the national system to which they have been assigned. More specifically, they will work as a team with the national counterparts assigned to them. Training of these national scientists will be one of their major duties, as the duration of their assignment will not normally exceed three or four years. This calls for practical on-the-job training, and for mature and skilled scientists.

In order for the teams to be fully effective, IITA will ensure that they have both the support staff and operating funds.

For resident scientist teams, viewed as an essential activity, IITA will provide operating funds, and will ensure that the cooperating country also contributes to the project. Since many African national systems have serious financial problems, tripartite arrangements will be developed. By these arrangements linking the national system, IITA and a donor, IITA will take responsibility for the salaries of its scientists, while operating costs for the project will be sought from the donor.

For resident scientist teams in the desired activity category, their total operating costs, including their salaries, will be sought from donors over and above essential funding.

Desirable additions. IITA consultations with leaders of NARS in West and Central Africa conveyed the strong impression that they placed highest priority on this mode of collaboration. IITA, therefore, will be prepared to support up to 8 resident scientists in the desirable category if funding is available. These scientists will not be members of IITA's permanent scientific staff, but they will be recruited on a project by project basis as funding permits.

Implementation of this proposal will lead to a reduction of 32 scientist-years allocated to institution-building projects over the five-year Plan period, as shown below:

	88	89	89	91	92	93
Desirable	46	39	36	8	8	8
Essential	0	2	4	6	6	6
Total	46	41	40	14	14	14

Expected output. The major outputs of the resident scientist teams will be development of adapted technologies on crucial agronomic problems and the strengthening of capability of national programs to sustain such research. Training of counterparts will contribute to the strengthening of the institutional building of the system. By 1993, it is expected that four or five small national systems would be progressing from stage I to stage II on the growth path shown in table 5.2.

6.9 Macroeconomics

IITA has built up a strong group of agricultural economists to deal with microeconomic or production issues in the context of the crop-based systems working groups and the resource management unit. It is important for IITA to be able to link its research to the broader policy environment and to understand the policy implications that will critically affect whether new technologies are adopted. Agricultural policies need to be examined in all ecological zones in view of (a) the inevitable increase in the number of small-scale farm families which will dominate the agricultural scene for the foreseeable future, (b) the varying intensities of population pressure on different parts of the region, and (c) the delayed benefits that accrue from resource conservation and intensification technologies. An IFPRI macroeconomist will be located at IITA to undertake this work, beginning in 1989.

6.10 Program management staff

The senior program management and administration staff in 1989 will comprise the Deputy Director-General for Research, the Deputy Director-General for International Cooperation and the senior staff of the International Cooperation Program, the Farm Manager and Assistant Farm Manager of the IITA research farm, and the managers of substations in eastern Nigeria and in the People's Republic of Benin. The number will remain constant throughout the Plan period.

6.11 Staff allocation on and off the Ibadan campus

Essential staff: For the purpose of this analysis, staff are taken to include visiting scientists and scientists from other IARCs working with IITA in Africa.

By this measure there will be 113 essential staff in 1989, of which 92 (being 81 percent) will be at the Ibadan campus and 21 (19 percent) off campus.

In 1993 the total is projected to increase to 123, with 89 (72 percent) remaining at Ibadan, but with an increase to 34 (28 percent) essential staff off-campus at IITA's 6 substations (at Onne and Kano in Nigeria, Cotonou in the People's Republic of Benin, Bouake in Côte d'Ivoire, Yaounde in Cameroon, and a location yet to be selected in eastern or southern Africa).

Total staff (essential and desirable): In 1989 there will be 173 essential and desirable staff, of which 101 (58 percent) will be at Ibadan and 72 (42 percent) off-campus, mostly in two large in-country programs (Cameroon and Zaire) and in the Biological Control Program located at the IITA substation in the People's Republic of Benin.

By 1993 total staff will have decreased by 26 to 147, with 95 (65 percent) at Ibadan and 52 (35 percent) off-campus. The major change will be the decrease by 31 of scientists working in bilaterally funded in-country programs.

Those data are summarized in table 6.3. Figures in brackets are desirable additions to the essential staffing pattern.

Table 6.3 Staff allocation on and off campus, 1989 and 1993

Staff	At Ibadan		Off campus	
	1989	1993	1989	1993
Resource management	13.5	16.5		5
	(3)	(1)	(1)	(1)
Crop management	10.5	10.5	7	4
	(1)	(1)	(2)	(2)
Commodity improvement	21	18	8	14
	(1)		(8)	(6)
Visiting and IARC scientists	5	4	2	3
	(2)	(2)	(1)	(1)
Research liaison scientists	2	3		
TOTAL RESEARCH	52	52	17	26
	(7)	(4)	(12)	(10)
Training	3	3		
	(2)	(2)		
Information	11	10		
Resident scientist teams			2	6
			(39)	(8)
Program Administration	7	7	2	2
TOTAL PROGRAM	73	72	21	34
	(9)	(6)	(51)	(18)
Adminstration and operations	19	17		
Total essential	92	89	21	34
Total desirable	(9)	(6)	(51)	(18)
TOTAL ESSENTIAL AND DESIRABLE	101	95	72	52

7. ADMINISTRATION AND OPERATIONS

In the Medium-Term Plan, high priority will be given to decreasing costs and reducing the proportion of resources allocated to these activities in relation to the total budget.

By introducing private sector standards into management and restructuring the personnel system to enable IITA attract highly qualified Nigerians recruited from the local market, over-all staff efficiency will be improved. Restructuring already underway in the budget and finance department and the commissioning of a new financial information system will lead to more efficient and improved control systems with less costly purchasing and payrolling.

By introducing these measures, costs are targeted to fall from 33 percent of the total budget in 1988 to 24 percent of the total budget in 1993. This is an extremely ambitious target but one that management sets deliberately. It is considered feasible and the discipline of having such a target will sustain the momentum of improving efficiency and keeping administrative and operational costs under strict control. The objective is to free money for essential research activities. Staffing levels and costs over the Plan period are given in the following table.

Resource requirements

1. **Administration.** This includes the activities of the Executive Office of the Director-General, the Office of the Deputy Director-General for Management, and the Office of Budget and Finance. Nine senior staff-years are provided for in 1989 and this number will remain constant throughout the Plan period.

2. **Operations.** Because of the peculiar circumstances of its location in Nigeria, a substantial part of IITA operations costs is accounted for by the necessity to provide utilities and services to the campus community, in addition to those required for its research activities. All international staff are accommodated in IITA's 57 houses, 4 apartment blocks, and various flatlets and dormitories.

Due to the limited utility services available in the locality, IITA must provide services which would normally be provided by a municipal authority. These include the provision of water supply, a water treatment and sewage system and a standby power generator. The operation, repair and maintenance of these utilities is the function of the Physical Plant Services Department

Table 7.1 Costs of administration and operations, 1988-1993

	1988		1989		1990		1991		1992		1993	
	SSY	$	SSY	$	SSY	$	SSY	$	SSY	$	SSY	$
Administration	9	4.1	9	4.0	9	3.8	9	3.7	9	3.6	9	3.5
Operations	10	3.1	10	3.0	9	3.0	8	2.9	8	2.8	8	2.7
Total	19	7.2	19	7.0	18	6.8	17	6.6	17	6.4	17	6.2

Notes
SSY = senior staff years. $ = million U.S. dollars.

which is also responsible for the repair and maintenance of all houses and buildings, vehicles, the central airconditioning plant and units, road repairs and the maintenance of IITA's extensive grounds. The Medium-Term Plan provides for 7 senior staff in 1989 which includes the Director, the Deputy Director and 5 service officers. Management intends to examine the organization of the department with the expectation of reducing senior staff to 5 in 1993.

IITA's auxiliary services also form part of the operations costs. These include the international guest house and restaurant, trainee dormitories, laundry, staff canteen, the IITA Lagos office and guest house at Ikeja, the medical unit to serve staff and their families, the security services and the operation of the IITA Aztec aircraft. There are 3 international professional staff in this area, and the number will remain constant throughout the Plan period.

3. **Community costs.** Many of IITA's administrative and operational activities, apart from being essential for efficient research operations, are necessary because of the inadequacies of the municipal services. Basic amenities must be guaranteed in order to attract and retain highly qualified international scientists.

During 1987, approximately US$1.5 million of the costs of administration and operations were attributed to such services, which represents 20 percent of the total cost.

8. CAPITAL REQUIREMENTS

IITA currently has over $50 million in fixed assets on its balance sheet although the current replacement value is a substantial multiple of this. Many of the buildings and basic equipment which form the infrastructure of the main campus are approaching 20 years of service. While the basic design and quality of the original campus were of high quality, the tropical environment and normal wear are causing inevitable deterioration.

In the previous single-year planning and budgeting exercises, efforts were made to identify specific capital expenditures for approval. This often proved difficult. Even on a one-year basis it was often not possible to foresee all of those needs. Therefore, many capital replacement costs were not specifically identified in IITA's one-year budgets. Also, some capital replacement is almost indistinguishable from major maintenance.

As IITA enters its third decade and shifts to a longer-term planning horizon, it is necessary to modify the past approach to capital planning. IITA must use engineering estimates of average annual replacement costs for both buildings and equipment. This can then be coupled with the capital required to support thrusts into new scientific disciplines and ecological zones. Additionally, because much of the basic infrastructure is approaching the end of its useful life, the mid-term period may have higher than average capital replacement demands.

A. CAPITAL SUMMARY

The summary table of essential capital (in thousands of U.S. dollars) is shown below.

Capital is high in 1988 and 1989 primarily due to new equipment and new construction. This relates to the completion of the biological control facility in the Republic of Benin, the maize substation, and the biotechnology unit in 1988 with total capital demands of $2.4 million. In 1989 extraordinary new equipment and construction capital of $1.1 million are planned for the substations for cowpeas and the humid forest ecology. After 1989 capital needs continue to be slightly above that of recent years due to higher estimates for replacement construction and equipment.

(in US$ 000)	1988	1989	1990	1991	1992	1993
Equipment replacement	1,403	1,637	1,635	1,699	1,592	1,678
New equipment	998	815	505	600	475	375
New construction	1,547	950	100	50	200	50
Replacement construction	387	495	560	560	560	560
Total capital	4,335	3,897	2,800	2,909	2,827	2,663

B. EQUIPMENT REPLACEMENT

The summary table of equipment replacement (in thousands of U.S. dollars) is shown below.

Vehicles are the largest component of equipment replacement. The planned replacement was calculated on a vehicle-by-vehicle basis, assuming that 60 of the older program vehicles do not need to be replaced due to more efficient utilization of the vehicle fleet. The average replacement was assumed to occur at 5 years of service and resale value was assumed to be 20 percent of the new price. The actual schedule was heavily skewed to 1988 and 1989 due to the large number of older cars. A level capital expenditure has been assumed for 1989 to 1993 which will even out the purchases, and eventually the age of the fleet. In the years before 1993, IITA will continue to have vehicles older than 5 years.

Most of the research equipment replacement is for relatively small, diverse items. Historical accounting records of capitalized research equipment do not differentiate accurately between new research equipment and replacement equipment. Therefore the best estimate of capital expenditure is 10 percent replacement of research equipment each year.

A major component of equipment replacement is for farm machinery. About 40 percent of the total spending is for tractor replacement. The age of the current fleet of farm tractors is evenly distributed and, unlike with the vehicle fleet, no catching up is required. The plan is based on replacement at 6 years of use. No additions have been planned for the new substations on the basis that the total tractor requirements will not increase beyond the capabilities of the current fleet and tractors will be redistributed to meet the new requirements. As a fallback position IITA can keep tractors longer than 6 years with some increase in maintenance costs. Another ongoing capital expenditure is for the other mobile and static farm equipment. These include sprayers, planters, combines, fertilizer spreaders, plows, harrows, driers, and threshers. The balance of capital in the farm equipment replacement category is for the replacement of a 20-year-old grader and the original irrigation pumps and fittings.

The capital replacement for computer equipment includes replacement of the non-standard disk drives on the existing computers. This will lower maintenance cost by allowing more flexibility in negotiating IITA's computer maintenance contract, as well as increasing the on-stream efficiency.

Other than vehicles, the major equipment replacement requirements are for the physical plant infrastructure items. With many items nearing two decades in service it is prudent to plan expenditures for gradual renewal of these systems. Major expenditures are anticipated in the power house ($710,000

(In US$ 000)	1988	1989	1990	1991	1992	1993
Vehicles	500	812	812	812	812	812
Research equipment	95	95	95	95	95	95
Farm	230	256	250	268	220	245
Computer	100	20	-	-	125	-
Physical plant	478	454	478	524	340	526
Total	1,403	1,637	1,635	1,699	1,592	1,678

over 5 years) and in the central airconditioning plant ($293,000 over the Plan). Replacement of housing appliances, workshop maintenance equipment, construction and heavy equipment, and routine renewal of roads and drainage are evenly distributed throughout the Plan period.

C. NEW EQUIPMENT

The summary table of new equipment (in thousands of U.S. dollars) is shown below.

The need for new equipment is primarily driven by new research and ecological thrusts, maize substation, cowpea substation, humid forest substation, biotechnology and biological control. Exact capital requirements will be known only after site selection, detailed research programs, and engineering designs are completed.

The Plan allocates a total of $300,000 for additional computing capability over the last 3 years. Given the history of rapid change in the computer area and IITA's effort to increase computerization, this is considered to be a reasonable estimate.

The remaining new equipment capital is for extension of the central airconditioning to the latter phases of campus housing, new electrical distribution equipment, a new sewage treatment tank to allow rebuilding of the 20-year-old facility as spare needed capacity, and miscellaneous building extensions.

D. REPLACEMENT CONSTRUCTION

This category is very difficult to estimate in detail. Examples of the types of projects are re-roofing, tarring of roads, ceiling renovation, replacement of wall coverings and carpets, repairs to housing, and remeshing of screenhouses. The detailed estimates for 1989 are $495,000 which is consistent with recent history.

For 1990 and beyond, spending estimates have been based on a percentage of the capital base. If a building is assumed to have a 50-year life, then on average 2 percent must be renewed each year. Using this approach IITA's $28 million of buildings will require $560,000 per year for replacement and renewal construction.

E. DESIRABLE CAPITAL PROJECTS

There are two projects which are desirable: an extension to the library and the replacement of IITA's piston-driven airplane with a used turbo-prop.

After 20 years, the library building has become inadequate. The last program review of IITA commented on the need for an extension to the library. This extension would cost approximately $500,000.

The current IITA airplane is a piston-driven Piper Aztec. This airplane has been heavily used in the past but, recently it has become difficult to buy the high octane aviation gasoline it requires. With the increased dispersion of IITA scientists, coupled with generally poor

(In US$ 000)	1988	1989	1990	1991	1992	1993
Research	898	800	450	400	300	200
Computer	70	-	-	100	100	100
Physical plant	30	15	55	100	75	75
Total	998	815	505	600	475	375

air connections even between the capital cities of Africa, upgrading this airplane would greatly increase the efficiency of staff utilization at IITA.

The airplane most suitable would be a Beech King Air C90A, which uses fuel widely available in Africa, and has sufficient range for our operations. It is estimated that a used one could be purchased for about $625,000. Without modification this aircraft could also be used to carry beneficial insects for biological control in remote areas although modification would be required if aerial releases are contemplated.

9. COST ASSUMPTIONS

Production of expense estimates for a period of five years in the future requires the use of a variety of techniques. For many types of expenditures, the best technique is to use standard costs multiplied by inputs such as senior scientist-years, or output units such as costs of fellowships per student-year. In other areas such as administration and operations, the costs are not well defined as multiples of such units, so standard costs are not used.

A. SENIOR SCIENTIFIC STAFF

IITA defines senior scientific staff as internationally recruited scientists, not including post-doctoral fellows and visiting scientists.

The cost of these senior scientific staff are based on 1987 actual costs. For 1988 these costs are $183,390 per scientist-year consisting of salary (27.8 percent), benefits (18.5 percent), staff support (10.2 percent), travel (6.6 percent), and supplies and other expenses (36.9 percent). The staff support and supplies and other expense categories include the research program costs for the post-doctoral fellows, but not their salary and benefits which average $50,000 per year. If the post-doctoral fellows were included in the staff counts, the cost per scientist would obviously be much lower.

As IITA increasingly moves scientists to neighboring countries at research substations and in resident scientist teams, the composition of these costs is expected to change. Costs will increase in benefits since cost of living, hardship differentials, and housing costs tend to be higher in most of those countries. It is assumed that the higher costs will be offset by a corresponding decline in support staff, supplies and other expenses due to the nature of their support and interaction with the host country programs.

B. TRAINING COSTS

Training costs were estimated using the current base with incremental costs for graduate research fellowships at $15,000 per student-year$$One additional senior training staff member was assumed to be desirable, adding $100,000 to annual cost.

C. ADMINISTRATION AND OPERATIONS

As discussed in chapter 7 of this plan, administration and operations are budgeted for cost decreases of 3 percent per year measured in 1988 dollars.

Budgets of all private sector companies, governments, and non-profit institutions tend to increase faster than inflation if subjected only to internal considerations$$It is often only when external pressures such as markets, taxing limits, or donor constraints are applied that all expenditures are critically examined.

The IITA Medium-Term Plan contains an expanded program designed to meet the very challenging research needs in sub-Saharan Africa$$The increasing funding requirements will present a challenge to IITA and its donors$$While absolute increases in total IITA non-restricted funding are necessary, IITA itself must strive to increase its efficiency.

Most organisms adapt more effectively to gradual rather than abrupt changes in their environment. The 3 percent target for annual real cost reductions is considered to be the gradual but constant pressure which will produce the most efficient adaptations in

IITA's management and administrative practices.

D. PRICE REQUIREMENT

The price requirement for the Plan was developed using a 3 percent annual inflation rate taken over all IITA expenses in all currencies.

IITA expects the rate of inflation in Nigeria to exceed 3 percent when denominated in local currency. However, our current working assumption is that higher inflation must be offset by corresponding changes in the free-market exchange rate due to the country's requirements for foreign exchange.

U.S. dollar payroll costs are likely to increase by more than 3 percent annually. On the other hand, we expect costs denominated in non-US dollar hard currencies to decrease somewhat in U.S. dollar terms, considering the current purchasing parity relationship of the U.S. dollar with other major currencies.

E. RECONCILIATION WITH THE 1988 PROGRAM AND BUDGET

Because the new TAC format used in the Medium-Term Plan presents activities as essential or desirable and not by funding source, it is necessary to reconcile the 1988 essential program presented herein with IITA's approved core budget presented in the 1988 program and budget proposal.

The 1988 essential program on table A-1 in the annex to this volume contains all the approved 1988 program and budget proposal core activities, plus activities from two projects shown as extra-core on the 1988 program and budget proposal. These extra-core essential activities are 3 senior staff years (SSY) in biological control activities and 4 SSY in the Africa cassava study. The total extra-core-funded, non-capital expenditures for these activities in 1988 amount to $1,134,000.

The essential capital program contains $1,495,000 of extra-core funds which are for the biological control facilities in the People's Republic of Benin.

ANNEXES

APPENDIX

CURRENT ACTIVITIES OF THE CASSAVA-BASED SYSTEMS WORKING GROUP

The cassava-based systems working group studies the role of cassava in farming systems in West and Central Africa and, in particular, the impact and roles of improved varieties. The varying significance of production constraints in different agroecological areas and farming systems is a major aspect of this research. In addition, postharvest processing and the influence of marketing factors receive attention as important factors that can govern the demand for cassava and preferences for various tuber qualities.

Current activities include on-station studies to devise improved multiple cropping and crop rotation systems and to examine the response of improved varieties to extended in-ground storage. Questions to be examined in these trials include the use of alley farming in existing systems to enhance and maintain soil fertility; the addition of a legume crop in the cassava/maize system to increase nutritional outputs and the screening of cowpea and soybean varieties for this purpose, fertilizer use in cassava/maize systems, and the evaluation of improved cassava and maize cultivars of the region.

A further area of major concern of the cassava working group is to identify and establish collaborative research and training with national institutions in the major ecologies in which cassava is a significant crop. To this effect, research linkages will be established with West and Central African national systems.

Finally, until 1991, the cassava working group will have links with a large-scale economic study of cassava in sub-Saharan Africa that will be a joint research project between IITA and CIAT. Surveys and data collection will be carried out in all of the main cassava growing areas of Africa, with four main subject areas as the focus of the research: (a) the production, processing, and consumption of cassava at the village level; (b) the marketing of cassava products and price formation; (c) the effect of urban consumption patterns and food demand; and (d) the impact of national price and trade policies. The results of this study should provide an unprecedented data base for continuing research on the improvement of cassava-based farming systems throughout Africa.

Table A-1 Essential program requirements, 1988-1993 (senior man-years and US $1 000)

	1988 SM-Y	1988 Cost*	1989 SM-Y	1989 Cost	1990 SM-Y	1990 Cost	1991 SM-Y	1991 Cost	1992 SM-Y	1992 Cost	1993 SM-Y	1993 Cost
Resource management	11.5	2 109	13.5	2 476	14.5	2 659	17.5	3 209	19.5	3 576	21.5	3 943
Crop management	18.5	3 393	17.5	3 209	17.5	3 209	15.5	2 843	15.5	2 843	14.5	2 659
Commodity improvement	25	4 585	29	5 318	30	5 502	30	5 502	31	5 685	32	5 868
Postdoctoral/visiting scientists	(12)	600	(14)	700	(20)	1 000	(20)	1 000	(26)	1 300	(26)	1 300
Research liaison scientists	0	0	2	367	3	550	3	550	3	550	3	550
Total research	**55**	**10 686**	**62**	**12 070**	**65**	**12 920**	**66**	**13 104**	**69**	**13 954**	**71**	**14 321**
Training	3	839	3	1 176	3	1 201	3	1 226	3	1 251	3	1 276
Information	12	1 216	11	1 132	11	1 132	11	1 132	10	1 132	10	1 132
Resident scientist teams	0		2	367	4	734	6	1 100	6	1 100	6	1 100
Program management and administration	9	1 834	9	1 834	9	1 834	9	1 834	9	1 834	9	1 834
Total program	**79**	**14 575**	**87**	**16 579**	**92**	**17 821**	**95**	**18 396**	**97**	**19 271**	**99**	**19 663**
Administration and operations	19	7 234	19	7 017	18	6 806	17	6 602	17	6 404	17	6 212
Total operating	**98**	**21 809**	**106**	**23 596**	**110**	**24 627**	**112**	**24 998**	**114**	**25 675**	**116**	**25 875**
Capital — new		2 545		1 765		605		650		675		425
— replacement		1 790		2 132		2 195		2 259		2 152		2 238
Total capital		4 335		3 897		2 800		2 909		2 827		2 663
Total operating and capital		**26 144**		**27 493**		**27 427**		**27 907**		**28 502**		**28 538**
Price requirement				825		1 670		2 527		3 577		4 545
TOTAL IITA REQUIREMENTS	**98**	**26 144**	**106**	**28 318**	**110**	**29 098**	**112**	**30 433**	**114**	**32 079**	**116**	**33 083**

Notes: Numbers of SM-Y in parentheses are not included in totals. *See chapter 9 for a reconciliation of the 1988 essential program with the 1988 core budget.

Resource management	2	367	4	734	4	734	2	367	2	367	2	367
Crop management	3	856	3	1 060	3	1 059	3	1 037	3	890	3	890
Commodity improvement	7	1 284	10	1 834	10	1 834	6	1 100	6	1 100	6	1 100
Postdoctoral/visiting scientists	(0)	0	(3)	150	(3)	150	(3)	150	(3)	150	(3)	150
Research liaison scientists	0	0	0	0	0	0	0	0	0	0	0	0
Total research	**12**	**2 507**	**17**	**3 778**	**17**	**3 777**	**11**	**2 655**	**11**	**2 508**	**11**	**2 508**
Training	1	833	2	1 472	2	1 403	2	1 396	2	1 039	2	1 023
Information	0	0	0	0	0	0	0	0	0	0	0	0
Resident scientist teams	46	8 069	39	8 455	36	7 538	8	2 041	8	1 300	8	1 300
Program management and administration	0	0	0	0	0	0	0	0	0	0	0	0
Total program	**59**	**11 409**	**58**	**13 705**	**55**	**12 718**	**21**	**6 092**	**21**	**4 847**	**21**	**4 831**
Administration and operations	0	0	0	0	0	0	0	0	0	0	0	0
Total operating	**59**	**11 409**	**58**	**13 705**	**55**	**12 718**	**21**	**6 092**	**21**	**4 847**	**21**	**4 831**
Capital — new		0		925		200		0		0		0
— replacement		0		0		0		0		0		0
Total capital		0		925		200		0		0		0
Total operating and capital		**11 409**		**14 630**		**12 918**		**6 092**		**4 847**		**4 831**
Price requirement		0		439		787		625		608		769
TOTAL IITA REQUIREMENTS	**59**	**11 409**	**58**	**15 069**	**55**	**13 705**	**21**	**6 717**	**21**	**5 455**	**21**	**5 600**

Notes: Numbers of SM-Y in parentheses are not included in totals.

Table A-3 Total (essential and desirable) program requirements, 1988-1993 (senior man-years and US $1 000)

	1988 SM-Y	1988 Cost	1989 SM-Y	1989 Cost	1990 SM-Y	1990 Cost	1991 SM-Y	1991 Cost	1992 SM-Y	1992 Cost	1993 SM-Y	1993 Cost
Resource management	13.5	2 476	17.5	3 209	18.5	3 393	19.5	3 576	21.5	3 943	23.5	4 310
Crop management	21.5	4 249	20.5	4 270	20.5	4 269	18.5	3 880	18.5	3 733	17.5	3 550
Commodity improvement	32	5 868	39	7 152	40	7 336	36	6 602	37	6 785	38	6 969
Postdoctoral/visiting scientists	(12)	600	(17)	850	(23)	1 150	(23)	1 150	(29)	1 450	(29)	1 450
Research liaison scientists	0	0	2	367	3	550	3	550	3	550	3	550
Total research	**67**	**13 193**	**79**	**15 848**	**82**	**16 697**	**77**	**15 758**	**80**	**16 461**	**82**	**16 828**
Training	4	1 672	5	2 648	5	2 604	5	2 622	5	2 290	5	2 299
Information	12	1 216	11	1 132	11	1 132	11	1 132	10	1 132	10	1 132
Resident scientist teams	46	8 069	41	8 822	40	8 272	14	3 141	14	2 400	14	2 400
Program management and administration	9	1 834	9	1 834	9	1 834	9	1 834	9	1 834	9	1 834
Total program	**138**	**25 985**	**145**	**30 284**	**147**	**30 539**	**116**	**24 488**	**118**	**24 118**	**120**	**24 494**
Administration and operations	19	7 234	19	7 017	18	6 806	17	6 602	17	6 404	17	6 212
Total operating	**157**	**33 219**	**164**	**37 301**	**165**	**37 345**	**133**	**31 090**	**135**	**30 522**	**137**	**30 706**
Capital — new		2 545		2 690		805		650		675		425
— replacement		1 790		2 132		2 195		2 259		2 152		2 238
Total capital		4 335		4 822		3 000		2 909		2 827		2 663
Total operating and capital		**37 544**		**42 123**		**40 345**		**33 999**		**33 349**		**33 369**
Price requirement				1 264		2 457		3 152		4 185		5 315
TOTAL IITA REQUIREMENTS	**157**	**37 554**	**164**	**43 387**	**165**	**42 802**	**133**	**37 150**	**135**	**37 534**	**137**	**38 683**

Notes: Numbers of SM-Y in parentheses are not included in totals.

Table A-4 Senior scientist-years (essential and desirable[a]) in the research program, by TAC activity, 1988-1993

IITA thrust	TAC activity	1988	1989	1990	1991	1992	1993
Resource management research							
Humid forest	Resource management research[b]:						
	- measurement of resource base	1.5	1.5	1.5	1.5	1.5	1.5
	- analysis of determinants of stability and degradation	0.5	2.5	3.5	3.5	3.5	3.5
	- devising resource management technologies	(1.0)	(1.0)	(1.0)	(1.0)	2.0 (1.0)	2.0 (1.0)
Transition zone	Resource management research:						
	- devising resource management technologies	4.5	4.0	4.0	4.0	4.0	5.0
	Machinery research						0.5
	Coordination of networks (alley farming)	(1.0)	(1.0)	(1.0)	1.0	1.0	1.0
Moist savanna	Resource management research:						
	- devising resource management technologies	1.0	1.0	1.0	2.0	2.0	2.0
	Machinery research						0.5
Inland valleys	Resource management research:						
	- analysis of the determinants of stability and degradation	1.0	1.5	1.5	1.5	1.5	1.5
	Water management		(1.0)	(1.0)	1.0	1.0	1.0
Service activities	Agroclimatology	1.0	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)	1.0 (1.0)
	Plant nutrition						
	- analytical services	1.0	1.0	1.0	1.0	1.0	1.0
	Statistical services	1.0	1.0	1.0	1.0	1.0	1.0
Total resource management research		**11.5 (2.0)**	**13.5 (4.0)**	**14.5 (4.0)**	**17.5 (2.0)**	**19.5 (2.0)**	**21.5 (2.0)**
Crop management research							
Cassava-based systems	Crop systems research	4.0	4.0	4.0	3.5	3.5	3.5
	Utilization research	2.0	2.0	2.0	1.0	1.0	1.0
	Nutrition/consumption studies	2.0	2.0	2.0	1.0	1.0	1.0
	Market demand studies	1.0	1.0	1.0	1.0	1.0	
Maize-based systems	Crop systems research	2.0	2.0	2.0	2.5	2.5	2.5
	Utilization research	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)
Rice-based systems	Crop systems research	3.5	2.5	2.5	2.5	2.5	2.5
All systems	Plant protection research						
	- biological control as a component of integrated pest management	4.0 (2.0)	4.0 (2.0)	4.0 (2.0)	4.0 (2.0)	4.0 (2.0)	4.0 (2.0)
Total crop management research		**18.5 (3.0)**	**17.5 (3.0)**	**17.5 (3.0)**	**15.5 (3.0)**	**15.5 (3.0)**	**14.5 (3.0)**
TOTAL RESOURCE AND CROP MANAGEMENT RESEARCH		**30.0 (5.0)**	**31.0 (7.0)**	**32.0 (7.0)**	**33.0 (5.0)**	**35.0 (5.0)**	**36.0 (5.0)**

IITA thrust	TAC activity	1988	1989	1990	1991	1992	1993
Commodity improvement research							
Maize[c]	Plant breeding/improvement	3.5	4.5	4.5	4.5	4.5	4.5
	Enhancement	2.0	2.0	2.0	2.0	2.0	2.0
	International trials	0.5	0.5	0.5	0.5	0.5	0.5
	Coordination of networks	(1.0)	(1.0)	(1.0)			
Total maize scientists		**6.0**	**7.0**	**7.0**	**7.0**	**7.0**	**7.0**
		(1.0)	**(1.0)**	**(1.0)**			
Cassava[d]	Plant breeding/improvement	2.0	3.0	4.0	4.0	5.0	6.0
	Enhancement	1.5	1.5	1.5	1.5	1.5	1.5
		(1.0)	(1.0)	(1.0)			
	International trials	0.5	0.5	0.5	0.5	0.5	0.5
	Coordination of networks	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)
Total cassava scientists		**4.0**	**5.0**	**6.0**	**6.0**	**7.0**	**8.0**
		(2.0)	**(3.0)**	**(3.0)**	**(2.0)**	**(2.0)**	**(2.0)**
Cowpea	Plant breeding/improvement	2.5	3.5	3.5	5.5	5.5	5.5
		(3.0)	(5.0)	(5.0)	(4.0)	(4.0)	(4.0)
	Enhancement	1.0	1.0	1.0	1.0	1.0	1.0
	International trials	0.5	0.5	0.5	0.5	0.5	0.5
	Collection and conservation/ characterization/documentation	0.6	0.6	0.6	0.6	0.6	0.6
	Coordination of networks	(1.0)	(1.0)	(1.0)			
Total cowpea scientists		**4.6**	**5.6**	**5.6**	**7.6**	**7.6**	**7.6**
		(4.0)	**(6.0)**	**(6.0)**	**(4.0)**	**(4.0)**	**(4.0)**
Yam	Plant breeding/improvement	1.0	1.0	1.0	1.0	1.0	1.0
	Collection and conservation/ characterization/documentation	0.2	0.2	0.2	0.2	0.2	0.2
Plantain	Plant breeding/improvement	1.0	3.0	3.0	3.0	3.0	3.0
Soybean	Plant breeding/improvement	1.0	1.0	1.0	1.0	1.0	1.0
Rice	Plant breeding/improvement	4.0	3.0	3.0			
	Enhancement				1.0	1.0	1.0
	Collection and conservation/ characterization/documentation	0.2	0.2	0.2	0.2	0.2	0.2
All crops	Enhancement (biotechnology)	1.0	2.0	2.0	2.0	2.0	2.0
	Plant protection research (virology)	2.0	1.0	1.0	1.0	1.0	1.0
TOTAL COMMODITY IMPROVEMENT RESEARCH		**25.0**	**29.0**	**30.0**	**30.0**	**31.0**	**32.0**
		(7.0)	**(10.0)**	**(10.0)**	**(6.0)**	**(6.0)**	**(6.0)**
Research liaison scientists			2.0	3.0	3.0	3.0	3.0
TOTAL SENIOR SCIENTIST-YEARS FOR ALL RESEARCH PROGRAMS		**55.0**	**62.0**	**65.0**	**66.0**	**69.0**	**71.0**
		(12.0)	**(17.0)**	**(17.0)**	**(11.0)**	**(11.0)**	**(11.0)**
Postdoctoral fellows[e]		12.0	12.0	18.0	18.0	24.0	24.0
Visiting scientists[e]			2.0	2.0	2.0	2.0	2.0
			(3.0)	(3.0)	(3.0)	(3.0)	(3.0)

Notes

a Figures in parentheses are desirable additions.

b A recommended TAC activity.

c In addition, 1 CIMMYT scientist for maize research.

d In addition, 1 CIAT scientist for cassava research.

e Not included as senior research scientists. The IFPRI macroeconomist is not included here.

Table A-5 Total essential man-years, 1988-1993

			Projected				
		1988	1989	1990	1991	1992	1993
Research	International	55	62	65	66	69	71
	Support	63	65	68	70	72	75
	Regular	460	460	470	475	480	480
	Subtotal	**578**	**587**	**603**	**611**	**621**	**626**
Research support	International	6	8	10	12	12	12
	Support	7	9	11	13	15	15
	Regular	85	91	96	101	106	106
	Subtotal	**98**	**108**	**117**	**126**	**133**	**133**
International cooperation and training	International	6	6	6	6	6	6
	Support	7	8	8	8	8	8
	Regular	14	14	14	14	14	14
	Subtotal	**27**	**28**	**28**	**28**	**28**	**28**
Information	International	12	11	11	11	10	10
	Support	13	14	14	14	15	15
	Regular	25	25	25	25	25	25
	Subtotal	**50**	**50**	**50**	**50**	**50**	**50**
Administration and operations							
Administration	International	9	9	9	9	9	9
	Support	40	40	40	40	40	40
	Regular	70	70	70	70	70	70
Operations	International	10	10	9	8	8	8
	Support	39	39	40	41	41	41
	Regular	447	447	447	447	447	447
	Subtotal	**615**	**615**	**615**	**615**	**615**	**615**
Subtotal international		**98**	**106**	**110**	**112**	**114**	**116**
Subtotal support		**169**	**175**	**181**	**186**	**191**	**194**
Subtotal regular		**1 101**	**1 107**	**1 122**	**1 132**	**1 142**	**1 142**
TOTAL SENIOR MAN-YEARS		1 368	1 388	1 413	1 430	1 447	1 452

Table of ratios (man-years)

Support/international	1.7	1.7	1.7	1.7	1.7	1.7
Regular/international	11.2	10.5	10.3	10.2	9.9	9.8
Support and regular/international	13.0	12.2	12.0	11.9	11.6	11.4
Research and research support/ administration and operations	1.1	1.1	1.2	1.2	1.2	1.2
Research, research support, international cooperation and training, information/administration and operations	1.2	1.3	1.3	1.3	1.4	1.4

Table A-6 Schedule of sources and applications of funds, 1985-1988 (US $1 000)

		1985	1986	1987	1988
Sources of funds					
Unrestricted	Australia	439	447	0	-
	Austria		100	100	-
	Belgium	596	0	948	-
	Canada	1 199	1 332	1 490	1 840
	China		20	20	-
	Denmark	44	67	92	100
	Germany, Fed. Rep. of	1 120	1 386	1 623	1 360
	India	50	50	24	20
	Italy	491	556	663	650
	Nigeria	575	145	120	-
	Norway	396	483	511	560
	Sweden	108	179	160	180
	The Netherlands	415	550	679	740
	United Kingdom	500	634	723	840
	United States	6 240	6 312	5 435	5 430
	World Bank	5 000	4 500	4 200	-
	Subtotal	**17 173**	**16 761**	**16 788**	**-**
Restricted	France	118	163	204	-
	Italy	0	217	797	-
	Japan	1 255	2 404	2 220	-
	The Ford Foundation	100	100	100	100
	The Netherlands	106	427	224	180
	The Rockefeller Foundation	200	50		-
	UNDP	0	941	352	-
	Subtotal	**1 779**	**4 302**	**3 897**	**-**
	Other	**707**			
	TOTAL CORE	**19 659**	**21 063**	**20 685**	**21 750**
Special projects		9 959	10 708	11 369	15 504
	TOTAL GRANTS	**29 618**	**31 771**	**32 054**	**37 254**
Other income		384	396	482	300
	TOTAL REVENUE	**30 002**	**32 167**	**32 536**	**37 554**
Expenses	Personnel	19 705	20 572	15 937	19 977
	Travel	1 311	1 605	1 670	2 092
	Supplies and services	7 054	5 911	9 304	10 256
	Fellowships	831	1 517	417	894
	Property, plant, equipment	3 588	2 660	3 044	4 335
	TOTAL EXPENSES	**32 489**	**32 445**	**30 372**	**37 554**
Exchange gains		352	3 529	-66	
To (From) Capital Development Fund		630		1 859	
To (From) Operating Fund		-2 765	3 251	239	

Table A-7 Essential and desirable capital requirements, 1988-1993 (US 1988 $1 000)

		1988	1989	1990	1991	1992	1993
ESSENTIAL CAPITAL							
1. New capital							
New equipment	Research	898	800	450	400	300	200
	Computer	70			100	100	100
	Physical plant	30	15	55	100	75	75
Total new equipment		998	815	505	600	475	375
Total new construction		1 547	950	100	50	200	50
Total new capital		**2 545**	**1 765**	**605**	**650**	**675**	**425**
2. Replacement capital							
Replacement equipment	Vehicles	500	812	812	812	812	812
	Research	95	95	95	95	95	95
	Farm	230	256	250	268	220	245
	Computer	100	20			125	
	Physical plant	478	454	478	524	340	526
Total replacement equipment		1 403	1 637	1 635	1 699	1 592	1 678
Total replacement construction		387	495	560	560	560	560
Total replacement capital		**1 790**	**2 132**	**2 195**	**2 259**	**2 152**	**2 238**
TOTAL ESSENTIAL CAPITAL		**4 335**	**3 897**	**2 800**	**2 909**	**2 827**	**2 663**
DESIRABLE CAPITAL							
Library extension			300	200			
Beech aircraft			625				
TOTAL DESIRABLE CAPITAL			**925**	**200**			
GRAND TOTAL ESSENTIAL AND DESIRABLE CAPITAL		**4 335**	**4 822**	**3 000**	**2 909**	**2 827**	**2 663**

Table A-8 Balance sheet projection, 1985-1989 (US $1 000)

	1985	1986	1987	Projected 1988	Projected 1989
ASSETS					
Cash and short-term deposits	5 123	4 607	7 207	6 210	6 269
Accounts receivable:					
Donors	2 100	2 599	4 525	2 000	2 000
Others	1 454	586	574	100	100
Inventories	4 004	4 466	4 604	4 865	5 108
Other assets	451	281	262	250	250
Property, plant and equipment	39 341	42 505	45 821	47 500	49 500
Total assets	**52 473**	**55 044**	**62 993**	**60 925**	**63 227**
LIABILITIES AND FUND BALANCES					
Liabilities					
Bank indebtedness	620	0	0	0	0
Accounts payable and other liabilities	2 913	4 158	5 489	4 025	4 227
Accrued salaries and benefits	3 451	3 148	3 884	4 000	4 500
Payments in advance: donors	5 857	2 458	3 347	1 500	1 000
	12 841	**9 764**	**12 720**	**9 525**	**9 727**
Fund balances					
Capital	39 341	42 505	45 821	47 500	49 500
Capital development	1 340	573	2 011	1 200	1 000
Operating	-1 049	2 202	2 441	2 700	3 000
	39 632	**45 280**	**50 273**	**51 400**	**53 500**
Total liabilities and fund balances	**52 473**	**55 044**	**62 993**	**60 925**	**63 227**

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