Report to the Government of
Papua New Guinea

Review of the Program and Organization for Crops Research in Papua New Guinea

International Service for National Agricultural Research

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

ISNAR is the youngest of the 13 centers in the CGIAR network, and it is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff requirements, financial and infrastructure requirements, and related matters, complementing the activities of other assistance agencies. In addition, ISNAR has active training and communications programs which cooperate with national agricultural research programs in developing countries.

ISNAR also plays an active role in assisting these national programs to establish links with both the international agricultural research centers and donors.

ISNAR is supported by a number of members of CGIAR, which is an informal group of more than 30 donors: countries, development banks, international organizations, and foundations. In 1983, funding for ISNAR's core program was provided by Australia, Canadian International Development Agency, Federal Republic of Germany, Ford Foundation, France, Italy, Ireland, The Netherlands, The Philippines, Spain, Switzerland, United Kingdom, United States Agency for International Development, and World Bank.

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Table of Contents

Summary

At the request of the Government of Papua New Guinea a team from ISNAR, with assistance from staff of the Department of Primary Industry, reviewed the programs and organization for crops research in PNG, and made recommendations for strengthening the agricultural research system. The report first discusses the role and scope of agricultural research in the development process and the kind of functions needed in an efficient research organization. This discussion serves as a framework to present findings of the review, and to highlight major issues involved in strengthening agricultural research in the country. A final section presents the principal conclusions and recommendations. A series of annexes deal at greater length with some topics to supplement the main report.

Following an initial project identification mission from the World Bank for improving agricultural support services in PNG, the Government of PNG invited ISNAR to make a more detailed review of the crops research system and to make recommendations on (a) the procedures for establishing research priorities; (b) the assessment of resources to carry out an appropriate research program; (c) the appropriateness of the agricultural research structure; (d) the need for training; and (e) the adequacy of communication linkages between producer, government, and researchers.

National Agricultural Research Systems

It is considered that a national agricultural research service is required (a) to deliver to the government information that is appropriate to the formulation of a national agriculture development plan; (b) to provide to the producer reliable information for more profitable crop and stock production; and (c) to build and maintain a well-trained body of research scientists capable of carrying out the necessary research and of interpreting and applying advances in world knowledge for the benefit of national agriculture development.

Any national agricultural research system needs have procedures and mechanisms: for maintaining linkages with development planning authorities; identifying critically important researchable problems; formulating a suitable research program; developing research manpower and providing facilities to carry out the program; and for reporting the conclusions from research to those who need the information.

Agricultural Research in PNG

The DPI provides most of the agricultural research services in Papua New Guinea. There is some research activity associated with rural development projects, a growing contribution from the industry boards, and a small contribution from other bodies, such as the universities. The crops research component has, in the past, provided a solid base for development, it has given confidence to investors as far as tree crops are concerned, but food crops have not been so well served. The system has well-sited research stations with moderately good facilities for implementing the research program.

Since 1977 there has been a sharp decline in the number of experienced research staff, as well as changes in the structure and policies in DPI. Mechanisms for managing research activity that may have served well in the past, do not appear to be efficient in the present and some modifications are proposed.

Planning linkages, and program formulation. As the DPI has expanded since the 1960s the linkages between technical research sections and policy and planning sections have become weakened. They should be strengthened again to improve the delivery to research scientists of key policy guidelines for research program formulation, and to ensure that interpreted conclusions from the research system go to policy makers and planners.

Research projects are planned and decided within the disciplinary sections and then aggregated to form the research program for the Agriculture Branch. A multi-disciplinary mechanism for formulating project priorities in crops research (with an input from the producers and consumers) would be more suitable for such a critical function in the research system.

It is recommended that these aspects could be greatly improved by appointing a Director of a Research Division who would have strong unifying powers over the disciplinary sections, and would have a direct voice on the Policy Secretariat.

Research Planning. The current distribution of research manpower over many crops shows little planned concentration on any crop except cocoa. National priorities for crops research are not at present clearly defined, but there are strong indications that the maintenance of potential yields of tree crops, and the improvement of traditional food crops are high on the list. A set of research priorities along these lines is assumed as the basis for an illustrative planning exercise. In this, the present research manpower is reallocated into a few viable interdisplinary teams on key crops. The plan includes additional scientists supported by the industry boards for cocoa, coffee and oilpalm.

It is clear from the exercise that, on current resource allocations for research, only two food crop farming systems and three tree crops can be given a concentrated team approach. Many crops will receive only "care and maintenance" research often with one scientist responsible for more than one crop.

If, as recommended for creative interaction, research scientists should be grouped in viable numbers at research stations, then only six can be adequately staffed. However a larger network of small testing stations is also required. It is recommended that these testing stations be maintained and staffed by Provincial extension staff working in close collaboration with research station staff.

Financing of agricultural research. Most of the financing for crops research is provided through DPI. Recent developments propose a welcome significant contributions to reseaarch from the industry boards of the major cash crops. The total allocation, however, will then only be 0.24% of Gross Domestic Product, or 1.03% of agricultural GDP (AGDP), which is low for a country whose population depends heavily on agriculture. It is

recommended that careful consideration be given to increasing the allocation towards 2% of AGDP, recognizing the importance of continually improving productivity and opportunities for development of major crops. Resources allocated for research should always be judiciously balanced between scientific staff and their back-up support. The latter is currently lower than optimum. Initially, any extra recurrent funds should be used to increase support staff and operational facilities available to research staff.

Manpower and Training. The future research service must depend as soon as possible on well-trained national scientists. Currently none of the 28 national scientists (out of a total of 69 in the research service) have any postgraduate degree, and few have long experience. As the number of long-term experienced expatriate staff declines, it becomes more and more urgent that all new staff be trained formally in research methods. It is recommended most strongly that a Master's degree should become the normal minimum qualification for research staff and that a systematic staff development training program should be launched. A scheme to produce 50 national staff with research-oriented postgraduate degrees (35 M.Sc. and 15 Ph.D.) by 1995 is presented. The Faculty of Agriculture should be strengthened to improve its capacity to supply both graduate and postgraduate training for the research service. Initially most postgraduate training will have to be done at overseas institutions.

Agricultural economics research. National policy lays great stress on the development of rural areas and income generation from agriculture. Pricing, marketing and other economic policies have profound effects on incentives for small holders to increase production; an increase in research capacity within the Planning, Economics and Marketing Branch (PEM) is recommended to deal with these aspects. In addition, the benefits of proposed improved production technologies must be assessed under farmers' conditions of management and their multi-faceted value systems. Agricultural economics has an essential role to play in providing fresh insights into targets for new technical research activities. It is recommended that farming system economists be posted to work in technical research teams on major research stations, although remaining administratively within the PEM Branch to preserve disciplinary contacts and to help improve linkages between the research and planning branches.

Communications and linkages. Communications of four types are important to the agricultural research system of PNG: communication with potential users to understand production problems and to get research findings to them; communication with world sources of agricultural science; communication within the organization; and communication with policy-makers. All aspects deserve strengthening. The appointment of a Director of Research should help linkages with policy-makers. A Deputy Director with a small programming unit could greatly improve planning and communication within the organization. It is also recommended that each major research team should have a "dissemination leader" emphasizing close relations with extension services to ensure the delivery of research conclusions to the farmers who grow the crops. The DPI central library is good but its linkages with research stations should be improved. The scientists' contacts with the progressive world of agricultural science should be strengthened both by attendance at conferences and through more investment in literature and modern data gathering systems.

Chapter 1

Introduction

The Government of Papua New Guinea invited ISNAR to carry out a review of its agricultural research organization and program and to advise on measures, consistent with the World Bank's 1981 review of agricultural services, to strengthen the national agricultural research service.

Following a preliminary visit by Dr W. K. Gamble, Director General of ISNAR, and a visit in November 1981 by Dr Matthew Dagg, who led the subsequent review, terms of reference for a mission were approved; an itinerary was arranged so a team could gain a reliable first-hand impression of the nature and scope of the research system and program.

The terms of reference were:

"The study team will review the program and organization of the agricultural research system in Papua New Guinea in relation to national goals and objectives with special reference to:

"(a) the efficacy of procedures for establishing research objectives, maintaining research priorities, and evaluating and monitoring research programs;

"(b) the assessment of resources required for an agricultural research service appropriate to national development plans, in terms of staff, equipment, and infrastructure, with due consideration given to any need for external supplementary assistance;

"(c) the appropriateness of the organizational structure to facilitate the smooth implementation of the research program, taking into account:

(i) staff management and technical oversight
(ii) levels of managerial and financial autonomy needed for flexibility to meet changing situations
(iii) integration of research activities into those of industrial organizations, provincial governments, universities, other institutions, and international and national agencies
(iv) maintenance of a satisfactory environment for research that encourages and permits research staff to express their potential creativity;

"(d) the need for training and professional development programs for research scientists, research administrators, farm managers, and supporting staff

"The study team will address its task taking full account of the World Bank Review of Agricultural Services in Papua New Guinea."

The World Bank review had concentrated mainly on tree crop research, and it was understood that the ISNAR team would concentrate on food crop research, but not to the exclusion of other crops. The team would not be concerned with livestock research except as it interacted with crops research.

In the period between January 25 and February 26, 1982, a team of seven scientists carried out the review. It first had discussions in Port Moresby with appropriate officers from the Department of Primary Industry (DPI), the Ministry of Finance, the National Planning Office, the Public Service Commission, the United Nations Development Programme, the University of Papua New Guinea, and other research institutions. The team then visited the main DPI research centers at Keravat, Bubia, Aiyura, Kuk, and Laloki; contacted the research groups attached to rural development projects in the Southern Highlands and East Sepik plus the Simbu Land Use Project; met with research groups being established by the tree crops industries (cocoa, oil palm, and coffee); and talked with staffs of the University of Technology at Lae and Provincial Rural Development Offices in Rabaul, Goroka, Kundiawa, Mount Hagen, and Mendi. (Details concerning members of the team, the persons contacted, institutions visited, and the itinerary are given in Annex 1.)

The discussions were concentrated on crops research, as directed by the terms of reference. This report thus deals with part of the total agricultural research system, which is itself part of a wider national scientific research operation. It is recognized that, ideally, a system should be examined in its totality; then interactive elements can be incorporated into the full perspective for planning. It was recognized in this instance that farmers' enterprise systems include important livestock and forestry elements in addition to crops. It is noted also that many issues discussed concerning the role of research and the environment for creative work are applicable to all sectors of research. Detailed discussion refers specifically to crops research.

This report first discusses the role and scope of agricultural research in the development process and the kind of organization thought to be needed for efficient research operation. This discussion serves as a framework to set out findings of the review of agricultural research in the country; it also guides discussion of the major issues in planning to strengthen agricultural research. A final section presents the principal conclusions and recommendations.

Chapter 2

Role of the Agricultural Research System

Productive development from the national resources of a country is a major concern for any government. There have been massive strides forward in productivity in Papua New Guinea, as well as elsewhere, stemming from a better scientific understanding of possibilities for development, and there is continuing scope for the systematic application of scientific enquiry toward further development.

Every government should have a defined science policy concerned with ensuring that appropriate knowledge, new and old, is gathered and made available in the country; that a sufficient number of men and women are properly trained and provided with facilities to bring modern science to bear on national development possibilities; that research and education programs are properly designed; and that appropriate institutions are established to serve these purposes (including how to associate researchers with the political and development purposes of government). Ideally these components should be closely linked and articulated together from the beginning; in practice, they often evolve separately and have to be brought together at some later stage, such as in a council for science and technology.

In many countries, including Papua New Guinea, agriculture is an important target for development. A policy to make the most of what modern agricultural science has to offer in research, extension, and development -- appropriate to the country -- is highly desirable.

The team was not asked to review all of national science policy, nor all of agricultural science policy, but to concentrate on crops research especially in the Department of Primary Industry. It is, however, pertinent to recognize that agricultural crop research cannot stand on its own, even though it may have the largest research program in a country. It is an integral part of the broader national scientific and development program and is intimately bound up within the national approach to the role of modern science in national development. Although public agricultural services may be divided into compartments, real farming enterprises -- especially among smaller farmers -- are usually complex composites of crops, livestock, forestry, processing and marketing, and long-term maintenance of the land resource, all included in an integral whole. While substantial progress can be made in research on specific components of the system, it is necessary from time to time to address the viability of technologies in relation to the whole farming system, both to producers and to government. If responsibility for components is in separate divisions of government, it is important that efficient lines of communication and collaboration are maintained for some joint research activities between divisions. With this proviso, the subsequent discussion is mainly limited to crops research.

National agricultural research is part of the services to boost the agricultural industry to meet national objectives. It is an industrial research activity, serving to increase the productivity of the industry that is going to be the biggest source of employment, livelihood, and nutrition in Papua New Guinea for many years to come. The research service has three major duties.

1. The government is concerned about planning new development projects towards achieving the national objectives, and development projects in the agricultural sector play a significant part in this planning activity. Central to any agricultural development plan is the primary productivity of the crops grown (including grass) and the willingness of farmers to exploit that productivity. The planners must base their estimates on existing established knowledge, or on inspired guesswork, or on reasonable hopes of improved productivity. For much of this planning exercise, the best informed sources of information on potential productivity and the likely factors that might restrict achievement of the potential, are the personnel in the national agricultural research system. They are in a good position to assess possibilities.

> It is the first duty of the research system to make available to the government, in an appropriately interpreted form, key elements of information on which reliable development plans can be based.

It is the job of the research system to ensure that the relevant information is suitably presented to be understood by the planners and other government agencies. (There is perhaps some obligation of the recipients to take notice of the information.)

2. The scientists in the research system are likely to recognize and highlight potential technical difficulties in possible crop development schemes. But they are also the people who can find solutions to problems or devise ways around difficulties. They should be the group to recognize new opportunities for accelerated agricultural development in PNG, based on advances made elsewhere around the world that can be adapted to local conditions. They are not tied simply to trends from existing knowledge and past performance. They are <u>agents of change</u> who can open new possibilities by new findings or new technologies, changing the parameters of assessment of feasibilities, or generating new margins to get things moving for the benefit of farmers. But the researchers must verify, by adaptive testing at the farmers' level of management, that new suggestions are beneficial in the farmers' own terms of reference.

> The second duty of the research system is to make available to the farmers, through appropriate channels, the detailed agronomic and economic information on which to plan production of crops and stock, based soundly on adaptive research at the farmers' level. It is an essential part of the research system role to ensure that the information is in a form easily understood by the recipient.

3. In order to carry out its role adequately and productively, the research service must have well-trained specialists in different disciplines, who can keep abreast of the latest advances made in agricultural science around the world and who can appreciate the

significance of these national and international research findings for development in PNG conditions. The strength of the interdisciplinary team of the national research system depends on the combined competence of the specialists in it.

> The third duty of the agricultural research system is to develop and maintain a group of well-trained, competent scientists in the appropriate disciplines in active research positions, capable of interpreting national and international scientific advances for the benefit of national development. It implies that there should be a well-planned staff development program ensuring systematic and rapid training to the highest levels attainable by the individual, so as to encourage creative research activity as soon as possible. Until a research scientist is being creative in interpretation of experimental and world knowledge, he or she is not really functioning in the system.

No national research system in the world is likely to be large enough to be able to generate internally all of the knowledge and technology required. The more modest the system, the more reliance there must be on incorporating and modifying advances made elsewhere. However, there is a great deal of research that must be done within the country; appropriate information cannot all be imported. An inventory of natural resources, positive and negative, of land and people, must be compiled steadily within a country (even if methodologies from elsewhere are used). Adaptive research must be done in the local environment, physical and socio-economic. Crop potential must be protected against locally identified hazards. Remarkably little applied research is being done anywhere in the world on many important crops of the tropics, especially food crops, and it may therefore be essential that some applied research, and even basic research, be undertaken locally. (See Annex 2 for further discussion.)

Cycles of Research Functions

The amount of information that can be generated from direct experimental work per year in a relatively modest research system is fairly small compared to the body of relevant world knowledge generated each year. It is critical, therefore, that the selection of projects for research must be carefully planned to make the most impact on the solution of PNG problems in agricultural development. This is an important step in the cyclical path of research activity (see figure 3 in Annex 2). From problem identification, a research program is formulated, which will require trained manpower and research facilities to be carried out, and after analysis and interpretation of the results from the research program, the conclusions must be interpreted in a form to bear directly on the initial problem.

The national agricultural research system must have an organization that permits efficient operation of this cycle and maintains an appropriate environment for the researchers to carry out creative work. It must also allocate appreciable resources for ensuring that the research staff can keep in close touch with the world of relevant agricultural research external to PNG.

These requirements have implications for the form of organization and the management of the research system. The implications are examined in later sections (and Annex 3) after the current situation in agricultural research in PNG is reviewed.

Chapter 3

Current Situation of Agriculture in Relation to Agricultural Research

Several excellent reviews (Densley, 1978, World Bank, 1981a, and World Bank, 1981b) are available that cover the economy of Papua New Guinea and its prospects in the 1980s. All stress the decline in prices of major export crops and minerals from PNG in recent years and the fall in production and investment in plantations, which have led to a reduction of earnings, a serious change in the balance of trade, and a rundown of foreign exchange reserves in 1980. This setback to the rate of development caused the government to revise its expenditure plans from a real growth rate of 3% (that had been maintained over the past few years) to a holding operation, with an expectation of moving ahead again in 1984 at 1% per annum.

For several years there have been reports suggesting low levels of nutrition in some parts of the country, and more attention has been given to improving food production. As export earnings have declined, the costs for large quantities of imported food have become burdensome, reinforcing a desire to be more nearly self-sufficient in food.

Priorities for development expenditure have come under intense scrutiny. In the policy statement on an economic strategy for the 1980s (NPO, Nov. 1981), it is stated that, "Particularly strong efforts will be devoted to the agriculture base of the economy because it is here that the majority of people earn their livelihood and it is here that the underlying strength of the balance of payments ultimately rests." High among top priority proposals is that to allocate additional overseas concessional funding for expanded agricultural extension and research.

Research deserves high consideration, for in times of declining prices, more competitive markets, and smaller margins, the agents of change can point the way to novel practices and technologies to reduce costs of production, maintain profitability and competitiveness, and improve efficiency of food production within the country.

The National Public Expenditure Plan (NPEP) document goes on to stress the tight financial circumstances in the near future, and in the general guidelines for new projects (p. 37), it points out that special attention should be given to proposals to improve the efficiencies of existing resources of personnel and facilities by redirecting and retraining personnel, and by rationalizing and improving existing organizations to bear directly on the most important issues. Much of this report is directed to these aspects of the research system and more efficient ways of allocating extra resources to agricultural research.

3.1 Agricultural Policy

Agriculture continues to contribute about a third of the gross national product of PNG, in spite of the increasing (albeit variable) contribution from the mining sector through major enclave developments, and a growing tertiary sector. Agriculture is even more important in its contribution to exports, about half, although if food imports are subtracted, the net contribution is only a third of the total. The agricultural export crops (coffee, copra, cocoa, palm oil, tea, rubber) initially came from the estate sector, but for several years now more than half of the production has come from smallholders (except for the relatively minor crops of tea and rubber). The comprehensive description of agriculture in PNG assembled by Densley (1978) remains authoritative.

After a period of sustained growth in the commercial agricultural sector, there has been some fall-off in recent years. The slowing in the rate of growth has been described in current World-Bank reports, (see footnotes 2, 3 on page 6). Several key constraints have been identified including (a) the weak services available to smallholders, (b) the insecurity or absence of tenure of land for development and high labor costs, with the consequent low levels of investment in plantations, and (c) the shortages of skilled national manpower at many levels, especially in the agricultural research and extension services.

Nevertheless, the prospects for growth in agricultural production are good, and national policy since independence has continued to give prominent attention to agriculture, as befits a predominantly rural population working with only partially exploited resources. The positive stance towards agriculture is enunciated forcefully in at least three of the nine strategic objectives of the National Development Strategy of 1976: increasing rural welfare; increasing economic production; and improving food production, subsistence, and nutrition.

In spite of such declarations of priority, agriculture has not recently been a favored sector for public support. These have been difficult times for public expenditure in PNG because of the slumps in major sources of revenue; agricultural development generally and support for agricultural research in particular have suffered along with most other areas of public expenditure. Recent statements in the NPEP 1982-85 document (NPO, Nov. 1981) have again been firmly supportive of agriculture.

In general, it is stated that the Government "has decided to pursue a strategy that develops agricultural production, and which allows people to remain in rural areas while still sharing in the benefits of development" (p. 37). It aims therefore both to upgrade subsistence production and increase earning opportunities from cash crops. It is recognized that there is a danger that the traditional food supply system could break down in the relatively near future, and improvements in these production systems are sought. This will require research attention.

There is a general desire to move towards self sufficiency, but the food supply to urban areas is heavily dependent on currently relatively cheap imported rice. A conflict arises between the desire to keep consumer prices at politically acceptable low levels, and the desire for domestic

production of important food crops. It is still not clear which food crops deserve the most intensive research attention if resources for research are restricted, but again, clearly research is needed as the prime mover for making changes in productivity parameters that can lead to more confident development decisions. The team did not see any written statement of research policy beyond the resolve to give more priority to food crop research.

3.2 Organization of Agricultural Support in DPI

The important agricultural sector in PNG is served by many governmental and private organizations. The Department of Primary Industry is responsible for developing national policy in the sector and for providing a wide range of services, including agricultural research.

The organization of DPI is outlined briefly here and discussed in Annex 3. (For a fuller treatment, see the excellent description available in the World Bank Agricultural Services Review.) DPI operates under the direction of a Minister and a Secretary. It is made up of seven branches: the commodity-based branches are: (1) Agriculture, (2) Livestock and (3) Fisheries, which report to the Deputy Secretary; department-wide basic services and control branches are (4) Management Services, (5) Agricultural Education and Training, (6) Planning, Economics and Marketing, and (7) Policy Review and Coordination, which report directly to the Secretary. (The last two branches are being reorganized to form a branch for policy, planning, and coordination.)

The seven DPI branch heads and the four regional (extension) controllers formerly coordinated activities in the monthly meetings of the Standing Committee on Agriculture. That committee served as a two-way communication channel between headquarters policy formulation and the field implementors. Its impact was weakened by lack of adequate secretariat services and by the decentralization process which assigned extension functions to the control of the 19 provincial governments. Following a World Bank recommendation, the committee, which includes the DPI Secretary, the Deputy Secretary, and heads of branches, has been replaced by the Policy Group; a policy secretariat has been established to serve it.

The Agriculture Branch, under an Assistant Secretary, includes eight disciplinary units: Agronomy Section, Agricultural Chemistry Section, Agricultural Development Section, Entomology Section, Horticulture Section, Land Utilization Section, Quarantine Section, and Plant Pathology Section. This branch is responsible for most of the public agricultural research in the country, and it operates 10 agricultural experiment stations that carry out research on food and tree crops.

The organic law that created the provincial governments, approved in 1977, transferred responsibilities and financial powers for several key activities from the central government to the provinces. The provincial government assumes responsibility for most activities in agriculture with the exception of research, credit, quality control, quarantine, and marketing of export commodities.

Each provincial secretariat includes a Provincial Agricultural Service with a Rural Development Division; the division is headed by a provincial rural development officer (PRDO) who reports to the provincial secretary and the provincial minister of agriculture. The PRDO is responsible for the planning and implementation of all agricultural programs within the province, including extension. Decentralization is still underway, and many issues still have to be resolved regarding the relative roles and effective working relationships of central and provincial departments. Agricultural research is an important example. It is a central government activity, but it needs close linkages with farmers and extension staff in order to define production problems and priorities accurately, and so work to develop the most appropriate technology to be introduced to and adopted by producers.

Linkages to other departments are mediated through the Policy Secretariat and, for some development proposals and internal DPI initiatives, the Planning Section. Key national linkages are to the National Planning Office (concerning National Public Expenditure Plan proposals, implementation, monitoring, and reporting), to the Department of Finance (for DPI budgeting, control, and expatriate staffing and for interaction on externally financed agricultural developments), and to the Public Service Commission (on organizations and staffing generally). Present linkages appear to be weak between DPI and other departments that have interest in agriculture, such as the Department of Minerals and Energy.

Agricultural Research in Relation to the Planning Process for NPEP Projects

On the basis of policy directives and guidelines from the National Executive Council, the DPI (along with other agencies) formulates and designs projects for potential funding in the NPEP. Draft projects are submitted via the Planning Section to the National Planning Office, which -- with the assistance of the Technical Evaluation Committee if necessary -- presents preliminary evaluations to the Budget Priorities Committee (BPC). The BPC recommends selected projects to the National Planning Committee for final approval. Approved projects are detailed and costed by the department or agency concerned and re-submitted for final decisions on funding allocation prior to implementation.

Technical and socio-economic contributions from agricultural research officers can be made to project development and evaluation at several points in the chain, especially at the project formulation and design stage; they have detailed knowledge of the technical possibilities (and limitations) in relation to the policy objectives laid down. However, there is frequently little interaction between the groups in different branches in DPI before projects are prepared; subsequent inter-branch examination does not appear to be thorough. Linkage for project preparation between the agricultural research and the agricultural development sections within the branch is better than between branches.

3.3 Agricultural Research in Papua New Guinea

History of Agricultural Research[1]

Agricultural research has always been a service of central government and has played a significant role in agricultural development in PNG. Crop

introduction and preliminary trials were centered at the experiment station at Keravat after it was established in 1928. The Highlands Experiment Station, Aiyura, was opened in 1937. After World War II, crops research was one of four divisions in the Department of Agriculture, Stock, and Fisheries. Agricultural research sections seem now to have less status; they are part of the Agricultural Branch (which includes the substantial Development Section), whose Assistant Secretary is one voice among seven heads of branches when policy issues are discussed.

The network of research stations and testing centers in the country and the overall research capacity were steadily expanded until the early 1970s. Major emphasis in both extension and research was on cash crops, and great advances were made in the major tree crops in plantation and smallholder farming systems. Only rice (the dominant food import) among food crops received much research effort. Recently both introduced and traditional food crops and farming systems have received more attention as evidence of malnutrition in some areas has accumulated. A new Horticulture Section was formed in 1975, the only significant structural change in the research organization since the early 1950s. This also brought the introduction of a cadre of field horticulturists, designed to improve linkages between the research workers on the experiment stations and the extension service staffs.

For most of the post-war period, the research positions have been filled with expatriates. National university graduates became available for recruitment first in 1976. (Only 28 of a total of 69 research posts are held by national scientists, and none of those have postgraduate research degrees.) As terms of service changed to limited-period contracts, many experienced expatriate staff elected to leave to seek more secure jobs elsewhere. The result has been a sharp reduction in the total research experience available, although the numbers of research scientists have not fallen appreciably.

Current Pattern at DPI

Crops research in DPI has long been organized formally on a disciplinary basis with section chiefs for agronomy, horticulture, entomology, plant pathology, agricultural chemistry, and land utilization. The chiefs are responsible for the preparation and implementation of the research program of their respective sections, subject only to priorities assigned by the Secretary of DPI.

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[1] Chief Agronomist A. E. Charles prepared a statement on the history of agricultural research in PNG. That statement is presented in Annex 4.

Officers at research stations answer directly to the chief of their discipline, and formal integration of projects across disciplines occurs only through discussions between chiefs or at the direction of the Assistant Secretary. (It was decided recently that all research staff on a station should be responsible to the officer-in-charge to encourage a coordinated station program; however, this regime had not yet been put into effect.)

In practice, the research stations have been run by the Agronomy Section. There has been informal coordination on a commodity basis, with the agronomist providing general leadership for a crop and calling in other specialists as needed. This system has worked with staff of long experience in the service, and research programs have brought progress on the tree crops. However, the leadership role of the Agronomy Section has never been formalized, and the informal approach has not proved so suitable for less experienced staff. Scientists tend to formulate their own research programs for approval and financing through their own section.

In the absence of formal machinery for developing interdisciplinary research planning at the station level, it is difficult to arrive at high-priority research projects to fill key gaps in information about a crop. In addition, there have not been clear guidelines from headquarters on overall agricultural objectives and on which crops, especially food crops, deserve most attention. These guidelines depend on basic policy decisions at parliamentary level and on subsequent development planning. In recent years there has been a general shift of emphasis of agricultural research from tree crops to food crops, but there is no written research program that conveys this emphasis unambiguously. The most common complaint of staff at research station level was of the lack of direction and guidance in what was expected of them. Duty statements have not changed much since the 1950s.

Research activity in DPI is centered at central laboratories and offices at Konedobu (Port Moresby) and at five main research stations placed to serve Lowland and Highland areas and the special area around Port Moresby. Five small substations serve specific purposes, such as the high-altitude station at Tambul for pyrethrum research.

The central facilities at Konedobu are located in several temporary buildings, some of which appear to be unsuitable to house valuable and irreplaceable collections. The dispersed arrangement does not facilitate good interdepartmental communication, and maintenance is costly and difficult. A new, unified facility could improve the communication flow as well as the management and supervision of the central services.

Research staff on the main stations generally considered the basic farm and laboratory facilities adequate for the role in hand. (Shortage of senior staff houses reduces flexibility of operations.) Shortage of equipment and transport is a constraint at some places, but the dominant shortage referred to at all stations was of trained technical and administrative support staff. The ratio of technical support staff to scientists is low (there is a total of only 51 technicians -- rural development officers (RDOs), technical assistants -- rural development technicians (RDTs), and field assistants -- rural development assistants

(RDAs) to 34 scientists on the main research stations). Doubtless a better provision of support staff would increase pressure on the available facilities and equipment. Members of the team felt that some of the research staff had grown too accustomed to operating under severe constraints and were ceasing to appreciate how much more efficient their contributions to the country might be with better support and facilities.

DPI has established a basic infrastructure of experimental stations and laboratories for agricultural research which has generated practical technology for production and protection of all important cash crops through selection of improved varieties and distribution of planting materials. It has also evaluated a number of possible alternative crops and developed considerable knowledge of the agronomy, pests, and diseases of the most important staple food crops grown in PNG. Research and scientific services by the Agriculture Branch have been an important factor in attracting external funding for major national development projects. In spite of these significant research results, there has been little evaluation of the research program in PNG to ensure that selected priorities are reflected, that new areas of concern are accommodated, and that those which have achieved their objectives are replaced.

Currently DPI is supporting some research activity on most of the major crops, but at variable levels of intensity. In the absence of an overall plan and expectation, it is difficult to assess the performance. A comprehensive list of all agricultural research projects in the country has been prepared by R. M. Bourke (included in Annex 5), but it does not give estimates of scientific manpower allocated to each. An alternative breakdown by research manpower for different crops is attempted in Table I (in section 4.3 and Annex 7). This analysis shows that of the 69 DPI crop research scientists, 22% are engaged in food and feed crop research, mainly on sweet potato and vegetables; 19% on cash crops, especially cocoa and tea; 8% on fruit, nuts, spices, and ornamental flowers; 32% on a range of central research services including chemical analysis (half on rubber alone), land utilization survey, pest, and food processing; and about 18% on extension liaison and administration.

Rural Development Projects

As the governmental office entrusted with rural development, DPI has been concerned with and supportive of regional rural development projects. Some of these have agricultural crop research components, such as the South Coast Food Project located in the Central Province; the East Sepik Rural Development Project with experiment and service stations in Saramandi and Hawain; the Simbu Land Use Project with headquarters at Kundiawa; and the Southern Highlands Rural Development Project centered at Mendi.

The research component of these projects is directed towards basic information on land use and farming systems, as well as towards producing quick results through adaptive research directly related to the agricultural systems covered by the projects. It has been intended that these could eventually become provincial research units. Although the research component supports the regional project as such, its linkage with the central service is weak. Coordination between their work and

that in main research stations is at the personal level. The study, consideration, and approval of these research components have been more an integral part of the projects themselves than of the central DPI research service.

Universities and Independent Institutions

The Faculty of Agriculture of the University of Papua New Guinea (UPNG) has a research program at Port Moresby and Lae, both under modest conditions and mostly directed towards support of the teaching function. The main concentration of research activities is on winged bean and taro; on erosion and land health; on local feedstuffs for livestock; and on marketing. In addition, the university has an overall fund for research which finances projects in other faculties that bear on agriculture. There is no formal arrangement for coordinating the research activities between DPI and the university, but the university teachers are invited to professional meetings held periodically by some of the DPI disciplinary sections, some DPI staff give lectures to university classes, and recently steps have been taken to set up a joint committee for coordinating research.

The University of Technology (UOT) at Lae houses part of the UPNG Department of Agriculture to handle the fourth year of the agriculture course; it also provides a 17 ha farm for teaching and research. The Department of Chemical Technology of UOT and DPI have jointly established a food storage research unit on campus, but beyond this linkage, there is no formal arrangement for coordinating agricultural research. The university has a modest fund for overall research in other projects and activities.

The Wau Ecology Institute, devoted to the preservation of the national ecology, is involved in biological insect control and in the development of methods of intensifying food crop production in subsistence agriculture, while conserving the natural resources. It is a privately funded institute, well known in PNG, and has collaborative arrangements with other research organizations overseas for work at its centers in PNG.

Commodity Boards

The technical quality of tree crop research has been high in the past, and the research results have benefitted the production of export crops. These factors have been appreciated by the industry, in which there is now worry about the decrease in funding and qualified manpower for research in tree crops. The oil palm industry has established its own research unit that is now run by the PNG Oil Palm Association. The promising beginning in oil palm has stimulated the Coffee Industry Board and the Cocoa Industry Board to follow a similar pattern; those boards have now begun to finance research programs for their respective crops.

Industry board research is financed through a levy on marketed production. The industry will benefit directly from that investment, and at the same time the development can liberate DPI research resources for other activities such as food crop research. DPI maintains strong

representation on the boards and on the research committees, and there are still DPI research staff actively involved in the research programs. The DPI should continue its participation to ensure that adequate account is taken of national priorities and that technologies are suitable for the smallholders, who produce more than half of the crops involved.

Agricultural Economics Research

Virtually all agricultural economics research for PNG is done within DPI in what has been the Planning, Economics and Marketing Branch. The work has covered: the gathering of some farm and production statistics through an annual census of commercial sector and some sample surveys of the subsistence sector at the provincial level; farm management studies and the economics of various enterprises and practices (by way of case studies undertaken mainly by area economists); evolution of alternative marketing and stablization schemes; evolution of specific development schemes and proposals; and policy analysis of broader issues, such as the role of agriculture in development. The present low staffing levels, the trend of fewer experienced staff in the relevant sections, the necessity to maintain the servicing of ad hoc requests, and the commitments to international commodity marketing agreements, all imply that economic research activity per se has almost ground to a halt. Little effective agricultural economics research is currently being done in the universities or the Institute for Social and Economic Research, the emphasis in the latter being mainly on sociological aspects.

3.4 Financing of Agricultural Research

Most of the financing for agricultural research is provided through the Department of Primary Industry. However, recent developments propose a significant contribution from the industry boards of the major cash crops.

Department of Primary Industry

The funding for crops research is mainly through the Agriculture Branch, with some relevant research work in agricultural economics supported through the Planning, Economics, and Marketing Branch. Funding for livestock research and fisheries research is through the Livestock and Fisheries Branches.

Within the Agriculture Branch, it is not easy to distinguish how much is allocated for research and how much for development and extension, since funds are lumped for crop production, research, and services. About 40% of the branch staff belong to the Agricultural Development Section, but it does not follow that funds would be divided in the same ratio -- research staff and activities tend to be more costly than development staff and activities. Of the funds allocated to outstations (about 40% of total), 34% is allocated to the Development Section. It is estimated that 35% of the total recurrent funding for the Agriculture Branch goes to the Development Section and 65% to crops research.

The total appropriation for the Agriculture Branch in 1981 was K5.5 million, (US$8.25 million) comprising K3.5 million for recurrent

expenditure and K2.0 million for NPEP projects. The allocation for crops research of recurrent expenditure, at 65%, was K2.3 million (US$3.45 million).

Some of the administrative overheads for research are borne by the Management and Services Branch, estimated at K100,000 per annum. The contribution from the PEM Branch on agricultural economics research amounts to about three economist years, about K150,000 per year.

The total DPI direct support for crops research for 1981 was therefore about K2.55 million (US$3.825 million).

National Public Expenditure Plan (NPEP)

It is even more difficult to separate research and development expenditure from NPEP and Asian Development Bank (ADB) projects, since the amount allocated for research (for example, the East Sepik development project) includes provision for extension activities such as raising seedlings. It is estimated that in 1981 about K300,000 of the food crops sectional program funds were spent on research and about K200,000 on other projects, giving a total of K500,000 (US$750,000).

The estimate for total expenditure on crops research in 1981 by government is, therefore, about K3.05 million (US$4.575 million).

Private Sector

Three organizations associated with production and marketing of certain commodities also support some research programs.

Cocoa Board

The Cocoa Board is financed by a cess on sales of cocoa at the rate of K20 per ton (US$30 per ton). Management and board costs are about K7 per ton, and K13 per ton is to be applied to cocoa research, training, and publications. On production worth about K46.4 million in 1980, this would mean an income for research on cocoa of about K340,000 (US$510,000).

Oil Palm Research Association

The Oil Palm Research Association is supported by a levy of K1 per ton of fresh fruit bunches of oil palm. This gave a total of about K210,000 (US$315,000) in 1981, which is about 1.4% of the total export value of the crop.

Coffee Industry Board Research Department

The new Coffee Research Department is to be financed from a component of a levy charged to support its stabilization fund. This operates on a complicated sliding scale: when the price of coffee is below a threshold price, as it was in 1981, the levy is a basic 1 toea per kilo, of which 0.5 toea is allocated to research. With the crop valued at K119 million (US$179 million), as in 1980, this would mean about K250,000 (US$375,000) for research support.

The total from the industrial sector for national crops research, therefore, is potentially about K800,000 (US$1.2 million), although that amount is not being applied yet.

Relation to GDP and GADP

The Gross Domestic Product (GDP) for 1980 was about K1,600 million (US$2.4 billion). The allocation of national funds for crop research (K3.05 million) was thus about 0.19% of GDP, which is low for a country whose population depends heavily on agriculture. The Gross Agricultural Domestic Product (GADP), based on the value of marketed and non-marketed commodities, is relatively low and perhaps does not reflect the true weight and importance of agriculture in PNG. Defined in these terms and referring to crops (excluding the value of forestry, fishery, and livestock products), the GADP for 1980 was about K375 million (US$563 million).

The government resources applied to crops research, K3.05 million, came to about 0.8% of GADP for crops. As suggested above, this figure is perhaps higher than a true reflection of the importance of agriculture might have given; even so, it is below the level of the 2% of GADP tentatively recommended in the World Bank Sector Policy Paper on Agricultural Research (June 1981) as a suitable level for government investment in agricultural research by developing countries. Including the potential contribution for the cash crop boards, the total research effort in PNG for agricultural research would be 1.03% of the GADP.

It is evident in the analysis and discussion in Section 4.3 and Annex 7 that several important areas of food and cash crops are receiving little research support; they could benefit substantially from increased support to improve the potential productivity and reliability of crops for the dominant rural population. However, in the discussion below it is noted that it would probably be more efficient initially to apply any available extra funding to improve the standard of junior staff support and operating facilities for research scientists in existing programs.

Support for Research Scientists

The K2.3 million in recurrent funds plus K0.3 million from Food Crops Sectoral Programme NPEP supported the activities of 69 senior research staff listed in December 1981 (41 expatriate and 28 national). As a simple average, that is an allocation of about K38,000 (US$57,000) per scientist for salary and allowances, technical support, facilities, and all supplies.

For reasonable exploitation of his/her potential, a scientific officer should have a support staff of the equivalent of 1 technician (RDO), 1 technical assistant (RDT), 1 field assistant (RDA), and about two man-years of labor). The precise needs will vary depending on the situation; the above is a modest allocation. The support staff listed above would cost about K15,000 (US$22,500) per year in salaries and allowances. An expatriate officer at S2 level would cost at least about K20,000 (US$30,000); a national officer at S2 would cost about K8,000 (US$12,000).

With reasonable staff support to an expatriate officer, there would be about K3,000 (US$4,500) left from the average of K38,000 to cover all transport, supplies, equipment, books, maintenance of facilities, work off station, and other costs. There would be a greater margin with national research officers, but they are currently in the minority.

With efforts to maintain even moderate facilities for work, it is impossible now to provide for adequate support staff. The combined support staff for 34 scientific officers stationed on six research stations is 51 (10 RDO, 19 RDT, 22 RDA), compared to a modest target for efficiency of 102. Administrative support on research stations is also low.

The low level of technical support staff is a serious constraint at the laboratories at headquarters. Loss and non-replacement of technical staff of the Agricultural Chemistry Section has drastically reduced output from the scientific personnel. (As of February 1982, six scientists were supported by six technical staff and three laborers). The routine administrative load falling on section heads, due to shortage of administrative support, makes it difficult for them to exercise the enlightened and innovative research management that should be their main concern and contribution to the system.

The net result of limited support is that the scientists' special skills are not being efficiently employed. While research program planning must be based on the senior research staff, the creative movers, financial planning should be based on realistic levels of support staff and operating costs. Based on experiences of many research managers, it can be stated as a general guide that personal emoluments should not exceed more than two-thirds of the total budget for a research organization.

3.5 Manpower and Training

An all-pervading problem for the agricultural research service in PNG is the acute shortage of manpower in relation to the perceived problems and the extent and coverage of agricultural research activities. This problem is further accentuated when considered in the context of qualified indigenous manpower for agricultural research. The 1981 World Bank report considered the assessment of the needs for trained personnel and the measures and implications for filling these needs as of the greatest importance to the rational planning of agricultural development. In the current situation, the total of 69 research staff in DPI includes 28 nationals, who have first degrees in agriculture or related sciences but no specific training for research. This indicates that training and manpower development for research constitute the most important constraint for the development of a productive and stable agricultural research service.

Historically, agricultural training in a university -- culminating in a first degree, honors degree and, in some cases, a postgraduate diploma -- has been considered adequate training for research. But an examination of such programs indicate that at best they provide a foundation for research but do not prepare personnel in areas of research problem definition, research methodology, or analytical research. The result is

that most of the research personnel, including expatriates, have had to pick up research procedures over a long time of field experience and practice, sometimes under the guidance of an experienced research worker. This procedure is not suitable for a country that requires an accelerated research-based development in agriculture, especially when the number of experienced researchers is falling low. Nowadays, it is necessary that personnel for agricultural research be adequately trained and prepared in the basic and applied scientific disciplines and in research and agricultural experimentation methodology; this almost invariably means training at least to the M.Sc. level and in some cases to the Ph.D. Research scientists so trained will have the capacity to link with, adapt, and utilize knowledge from the world scientific community and be in a position to initiate and execute relevant research programs with minimum supervision.

It is clear that the long-term hope and plan should be in the systematic and progressive higher level training of present national staff and those to be recruited into the DPI in the next 10 to 20 years. This will require major investments in human resources development; such investments are considered worthwhile in the light of the contributions that agricultural research could make to overall development.

Moreover, many of the expatriate staff are looking ahead to research careers elsewhere, typically in an industrialized country. Their criteria for successful performance will tend to be based on the value systems and requirements of the more technically advanced and affluent countries. (As indicated in Annex 2, such countries can afford to leave adaptive research to commercial suppliers and large farmers, expecting national research staff to concentrate on applied and more basic research.) These criteria are not seen as the most desirable in PNG at present. It is important to develop as soon as possible a national cadre of research scientists pursuing research objectives of top national priority based on criteria important in Papua New Guinea.

Discussion of the program of the Agricultural Education and Training Branch of the DPI showed that, although there are two sections concerned with training and staff development, activities seem to be concentrated on maintenance of records and staff appraisal. There is no consolidated manpower development plan, and staff development arising from appraisal appears to be ad hoc. The bulk of the other activities of the branch, apart from information, focus on the administration and staffing of colleges, recruitment, and administrative aspects of current training courses. There is no coordinated program for the identification of suitable courses to prepare scientific officers or support staff for their functions in the research service. For example, of the 20 members of staff of DPI on overseas training in 1981, only three were on research-oriented courses of longer than one year (two for M.Sc. and one for postgraduate diploma).

National Survey of Manpower Needs

The Government of PNG, DPI, and the National Planning Office have been aware of the manpower and training issues in the agricultural development plan of the country. At the instigation of the National Planning

Committee, the NPO commissioned analyses of future manpower requirements, with their implications for policies in education, training, and localization (Colclough Report). More recently, through a firm of consultants (McKillop, Williamson & Associates Pty Ltd.), DPI has undertaken a review of existing manpower requirements and an assessment of pre-service and in-service training needs for agriculture specifically. A draft of the McKillop report was made available to the team, which drew heavily on its findings as far as sub-degree training for resarch support staff was concerned. The report examined the training and manpower development in colleges of agriculture, providing recommendations that would strengthen and reform these colleges and the agricultural industry training centers expected to replace some of them. The strengthening of these training institutions along the general lines suggested in that report can be expected to provide suitable intermediate-level manpower and support staff for agricultural research in the future.

Colleges of Agriculture: Training of Research Assistants

The colleges of agriculture and the two universities -- University of Papua New Guinea (UPNG) and University of Technology (UOT) -- are important elements in the agricultural education scheme of the country. But the foundation for agricultural training in the colleges and universities is laid in the teaching of sciences and agriculture in the high schools. Experiences indicate the need for strengthening this foundation. It may be well to examine the contents of agricultural science taught at this level and to consider the introduction of a national examination in agriculture.

The minimum requirements for admission to the colleges of agriculture are upper passes in English, mathematics, and science in Grade 10. At present, it appears that the colleges rate highly in the preferences of students, perhaps only second to education. There is a strong trend towards the maintenance of uniform curricula in the four colleges of agriculture, which now offer only the two-year certificate-level training (there was formerly also three-year diploma training). In some cases certificate holders, after three years in the field, return for one more year of training to qualify for the diploma.

While it is considered desirable that this first level of formal training in agriculture should feature broad training in the theoretical and practical aspects of agriculture, the tendency to cover too many areas in the certificate program (up to 76 courses) results in lack of depth in the treatment of areas such as crop husbandry, soil science, animal husbandry, farm management, and extension education. Also key areas essential in the training of research support staff, such as statistics and field experimentation, are not covered or are given only superficial treatment. Although the training in the colleges cannot be expected to prepare candidates fully for the research assistant position (for example, much of the training in techniques of experimentation, data collection, and technical assistance in research have to be given as in-service training), their programs should provide a good foundation. It seems that the scientific staff of the research service might play a greater role in contributing ideas to the curricula in these colleges.

The career prospects for RDTs in the research service are not as attractive as for those in the colleges or the provincial extension services. This makes it difficult for the system to attract well-trained and competent RDTs as research support personnel. There is need for the creation of positions and opportunities for in-service training as well as the recognition and reward of performance for technical support personnel. This would require a review of the ceilings and establishments and the creation of a structure that would recognize performance as the basis for advancement and promotion.

Universities: Training for Research Scientists

The University of Papua New Guinea is the main formal institution for the higher education of future research scientists for the Department of Primary Industry, the provincial extension services staffs, and the agricultural industry in general. The university offers a four-year Bachelor of Agriculture degree. The Faculty of Agriculture was established in 1975 and is still relatively undeveloped: it has one academic department and 10 academic staff, with programs split between UPNG in Port Moresby and the University of Technology in Lae. The first three years of the degree program, including one science foundation year, are undertaken in Port Moresby (using supplementary teaching from seven other faculties, notably science and social sciences) and the final year is at UOT, where facilities exist for technical and practical training in agriculture. Since its inception, the faculty has produced 115 B.Agric. graduates, and 9 Honors graduates (one additional year after the B.Agric.), and 7 Masters graduates; 108 of these were initially employed in DPI central and provincial posts. There is some dissatisfaction in DPI about the level of technical knowledge and competence of UPNG graduates in agriculture. This might be because the curriculum as taught at present appears to be a compromise that depends on the teaching of more than 50% of the courses by staff outside the agriculture faculty, and because the teaching program is split between two universities. The faculty and DPI have set up a joint committee to look into this problem. Opportunities for research and research collaboration are limited in the faculty of agriculture. If the faculty is to meet the increasing demands for agriculture graduates from the centralized agricultural research system and the decentralized agricultural extension services, its teaching and research capabilities should be strengthened; unified and adequate facilities need to be provided; and a postgraduate program should be developed. Decisions on priorities are needed to guide early attention to these many important needs.

3.6 Research-Extension and Other Linkages

During the post-World War II period, both agricultural research and extension services were national functions administered in what was later reorganized and named the Department of Primary Industry. Most officers in the two services then were expatriate graduates or diplomates with university training in agriculture. Emphasis was primarily on export crops, whether the clientele were from plantation or smallholder enterprises. With decentralization and localization, the extension services were transferred to provincial administration. Staffing now

comes primarily from two-year agricultural college leavers, with diplomates and a few university agricultural graduates placed mainly in provincial headquarters posts.

Research-Extension Linkages

DPI researchers have at least an implied mandate to provide research results to the extension services; one staff unit within DPI has a continuing (though not explicitly defined) responsibility for training activities with the provincial extensionists. Publications are the main tangible evidence of the linkage of researchers to extension services. Except for the major reporters of scientific findings (the Papua New Guinea Agricultural Journal and research bulletins), extension officers are named among prime audiences for the several levels of materials produced. These series, by descending order of reading difficulty, include: departmental reports, field station reports, rural development handbooks (on specific subjects), Harvest magazine, Farming Notes, and Village Talk. Also the DPI includes provincial extension staff among audiences for its house organ, Didimag, which deals mainly with policy, procedural, and personnel news from the headquarters.

The extension service organization and staff capabilities were not specifically included in the terms of reference of the ISNAR mission. Communications linkages were identified for attention. Communication with the extension systems came up in visits to provincial extension units in several provinces, and major studies were available which included some aspects of the research-extension linkage. The most recent and extensive of these studies was the 1981-82 appraisal by McKillop and his associates. This report raises pervasive questions about the strength of the linkage, suggesting inadequacies on both sides. McKillop's tests of technological knowledge, administered to samples of extension staff, plus ratings by observers of extension activities, indicated relatively low performance capabilities of field extension staff. Extension workers' evaluations of contributions from research indicated perceived shortcomings in (1) a general lack of applicable technology, especially for subsistence gardeners, and (2) such complexity in presentation of research findings as to make them unusable by field extension staff.

Observations by the ISNAR team tended to confirm both positions. Little evidence was seen of extension staff use of research materials, and research workers reported little confidence in extension staff to use research results to advise producers. Except for some instances of personal visits to research stations or personal contacts in respective offices, few cases were found of planned or formalized interaction between research and extension staffs. The recent creation of the post of field horticulturist appears to address this need; however, the team found some inconsistency in the value attributed to these activities.

It was observed that some improved varieties and improved practices are appearing in the fields of food producers. Undoubtedly there are research-extension linkages involved in stimulating some of those changes. But there is little evidence to suggest a continuous, planned process of diffusion from research to practice.

Another aspect of research-extension linkage is that which brings information on producer needs and situations to the researchers. Little evidence was seen that extension staff is in close communication to help researchers gain this understanding. Nor was there found among researchers a particular openness or desire for this relationship. Cases were seen where researchers were going to the gardens of producers to gain knowledge of cropping systems and local practices, yet there was no indication that researchers viewed the extension staff as an appropriate source for such information.

Observers who have known the agricultural production situation in PNG over the last three decades regard research-extension linkages as weaker now than in earlier periods. Some of that weakening might be attributed to division of responsibilities between national and provincial levels, or to changes in the relative educational attainments of the principals (both the research staff and the extension workers have less academic preparation on the average than was the case a decade ago), or perhaps to other factors. For whatever reasons, the research-extension linkage now must be considered less than optimum for the two-way flow of information. Only with effective linkage is there greater probability (1) that researchers will be working on the right problems and developing appropriate technologies and (2) that the results of their research will move promptly and effectively to those who can use it.

Links to World Knowledge

Awareness of existing world knowledge in his field is the base from which the individual researcher builds his own work. The research system can gain from world knowledge sources because researchers elsewhere may already have solved a given problem or have developed technologies that can be adapted and adopted. Two main ways are involved in keeping in touch with world knowledge: a continuous inflow of information, usually via the scientific journals in the relevant fields; individual scientists participate with others in various activities, such as professional society meetings, conferences, and symposia.

For the scientists in a small country, professional interactions usually mean costly international travel. In many systems some resources are provided to assist staff. Some concern was discovered by the review team regarding the use of such funds: it was suggested by some that these travel funds were being used mainly to support administrative travel rather than for scientific interactions. Another area for system initiative is in staging events in which scientist interaction may be stimulated -- seminars, task force activities, problem-oriented conferences, for example. Such events take researchers out of their laboratories or plots, but they may be highly productive in encouraging creative interdisciplinary approaches to research tasks.

The DPI Library, the system's link to world science, appears to have a well-rounded and reasonably up-to-date collection of current periodicals and references. Funding levels cause some concern: there was a question, for instance, whether it would be possible to meet the cost of 1982 journal subscriptions from the allocations available.

Field station researchers expressed satisfaction with table-of-contents services provided by the library staff and considered that they had reasonable access to library resources. The extent and currency of literature collections were found to vary widely between different field stations. An inventory of the resources at the several stations, perhaps consolidating at either the national library or in special collections related to the work of research teams at certain sites, might strengthen the linkage for outposted researchers.

Links to Policy-Makers

A key linkage of a research system is to the policy-makers and leaders (including politicians) whose support is crucial to its existence. Such leaders may reasonably expect to have regular reports of the results of investment in research. They may also reasonably expect that the research system will devote some of its effort to bring the expertise of researchers to bear on matters that are important to the policy-makers -- such as the potential societal returns to different levels or different areas for investment in agricultural research.

The linkage seems to hinge on the chief officer of the research system; it is not a responsibility to be delegated to others. While the review team found a general receptiveness among policy leaders and planners to research system inputs, it did not find a person or post in the research system where that linkage responsibility clearly resided. Persons in higher administrative posts in branch or department have important roles in the linkage, but they are usually not close enough to the research operations day-to-day to carry out the task alone. A director for research (which is suggested in the team's recommendations) could undertake this role, which is not now exercised to the extent needed.

Chapter 4

Major Issues in Relationship to Agricultural Research

Following the review of crops research in Papua New Guinea, the ISNAR team concluded that there were five issues of major importance for strengthening the national agricultural research systems: manpower and training; organization of crops research; research program planning; role of agricultural economics research; and communications and information organization. These issues are examined in the following sections.

4.1 Manpower and Training

One of the major issues emerging in the review of agricultural research in PNG is that of manpower and training. There is a low ratio of national to expatriate research manpower in the agricultural research system, and nearly all nationals have had no formal research-oriented training beyond the first degree. This factor affects the planning and productivity of research as a whole. It also represents a constraint in the development of a stable and productive agricultural research system that can meet the challenge of need for increasimg productivity in the agricultural industry's food crop and export crop sectors during the next two decades.

Training for Research Posts

It is important that PNG should immediately embark on a systematic training program of indigenous personnel for research positions. Such a training program should envisage the training of the qualified existing staff in the research service to the Masters level and the recruitment and training of new staff progressively to replace the expatriate staff who leave the service at the end of current or renewed contract periods.

Research Support Staff

A second major manpower problem is the lack of suitably trained and experienced support staff for the research service. No consistent attempt has apparently been made to train research support staff who could enhance the productivity of research scientists by providing technical assistance in field and laboratory work. The colleges of agriculture are suitably placed to train many such research support staff, and the reforms proposed in the McKillop report should provide for some of the specialized training needed. The research service should play an important role in assisting the colleges and the training centers in the identification of curriculum and the provision of some in-service training for such staff. In addition, the universities -- especially UOT, which already has some facilities for the training of technicians -- should be encouraged to provide both formal and informal training

programs in such areas as biological, biochemical, and electronic techniques suitable for technicians in an agricultural research service. DPI should be encouraged to identify, recruit, and sponsor suitable candidates for these courses, persons with basic training in agriculture or science. Some of the programs may need to be tailor-made to fit the role of technical assistance to be played by the candidates.

Manpower Development Plan

In order to achieve the objective of a strong, stable, and productive research system, a national plan is needed for the training of agricultural manpower. This training program should envisage yearly allocations of training positions and fellowships that would enable the present national research staff, and additional staff to be recruited, to be trained progressively over the next 10 or more years. Such a comprehensive and intensive postgraduate training program should attempt to train national staff to at least the M.Sc. level and some to the Ph.D. Initially most of the training will have to be undertaken in university institutions outside the country, until the Faculty of Agriculture can provide the staff and resources to mount an appropriate range of postgraduate programs within PNG.

A Long-Term Plan

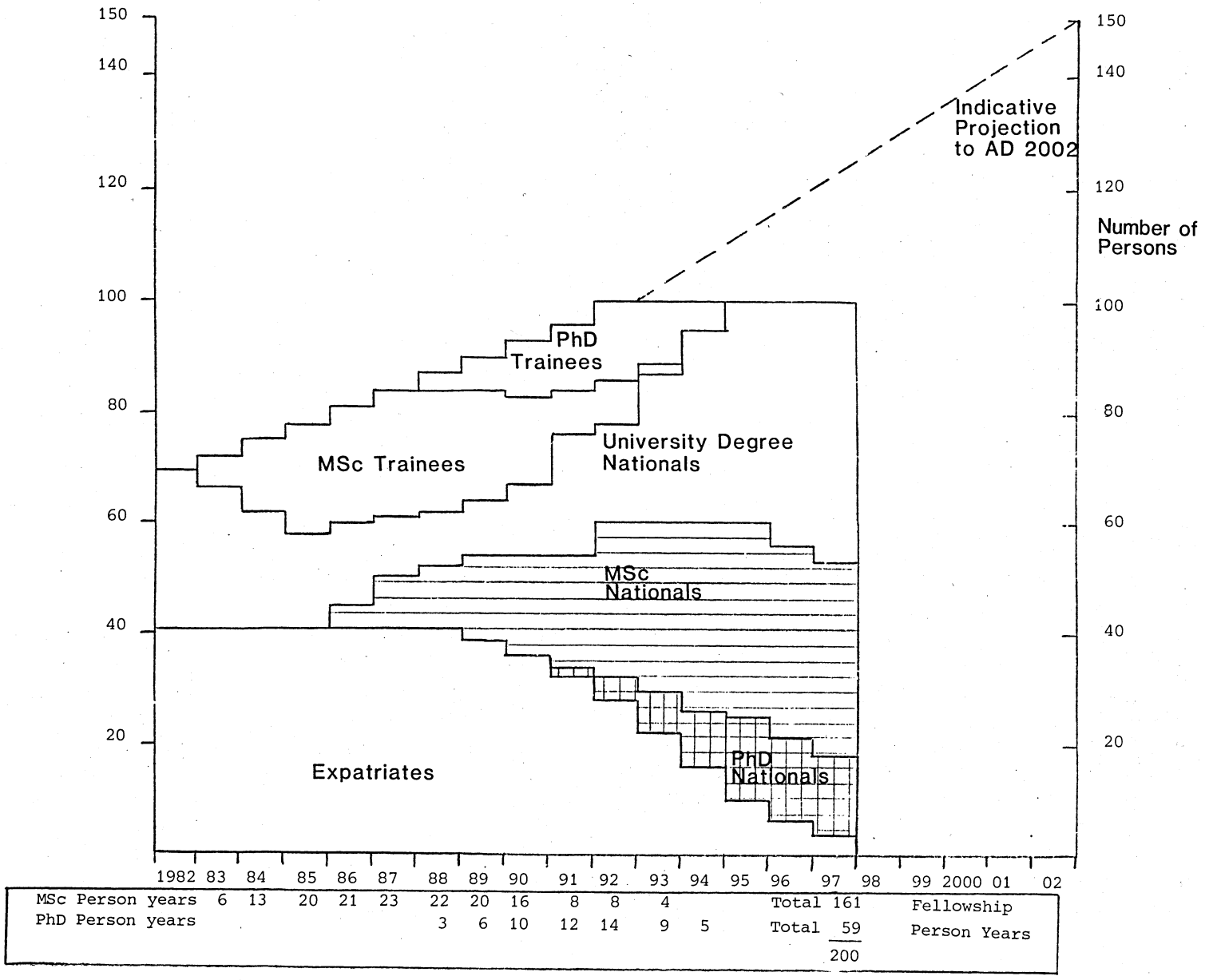
It is recommended that a manpower development plan be adopted, phased over a 15-year period, as developed in Annex 9 and summarized in Figure 1. This plan envisages a net growth of 3.7% in research staff (equivalent to three positions) per year. This would increase the number of positions modestly and progressively from 69 in 1982 to about 100 in 1992, with further increase, depending on research program expansion and development, to about 150 by the year 2002. These provisions would involve 6, 13, 20, 21, and 23 fellowship person-years in the first, second, third, fourth, and fifth years of the training program; the peak would come in 1989 and 1990, with 26 fellowship person-years required (16 M.Sc. and 10 Ph.D.). The plan would provide for training 64 national staff and require a total of 220 fellowship person-years (with 2.5 years estimated for M.Sc. and 3 years for Ph.D. programs).

Under these conditions, all agricultural research activities could be undertaken and directed effectively by national staff by 1995; the staff then would include 50 with advanced research-oriented training (15 Ph.D. and 35 M.Sc.). The retention of the present level of expatriate staff until 1988, and their progressive replacement by trained national staff (as indicated in figure 1), would ensure continuity and stability of the research programs and the retention of valuable experience during the period of build-up of an indigenous research service.

Training Officer Recommended

A manpower development plan of this nature would require much planning, management, and monitoring. It is suggested that a Training Officer in the Directorate of Research be provided. He or she would be expected, in consultation with the director, deputy director, and the research program leaders, to identify, place, and supervise suitable candidates in the training programs. The development plan would be suitable for external funding as a 10-year (or two 5-year) project through NPEP.

Figure 1. Plan for developing research scientist manpower, Crops Research, Department of Primary Industry.



Supernumerary Positions Needed

A major related issue is the staff establishment ceilings in DPI, which may affect the build-up of staff positions, the initial release of existing staff for training, and addition of new staff later in the program. In view of the importance of the need for manpower development in the agricultural research area, it is recommended that provision be made for the creation of supernumerary or training positions, initially funded through the fellowship program and progressively absorbed into the establishment on a planned basis. This step of creating supernumerary positions during the development of indigenous research manpower to replace expatriate research staff has been found to be useful in other developing countries where the same goal has been pursued. It has enabled the progressive development of viable and responsive research systems. This approach should be given serious consideration in PNG, since it is believed that the entire manpower development plan, and the stability and continuing productivity of the research service, could depend on it.

4.2 Organization of Crop Research

The organization of the crop research system should facilitate its capability to carry out its three-part role of (1) supplying information to government for development planning; (2) generating and supplying agronomic and economic information to enable farmers to improve their farming systems and incomes; and (3) developing and maintaining a group of well-trained research scientists capable of keeping abreast of advances in world agricultural research for the benefit of PNG development.

Several shortcomings have been recognized in the present organization, some concerning external contact and communication with government development planning bodies and some concerning management arrangements within the research organization. (The issues in organization are discussed in more detail in Annexes 3 and 6.)

Classical Hierarchical System

A major organizational limitation is that the research sections are managed on the standard civil service pattern, with a classical hierarchical system of line authority. This is considered to be an appropriate system for departments where the concern is with control of people or property, or the expenditure of funds on predetermined programs; it is not appropriate for a research service essentially concerned with creation and delivery of new information that can change existing plans.

Within the Agriculture Branch, research sections are associated with the Development Section. The Development Section is concerned with control and implementation, and it does require a managerial structure; however, that structure does not fit the needs of a research service.

Separate Crop Research Division

As a minimum, it is strongly recommended that a Crop Research Division be separated from the Development Section. This would provide a more appropriate structure for creative research tasks, and as a separate division it could be perceived to speak clearly to its role of research. This action was recommended in the 1981 World Bank Review, and the ISNAR review team strongly endorses that proposal.

Research Scheme of Service

It is further recommended that the new division should have a "research scheme of service" (similar to those operating in other parts of the world), which mainly rewards effective research activity, rather than administrative responsibility.

A Semi-Autonomous Institute

It is believed that the best organization, if it should be possible, would be a Crop Research Division as a semi-autonomous institute. Such an institute would be placed within DPI, with its own budgetary system, but with the budget still controlled by Management Services through an officer placed in the management structure of the institute.

Internal Management Arrangements

This review team agrees with stress placed in the World Bank Review on the disruptive effect of having the research function dispersed among several distinct disciplinary sections. The structure militates against cooperation between colleagues and the development of interdisciplinary teams.

Director of Crops Research

The team endorses strongly the recommendation that there should be a Director of the Crop Research Division. The director would provide the technical leadership to the various heads of disciplinary sections, would present a balanced view to planning authorities, and would transmit policy directives in appropiate technical terms to the research staff.

A Programming Unit

There should also be a Deputy Director, who would head a small research programming unit that would develop a consultative system for determining research project priorities and maintain a flow of information within the system. There should also be an administration cell to handle much of the routine administrative load.

Research Stations

With the probable development of industry-backed research teams for some of the major tree crops, many activities of the main research station could be regrouped. The following assignments are suggested:

Cocoa and Coconut Research Program	centered at Keravat
Coffee and Tea Research Program	centered at Kuk
(Oil Palm Research Program	centered at Dami)
Highlands Food Crop Research Program	centered at Aiyura
Lowlands Food Crop Research Program	centered at Bubia
Port Moresby Food Supply Research Program	centered at Laloki

The officers-in-charge at these main research stations should have more administrative and financial authority than at present. Each main research station should have a major multidisciplinary team for a crop or group of crops, each team with a leader responsible to the Director of Research for the progress of research in that crop throughout the country.

Testing Centers

Adaptive research, including the testing of recommended practices in new areas or on farmers' fields at the farmers' level of management, is an essential part of the research system's activity. It would be impracticable (and probably undesirable) for the central research service to maintain directly the number of testing centers that should be operating. It is recommended that the provincial rural development staff should carry out these trials in collaboration with research scientists from the main research stations. Currently it might be difficult to find extension staff with adequate training in experimental methods and research technique. However, if proposals contained in the McKillop report for more specialized in-service training for extension staff are approved, it should become possible for specially trained extension staff to take on this role. Collaboration between research staff and extension staff at the adaptive testing stage at the farmers' level may be a further way of forging stronger links between research and extension.

4.3 Research Program Planning

The need for a coherent system for planning the national research program has been stressed previously. It is believed that the change in organization proposed, from the separate disciplinary sections to a unified Crops Research Division, is a necessary step towards systematic planning. It is also believed that a programming unit under the deputy director would provide a means for better consultation among research scientists to establish firm technical priorities for research projects.

Focus on National Objectives

The research effort must be carefully addressed to prescribed national objectives and development plans in agriculture. These are not yet set out clearly, which makes it difficult to plan appropriate research thrusts. The need to maintain and increase cash crop revenue is strongly urged, but so too are the needs to: boost the productivity of traditional food crops; to reduce food imports; and at the same time to maintain low food prices in urban areas. These present a wide variety of targets for a limited research staff; there is little to focus on.

With senior staff allocated and listed on a disciplinary basis, it is not easy to determine the exact weight of research effort by major crops and problem situations. The review team attempted to recast the staff resources on a basis of research on crops and supporting research activities -- described further in Annex 7. (While it is important for the quality of the conduct of research to maintain good contact between colleagues in the same discipline, it is equally important in planning research programs to consider the problem of the whole crop production system and the size of the teams assigned to these problems).

Allocation of Manpower Resources

Table 1 in Annex 7 shows the allocation of current senior research staff by person-years per year to the different tree crops, food crops, and other research services and activities. It shows a thin allocation to a wide range of crops, with only the group in cocoa approaching the level of a reasonable interdisciplinary team of sufficient strength to achieve a significant rate of progress.

Interpretative Core

It is clear that most of the crops in the country cannot receive more than cursory attention from the modest research system. It is, therefore, all the more important to maintain a constant monitoring of research advances being made in the world, so that new opportunities arising elsewhere can be exploited quickly. This requires a minimum core of experienced research specialists who can interpret new findings in the light of PNG conditions.

Some Research Teams

Some crops are critical for the well-being of the country, and deserve more attention than monitoring. Limited choices of top priority have to be made, with viable teams of scientists of different disciplines mounted to focus on a few key crops. In tree crops, the private sector has taken the step of supporting directly research on those deemed most important: coffee, cocoa, and oil palm. In food crops, the Horticulture Section has intensified research effort on traditional food crops, especially following the 1978 statement on Food and Nutrition Policy for Papua New Guinea.

An Illustrative Research Program Plan

Although the review team did not discover firm priorities on cash and food crop research, it made assumptions about priorities, using them as a basis for an illustrative exercise on how the research staff might be reallocated, and to examine the degree of allocation flexibility available. The assumptions were:

* The total number of senior staff in the Crop Research Division should not increase beyond its December 1981 level of 69 scientists. (This is seen as a severe constraint and by no means desirable. The

current level of research funding is still well below the level of 2% of gross agriculture domestic product, which was suggested as a guideline for developing countries in the World Bank Sector Policy Paper on Agricultural Research, June 1981.)

* The minimal tree crops research program would seek to protect the massive investment already made by concentrating on: maintaining yield potential of the trees and soils and on increasing productivity of smallholders by investigations to understand and improve the small farmers' production system that includes the tree crops. It is also assumed that the respective industry boards would support 4.5 man-years per year each on cocoa, coffee, and oil palm.

* In food crops, top priority would be given to improving sweet potato-based farming systems in the Highlands and taro-based farming systems in the Lowlands.

* The necessary input into the research teams in farm-level economics would be supplied by the Planning, Economics and Marketing Branch. This would require one economist posted to each of the main research centers for cocoa, coffee, and oil palm, and highland and lowland food crop farming systems.

The implications for mounting minimal interdisciplinary teams on these assumptions are worked out in Annex 7. It is stressed that intensified research work on improvement of the major food crops must be carried out under conditions that realistically represent farmers' systems of cultivation, with part of the work devoted to improving the whole system. The distribution of research time resulting from this planning exercise is shown in Table 2. (The estimate of research effort from "other research groups" is approximate, probably overestimated, and there is no information on the proportion of time given to administration and extension. The estimate includes the economists.)

Sweet Potato Research

The major change with respect to sweet potato work would be in assembling the mix of disciplines at one main research station, rather than having them widely scattered as at present. An additional breeder and a physiologist would be needed to speed the rate of generation of new materials towards producing cultivars and systems that show a large advantage to traditional farmers -- small improvements are not likely to convince farmers to change. (A detailed program for sweet potato breeding was described by a consultant member of the team and provided to the division. A copy may be obtained from ISNAR.)

Taro Improvement: The taro improvement program would involve drawing senior staff positions from other crops. There is a limit to how far this sort of transfer could be carried, which severely limits the choice of action.

In this exercise, interdisciplinary teams have been mounted for research on two principal crops in the settings of small-farmer conditions. The number of research staff available for food crops work in the example includes those staff released by the industry boards assuming major responsibility for tree crops research. Even with that increase, staffing minimally for the two crops programs would leave resources only for maintenance efforts on all other crops, with little opportunity for technology development in any.

The small number of remaining staff would permit some individual responsibility for maintaining awareness of world progress on certain crops, as well as some time for some variety introductions and adaptive research collaboration with provincial extension staff. Intensive research on other crops would only be possible with an increase in the size of the national agricultural research team.

The training scheme described in 4.1 assumed a rate of increase in total staff of three per year. Even with that rate of increase, the effective number of staff in place would not reach 69 persons until 1990; in the meantime any added strength would come from recruitment of extra experienced expatriates.

The exercise set out in Annex 7 illustrates research planning under assumed decisions on which crop systems deserved most research support. It is not intended to indicate what the top priorities should be. It is recommended, however, that the evolution of a research plan should be based on approaching the production problems from a farmers' standpoint and recognizing the need to develop interdisciplinary teams of sufficient strength that a significant impact can be made in a short time.

Table 1. Allocation of Agricultural Research Manpower Resources in PNG in Man-Years per Year Based on Estimates of Division of Time Spent on Research and Administration. Collected on Visits to Research Stations.

Crop Activity	Agricultural Branch DPI	Other Research Groups	Total
Cocoa	5.5	2.5	8.0
Coffee	1.5	2.75	4.25
Coconut	1.25		1.25
Oil palm	1.0	5.25	6.25
Tea	2.25		2.25
Rubber	0.25	0.5	0.75
Pyrethrum	1.25		1.25
Subtotal	13.0	11.0	24.0
Sweet potato	4.67	2.0	6.67
Taro (aroids) and yams	0.5	2.0	2.5
Vegetables	4.25	0.25	4.5
Rice	2.0		2.0
Pulses	0.5	0.25	0.75
Bananas/cassava	0.83		0.83
Feed	0.5		0.5
Fruit, nuts, spices	3.75		3.75
Sugar	0.25	2.0	2.25
Flowers	2.0		2.0
Farming systems	2.17	4.83	7.0
Subtotal	21.42	11.33	32.75
Storage/processing	2.0		2.0
Pathology services	3.75	0.25	4.0
Entomology services	1.0		1.0
Soil and plant analysis	5.67		5.67
Land use services	7.5	3.0	10.5
Biometrics	2.0		2.0
Subtotal	21.92	3.25	25.17
Extension/liaison	5.0		5.0
Administration	7.5		7.5
Subtotal	12.5		12.5
TOTAL	69.0	23.75	92.5

Table 2. Hypothetical Allocation of Agricultural Research Manpower in DPI Crop Research Division in Man-Years per Year. Based on Assumed Priorities for Protecting the Potential of Cash Crops and Boosting Production of Traditional Food Crops.

	Revised Crop Research Division	Industry Boards	Other Research Groups	Total
Cocoa	1.5	4.5	0.7	6.7
Coffee	1.5	4.5	0.7	6.7
Coconut	1.3			1.3
Oil palm	1.5	4.5	2.7	8.4
Tea	1.3			1.3
Rubber	1.3		0.5	1.8
Pyrethrum	0.6			0.6
Subtotal	9.0	13.5	4.6	27.1
Sweet potato	5.4		2.0	7.4
Taro (aroids) and yams	3.8		2.0	5.8
Vegetables	2.3		0.25	2.55
Rice	1.6			1.6
Pulses	1.0		0.25	1.25
Bananas/cassava	2.1			2.1
Feed	0.4			0.4
Fruit-nuts, spices	0.8			0.8
Sugar	0		2.0	2.0
Flowers	0.2			0.2
Farming systems	5.6		4.83	10.43
Subtotal	23.2		11.33	34.53
Storage/ Processing	2.7			2.7
Pathology Services	0.3		0.25	0.55
Entomology Services	0.3			0.3
Soil and Plant analysis	4.0			4.0
Land use Services	6.5		3.0	9.5
Biometrics	2.6			2.6
Subtotal	16.4		3.25	19.65
Extension/liaison	4.1	2.0		6.1
Administration	16.3	2.5		18.8
Subtotal	20.4	4.5		24.9
TOTAL	69.0	18.0	19.18	106.18

4.4 Role of Agricultural Economics Research

Any decision as to how to combine scarce resources (such as land and labor) productively towards some end falls in the domain of economics. Thus, management decisions of subsistence farmers in traditional villages are just as legitimate as subjects for economic analysis as are those of other more commercially oriented enterprises, such as plantations, producers' cooperatives, agricultural handling and processing firms, marketing boards, or bureaucracies managing a development project or an economy.

In a sense all agricultural research workers whose activities are concerned with efficient use and allocation of scarce resources are doing agricultural economics research. However, this term is usually reserved for work where the emphasis is on efficiency of production, marketing, and policy arrangements. Economists are trained in the methods and limitations of economic analysis and should be able to involve these skills usefully in DPI research programs generally and in crops research in particular. However, as noted in Section 3.3, agricultural economics research activities are presently at a low level in DPI.

Past work has been concentrated on marketing and price stabilization of the export crops. There has also been some attention to production economics research and related project evaluation, confined mainly to the commercial sector (especially plantations) and development projects involving establishment of export crops, import-substitution crops, and livestock enterprises. It appears that one group of agriculturists has thus been missed by research workers in agricultural economics: namely, the subsistence farmers.
The majority of agricultural producers are to be found in traditional farming communities. They operate a complex and intensive intercropped farming system, usually with important livestock elements. There is typically little marketed surplus. Even when there is surplus, many marketing problems stand in the way of handling usually highly perishable goods over difficult terrain served poorly by transport facilities. Doubtless such difficulties largely explain the scant attention given to the subsistence sector.

It has been widely held that the prospects were poor for economic growth via a more productive and efficient traditional agriculture. However, traditional agriculture is not static. Growing intensity of land use in many areas is leading to reduced soil fertility and productivity, increased nutritional stress, and emigration towards urban unemployment and consequent social tension. Some areas have successfully incorporated smallholder production of export crops, enhancing cash flow and improved nutrition via purchased foods. There have been a few unconnected attempts to study such systems, mainly in the integrated rural development projects.

Study of complex farming systems involves several disciplinary perspectives, ranging from soil science through agronomy, animal husbandry, economics of production and marketing, and possibly social

anthropology. These perspectives must be merged so that a system can be examined as a system of interrelated elements.

As national policy lays greater stress on the development of rural areas and the importance of agriculture in generating rural income, so greater stress comes for economically and socially attractive crop production technologies for smallholders. The contributions of agricultural economists, jointly with agronomists in surveys of production problems at the small farmers' level, can give new insight into, and targets for, fresh technical research endeavors. The benefits of proposed technologies must be assessed under farmers' conditions of management and with his/her value system, carefully taking into account the multiple demands for labor and the values of leisure by those engaged in the farming enterprise. These are aspects that technical research scientists may overlook, especially if the research work is confined to the environment of the experiment station. For impact in the rural areas, more on-farm research activity is needed by interdisciplinary groups.

Agricultural economics should be a strong integrator in a farming systems research effort. There is, however, no tradition of such work in PNG. This should be the next frontier for research economists, to be members of interdisciplinary teams addressed to improving the efficiency and performance of the diverse traditional farming systems of PNG and of the new complex cash cropping patterns of smallholders.

In due course there should be agricultural economists associated with each of the main interdisciplinary research teams, based on the research stations in order to interact closely with the biological scientists in the teams. The illustrative research plan, set out in Section 4 and Annex 7, implies a target of one farming system economist on the research stations for, respectively, cocoa/coconuts, coffee/tea, oil palm, plus highland and lowland food crop farming systems.

Such staff could be appointed into an agricultural research division. However, the majority of economists will likely be in the Planning, Economics and Marketing Branch, and it is recommended that the farming systems research economists be appointed in that branch and posted to experiment stations. They would thus retain their professional association and would provide an additional linking mechanism between the Research Division and planning operations. Their research effort would be part of the crops research program to which they were assigned, carried out under the direction of that team leader.

(The emphasis here on past neglect of the main food production and smallholder cash-crop systems is not intended to imply that further research on the economics of commercial farming systems -- new and old, marketing of and trade in agricultural products -- new and old, and analysis of agricultural projects and policies -- new and old, will not be required on a continuing basis. The more detailed staffing suggestions set out in Annex 10 for several senior economists, and their related subsections of research staff and in-training personnel, are designed to ensure a continuing capacity to meet these responsibilities.)

4.5 Issues in Communication

Communications activity of an organization may be divided into three areas according to different functions it must carry out. One function is that of bringing to the organization the information it requires for effective operation -- the inflow of information from policy-makers within the country, from the world community of scientists, and from others who influence the work of the organization. A second function relates to the output or delivery of findings to the people and organizations that can use them. A third function is the interchange within the system, the flow of information that affects the efficiency and effectiveness of work by the various elements. These three broad functions provide a means for classifying issues that appear to affect the performance of the system, and they are used to organize the following discussion.

Bringing in Information

The organizational structure for crops research activities within DPI places it within one of the foremost departments of the government. That should assure access to policy-makers. As a unit, however, it is separated by two or three additional administrative levels; in principle, this raises concern for the adequacy and accuracy of information flow. The review team did not specifically analyze this linkage and thus offers neither criticism nor reinforcement of the present situation.

The modest resource allocation of DPI to its library seems to give favorable returns. Scientific personnel expressed approval generally of (1) the range of reference and resource materials available to them and (2) the responsiveness of library staff to their needs. That applies to the central library and its services (providing material on request and circulation of tables of contents from which interested persons may make specific requests). The documentation support at field research stations was found to be varied. Such a large and long-established station as that at Keravat appeared to support this work reasonably well in terms of resources devoted to obtaining materials and staff to give service. Other stations were less well served, leaving an individual mainly on his own initiative to use the relatively time-consuming process of roundtrip communications with the DPI library.

The review team was concerned to hear that the possibility of limited funds might make it impossible for the library to maintain its collections of scientific journals. Should such a squeeze on funds occur, it is urged that greatest care be given to any decision that might interfere with scientists' ability to keep current in their fields. On the other hand, it appears that added resources could be justified to improve access of field scientists to such information.

Also in the area of supporting scientific contacts, it was noted that there are relatively few opportunities for interaction within a professional discipline -- and still fewer for interdisciplinary activities. Some of the disciplinary groups, economics and plant pathology are examples, have periodic professional programs; but few instances were reported in which a mix of scientists from several disciplines had come together to approach common problems or interests.

A number of DPI scientists voiced concern that few opportunities are available to them for professional interactions that help them keep up-to-date scientifically and contribute to personal morale. Some expressed the belief that funds for meetings, especially international meetings, were mainly used for administrative travel and not for scientific contacts. The review team did not gather enough evidence to offer a recommendation; however, the issue seems of sufficient importance to merit thoughtful study.

Reporting the Results of Research

Under the government structure in PNG, the provincial extension services are the key institutional channel through which agricultural research system results reach the many scattered farmers. The review team found the research-extension linkage relatively weak, finding evidence in line with the recent intensive McKillop study. As McKillop noted, each partner cited shortcomings in the performance of the other. The organization of extension in PNG was not within the terms of reference of the ISNAR review, and the team thus did not address measures that would directly affect that part of the system. However, it did consider possible initiatives by the research system that should strengthen the linkage and encourage prompt and accurate transfer of research results. Several initiatives appear to be within the role of the research group, including: (1) greater collaboration in on-farm testing; (2) increased interaction of personnel, both in the field and in training activities; (3) addition to each principal interdisciplinary research team of a staff member whose primary role would be to develop linkage with extension in definition of farmers' problems and dissemination of results; and (4) increased communications specialist staff to provide greater service to extension officers and farmers as audiences for research information.

A wide range of print materials has been developed to report research results to various audiences. In numbers of series and in allocation of resources, the greater attention seems to have been given to technical rather than applied aspects of the findings. (Limited interaction with provincial extension staff, for example, indicated a view that most DPI publications were too complex or not applicable by the extension workers.) Leadership in editorial and information work is provided by competent expatriates, but the resources are few, and long production delays are usual. Additional equipment could reduce some of the delays, but additional personnel resources appear to be needed, especially professionals who can produce materials that can be used effectively by extension services, other advisers, and perhaps by farmers themselves. The review team did not find any current programs in PNG universities or colleges that were giving pre-service training in areas needed by professional communicators. Workloads on DPI professional staff did not appear to permit them to devote time to offer internships or in-service training to meet the current and future needs.

Papua New Guinea has developed telephone and radio communications to an admirable level of technical excellence. The review team noted little exploitation of these media for transfer of technology from DPI work. A possible reason for lack of programmed use is what appeared to be relatively weak linkages between the research system and provincial

extension staffs (as are discussed elsewhere). The radio system, with its provincial broadcasters, appears to offer a remarkable opportunity to reach farmers and others with up-to-date information; the opportunity probably cannot be exploited without important leadership inputs from at least one of the interested parties and support from the others.

The continuing lack of professional personnel in communications will limit dissemination of results in both amount and speed -- whether by radio, print, or other media. A persuasive case could be made for more investment in such resources.

Communication Within the System

Sufficient interchange of information for coordination and efficiency of operations is difficult to achieve within any relatively large organization. The task is complicated further when units are separated geographically (space is an especially formidable barrier within Papua New Guinea). Other complicating factors are present within the country, such as effects of the transition from a colonial to independent administration and less than a decade to develop its own institutions for technical training and higher education.

As an example of internal communication need, the team was told by some field-based research personnel that they wished to have an increased interchange of information with their headquarters; some noted a desire for a more specific and focused statement of objectives for their own research program. (Some said they had received only a generalized duty statement upon entering the service, a statement that did not deal specifically with their own activities.) Periodic reports were considered useful by a number of field researchers who submitted them, although some indicated that they would like to have had acknowledgment and, especially, feedback on questions they had posed. (While some field staff wondered if their reports were actually read, some headquarters staff said good things about the quality of reporting; such reports, some noted, provide their main source of information on field operations.)

The team concluded that some added attention should be devoted to keeping headquarters in closer touch with the field and the field in closer touch with headquarters. It appears that field personnel would appreciate more input from headquarters in terms of keeping research objectives current and in receiving more information that would help them coordinate their work with the needs of the department.

The brief time of this team, with its mandate to observe a wide range of structures and functions, did not permit a definitive analysis of needs for the flow of information among those engaged in research. Its general finding was that attention needs to be given to improving communications within. It is believed that some progress could be made simply through making this an area for careful thought and innovation. More progress might result from engaging an organizational communication consultant for analysis and recommendations.

(A more detailed analysis, with staff and programming suggestions, was prepared by a member of team and provided to the division. A copy is available from ISNAR.)

Chapter 5

Conclusions and Recommendations

There is much evidence that the agricultural research service in Papua New Guinea has provided a solid base for agricultural development in the country; it has given basis for confidence by investors to pursue development. The research service has a good legacy to build on in some scientific fields, and it operates a set of well-sited research stations. However there are weaknesses to be remedied, some of which appear to be common to many departments.

Some of the major issues to be dealt with in the crops research program in Papua New Guinea include the following:

* There has been a steady decline in the total staff research experience available to address the problems of crop production, although the number of graduate research staff has not changed markedly. Much time will be needed for the recently graduated national staff to gain experience; an aggressive start must be made in foundation training in research methods.

* There was little evidence of interdisciplinary team research effort. This is thought to stem largely from the structure of disciplinary sections within the Agriculture Branch. The review team recommends that this structure be modified to encourage a broader interdisciplinary involvement in many research areas.

* There has been little direct participation of economists with technical scientists on research teams; yet their research input is considered crucial for studies of smallholder agricultural enterprises.

* Food crops research has been neglected until relatively recently, in comparison to research in cash crops.

* Planning, direction, evaluation, and communications within the research system are frequently found to be inadequate; serious attention to them is needed now.

One goal of stated urgency in the country is that of increasing cash incomes from exports. Looking beyond that immediate goal, it can be seen with certainty that improvements will be needed in food quantity and to meet nutritional needs of the people of Papua New Guinea; these will loom as steadily larger problems with time. Self-sufficiency in food will probably become a more pressing target.

These national needs bring demands to the research system. Much of the improvement in production must come from the small farmer, who already produces more than half of all cash crops and the bulk of the food crops. Many of the current research-based recommendations have been derived for

well-managed, large farms. To improve small-farmer production will require intensified research into their existing systems. The need will grow for strong adaptive research programs at the farmers' level, backed by concentrated applied research at the main research stations. Eventual self-sufficiency in well-trained manpower in the research system is already an important middle-range objective; intensive programs will be required to gain that objective.

The recommendations that follow are based on the review team's effort to point the way to policies and actions that should help overcome some of the present inadequacies. The recommendations are divided into those relating to manpower and training, organization, research programming, economics research, and communications and linkages.

5.1 Recommendations on Manpower and Training

Manpower plays a central role in an agricultural research system. This report refers in many instances to needs for further development of manpower, noting the significant requirements for resources to train manpower for different levels of activity. The review team proposes a plan by which graduate national staff can be recruited, trained, and developed to serve the system, while reasonable productivity is maintained. The initial plan is cast over 13 years, during which 50 nationals would receive postgraduate training and progressively replace expatriate staff. This would lead to long-term stability, with national scientists carrying out the work of the system. Actions of several kinds will be necessary to achieve this goal. They are set out here as recommendations:

A. It is recommended that research-oriented postgraduate training to at least the level of Master of Science be established gradually as the normal minimum qualification for scientific research staff; it is further recommended that a systematic staff development program be undertaken to raise all research staff to that level.

This recommendation implies certain other requirements, including the strengthening of PNG educational institutions, creation of a large scholarship program, and changes or relaxation in rules for ceiling numbers of personnel in order that both the manpower development program and needed continuing research may be carried out. The following recommendations relate to them:

B. It is recommended that efforts be made: to strengthen the quality of science and agriculture instruction in high schools to improve the supply of university and college entrants; to reorganize and strengthen the colleges of agriculture so, among other possible benefits, there will be an improved standard of preparation for research support staff and extension staff for collaboration with the research program; and to strengthen the faculty of the university in order that graduates emerge with better preparation for work in the scientific and technical areas related to research.

C. It is recommended that present ceiling numbers for personnel in DPI sections be relaxed to facilitate the manpower development plan for the agricultural research system. This accommodation will be necessary in order that national staff can be released or sponsored for advanced studies while essential research posts remain filled and work continues.

D. It is recommended that planning approval be requested for technical assistance of several kinds to be sought from international sources to facilitate the plan proposed here:

1. Financial support for fellowships to finance training in overseas and local institutions -- a total of 220 person-years over the next 10 years.
2. Financial support for intensive programs to strengthen the Faculty of Agriculture in order that it may quickly upgrade the quality and extent of postgraduate programs for agricultural research.
3. Financial support for supernumerary positions in DPI that will permit continued employment of scientists in active research programs while the manpower development plan is carried out.

5.2 Recommendations on Organization and Finances

The team considered the most important improvements in organization to be development of a structure that would be more conducive of a balanced, interdisciplinary approach to planning and carrying out the research program plus adoption of a "scientific research scheme of service" to provide an environment in which incentives and opportunities for research workers would relate directly to their research contributions.

A. It is recommended that the crops research sections be separated from the Agricultural Development Section, to be established as a Crops Research Division reporting to the Policy Secretariat, either directly or through an Assistant Secretary for the combined divisions.

B. It is recommended that the executive authority for the Crops Research Division, with overall leadership and responsibility for the research program, be vested in a Director of Research. Interdisciplinary teams under team leaders should be encouraged in research stations. The present administrative independence of the disciplinary sections should be modified in line with revised organizational arrangements; however, strong leadership for maintaining professional standards within the discipline must be retained.

It is further recommended that the Director of Research be supported by: (1) a deputy director and a programming unit of two officers to improve planning and communication within the division and with outside bodies, and (2) an administrative cell comprised of an executive officer with essential service staff.

C. It is recommended that steps be taken to strengthen the Agricultural Chemistry Laboratory, especially at the technician level. The laboratory should be enabled specifically to handle a large volume of soil and plant analyses needed to facilitate studies of long- and short-term trends in soil fertility related to managment practice.

D. It is recommended that research activities of the several main research stations be regrouped and that all be provided personnel to achieve a minimum critical mass to carry out the assigned research objectives. One suggested regrouping follows:

Cocoa and Coconut Research Program	centered at Keravat
Coffee and Tea Research Program	centered at Kuk
(Oil Palm Research Program	centered at Dami)
Highlands Food Crop Research Program	centered at Aiyura
Lowlands Food Crop Research Program	centered at Bubia
Port Moresby Food Supply Research Program	centered at Laloki

E. It is recommended that steps be taken to establish a network of testing stations where adaptive trials of management at the farmers' level can be carried out to assess materials and procedures before they are passed on for use by farmers. It is proposed that the stations be maintained and staffed eventually by provincial extension staff, who would collaborate with staff at the main research stations. The extension personnel manning these testing stations would receive in-service training in experimental techniques and methodology.

F. It is recommended that a scheme of service for research staff be adopted in which promotion is based primarily on active research performance and creative contributions toward agricultural development (not based on administrative responsibility); the scheme should permit an individual to advance to highest grades within one established position (not dependent on listed vacancies in the higher grades).

G. It is recommended that greater allocation of resources to crops research be considered, recognizing the importance of continually improving productivity and opportunities for development of major crops. It is strongly recommended that resources be added to increase the present inadequate level of staffing and services to support the existing research staff, permitting fuller exploitation of the researchers' capacities for creative contributions.

5.3 Recommendations on Research Program Planning

Under the current organization and allocation of staff by separate disciplines, the team was not able to appraise allocation of resources for defined research objectives by priority crops. Elsewhere in this report an illustrative reallocation of research staff time was made, with assumed priorities and with acceptance of the constraint of no increase in numbers of senior staff. The following recommendations are based on principles used in that allocation exercise:

A. It is recommended that research program planning be based on allocation of research time to specific crops, and that there be a steady movement towards budgeting by research project.

B. Based on priorities established for major crops, it is recommended that interdisciplinary teams be developed according to requirements inherent in the research assigned.

C. It is recommended that policies clearly encourage the assumption of major research responsibility for cash crops by the respective industry boards; the Crops Research Division should participate fully in the planning, evaluation, as well as -- to a limited extent -- in the implementation of such research.

5.4 Recommendations on Agricultural Economics Research

Economists should fill several key roles in research within DPI, although it is considered best that they be organized within the Economics Section. Those on assignment to research teams in crops and farming systems should be responsible in that work to the leader of the team. The following recommendations relate to overall arrangements for work in agricultural economics in DPI as dealt with in Annex 10. They are not limited to crops research.

A. The review team strongly endorses the recommendation that economists from several former units be grouped in a single functional organization. The following suggestions are offered:

   1. The main responsibility of the chief agricultural economist should be to lead and administer the program in agricultural economics research;
   2. To ensure that the chief agricultural economist can devote primary attention to those responsibilities, a senior officer should be appointed to serve as chief policy economist, situated either in the Economics Section or the Policy Unit.

B. In order to strengthen and disperse economics expertise, it is recommended that there be provided (by appointment or relocation) senior economists responsible for economics research in, respectively: coffee and tea; cocoa, coconut, and oil palm; food crops and farming systems; economic and policy analysis; livestock; fisheries; and training. These economists would deal with economics of production, marketing, and policy. (The Economics Section will serve other special needs, and some additional staff will be necessary to meet those demands without diverting persons in commodity-oriented posts from their prime responsibilities.)

C. It is recommended that persons currently in area economist positions be reassigned to either of two other roles: (1) farming systems economist, associated with a specific research team or a rural development project; or (2) planning economist, in a provincial planner role.

D. It is recommended that appropriate staffing be provided for the Rural Statistics Section and that high priority then be given to

collecting data to deepen the present shallow base of information for agricultural research and policy. Data urgently needed include those on production, incomes, and consumption in rural households.

E. It is recommended that changes be made in staff structure and remuneration to make posts in the Economics Section more attractive to able prospects. Changes should include: (1) classifying the staff as "economist" rather than as "clerk"; and (2) providing for research economists the same conditions of employment as given scientific officers within DPI.

F. In order to implement these proposed steps, it is recommended that the Economics Section be authorized to utilize its nominal "establishment" level; the changes can not be made under the limitation of number of positions currently funded.

5.5 Recommendations on Communications and Linkages

Communications of four types are important to the agricultural research system in PNG: communication with potential users to understand production problems and to get research findings to them; communication with world sources of agricultural science; communication within the organization; and communication with policy-makers.

Communication With the Production System

A. It is recommended that the several research teams be given specific responsibility for initiative with provincial extension officers to develop two-way flow of information between research and producers. It is proposed that there be added to each research team a senior staff member whose role could be described as "dissemination leader." One aspect of the role would be to understand problems of farmers who grow the crops; the other aspect would be initiative to plan dissemination efforts when research results justify. Additional communications resources would be needed to support these initatives.

Utilizing World Scientific Knowledge

B. The DPI central and research station library resources must play an increasingly strong role in linking researchers with the literature of world agricultural science dealing with crops and systems important to PNG. In addition to ensuring better access, it is recommended that creative efforts be made to utilize such knowledge sources more fully. For example, a consultative relationship could be established with a leading institution, which could provide digests of relevant scientific findings and, when justified, hold conferences and in-service training for appropriate persons in PNG .

Communication Within the Organization

C. It is recommended that special consideration be given to ways to encourage the two-way flow of information within the Crops Research

Division, including acquainting staff with research program objectives and expectations relevant to their own work.

Communicating With Policy-Makers

D. It is recommended that communication with policy-makers be regarded as a high-priority task of the most senior officer of the DPI crops research system. The content of communication should present at least the significance and implications of the research, appraisal of problems in development to which agricultural research can offer aid, and identification of areas where development requires ancillary policy steps. The officer should draw support from the policy economist and communications specialists.

LIST OF REFERENCES

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National Planning Office (Papua New Guinea) (Nov. 1981). National Public Expenditure Plan 1982-1985 (p.15).

World Bank (1981a) PNG: Agricultural Services Review, No. 3161-PNG.

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ANNEX 1

Members of ISNAR Team and Itinerary

The members of the ISNAR team were:

Leader: Dr. Matthew Dagg, Senior Research Officer, ISNAR.
(Jan 24-Feb 27, 1982)

Dr. J. R. Anderson, Associate Professor, Dept. of Agricultural Economics and Business Management, University of New England, Armidale, NSW, Australia.
(Jan 24-Feb 7/Feb 12-26, 1982)

Dr. S. Fonseca, Senior Research Fellow, ISNAR.
(Jan 24-Feb 27, 1982)

Dr. K. Robert Kern, Communications Officer, ISNAR.
(Jan 25-Feb 27, 1982)

Dr. S. Shih-Min Lin, Plant Breeder and Sweet Potato Coordinator, Asian Vegetable Research and Development Center, Taiwan.
(Feb 5-27, 1982)

Dr. T. A. Taylor, Director, Institute of Agricultural Research and Training, University of Ife, Ibadan, Nigeria.
(Jan 24-Feb 11, 1982)

Dr. G. F. Wilson, Agronomist, Farming Systems Program, International Institute for Tropical Agriculture, Ibadan, Nigeria.
(Feb 1-19, 1982)

Itinerary of ISNAR Team

Sun. Jan 24		J. Anderson, M. Dagg, S. Fonseca, T. A. Taylor arrive Port Moresby. Met by A. E. Charles, Chief Agronomist, DPI.	
Mon. Jan 25		Discussions with A. E. Charles and Richard Doery at DPI.	
Tues. Jan 26	a.m.	Meeting with Policy Group of DPI	
		Secretary, DPI	Brown Bai
		Asst. Sec: Agriculture	Paul Kahata
		Asst. Sec: Policy Group	Gima Temu
		Asst. Sec: Management Services	Patrick Haino
		Asst. Sec: Livestock	George Malynicz
		for Asst. Sec: Education and Training	Veuga Kila
		Asst. Sec. (Attached Agriculture)	Richard Doery
	p.m.	Meeting with Minister for Primary Industry, Hon. Paul Torato	
		Planning, Economics and Marketing Branch	
		Chief Agricultural Economist	Michael Wheeler
Wed. Jan 27	a.m.	Administration, Agriculture Branch	
		Executive Officer	Colin Button
		Management Services Branch (MD,SF, TAT)	
		Asst. Secretary	Patrick Haino
		Accounts	Godfrey Simei
		Budget	Hunter Moi
		Planning, Economics and Marketing Branch (JA, KRK)	
	p.m.	Chief Agricultural Economist	Michael Wheeler
		United Nations Development Programme	
		Resident Representative	N.S. Subbaraman
		Rubber Development Section	
		Agronomist (FAO)	Serge Langlois
Thurs. Jan 28		Technical Sections of Agriculture Branch (SF,KRK,TAT)	
	a.m.	Agricultural Chemistry	Nelson Toreu
	and	Plant Pathology	Gapi Kula
	p.m.	Entomology	Jan van Greve
			Fred Dori
		Horticulture	Sister Mary Drum
		Quarantine	David Kanawe
		Area Horticulturist	Malcom Levett
	a.m.	Agricultural Development Section (JA,MD)	
		Hybrid Coconut	Lamalua Makara
		South Coast Food Project	Gwaibo Banaga
		Rice	Ernest Natera

		Livestock Branch (JA,MD)	
		Asst. Sec.	George Malynicz
		Animal Production and Development	John Mandage
	p.m.	Public Service Commission (JA,AEC,MD)	
		Chief Inspector, Psychological Services	K. Watangia
Fri. Jan 29	a.m.	Education and Training Branch (SF,KRK,TAT)	
		Education Section (Colleges)	John Cooper
		Extension	Tim Bannister
		Asst. Publication Editor	Catherine Kilroy
	a.m.	Veterinary Laboratories (JA,MD)	
		OIC, Ag. Chief Vet. Officer	Mike Nunn
		Parasitologist	Ifor Owen
	p.m.	University of Papua New Guinea	
		Dep. Vice-Chancellor	Dr. Elton Brash
		Dean of Agriculture	Dr. Tom Varghese
		Head of Biology	Prof. Dick Morton
		Head of Geography	Prof. Jackson
		Plant Pathologist	Dr. Mike Pearson
		Lecturer, Agriculture	Mr. Nicholas Kuman
Mon. Feb 1	a.m.	Agricultural Research Station, Laloki (SF,KRK,TAT)	
		OIC, Horticulturist (Vegetables)	Peter Bull
		Horticulturist, Staple Food	G. King
		Field Horticulturist	R. Herring
		Planning, Economics and Marketing (JA,MD)	
		Head of Planning Section	Mike Thomas
		Biometrics Sections (Agriculture)	David Moles
			Jane George
	p.m.	Institute for Applied Social and Economic Research, IASER (JA,KRK)	
		Senior Research Fellow (Econ)	P.A.S. Dahanayake
		Senior Research Fellow (Econ)	John Wyeth
		Research Fellow (Econ)	Kila Ai
		Managing Editor	Gene Thornton
		UPNG	
		Education Research Unit (KRK)	Sheldon Weeks
		Economics Department (JA)	Brian Brogan
		Development Section, Agriculture (MD)	
		Head of Section	John Christienson
		Infrastructure Technical Sections (SF, TAT)	
		Land Utilization Section (MD,SF,TAT)	
		Ag. Section Head	David Freyn
		Dr. Wilson joined team.	

Tues. Feb 2	a.m.	National Planning Office	David Edwards Ian Morrison
		Finance Dept. General Finance and Economic Policy (macro-economics)	Rory Allen Robert Clement-Jones Clement Kote George Paru
	p.m.	Office of Environment and Conservation (MD,SF,TAT,GW)	
		Director	Barney Rongap Moki Makup
		Wildlife	B. Kwapma
		Natl. Parks	Romeo Esangga Salvatore Giobu
		Public Service Commission (JA)	Jack Chawani
		Information Section (KRK)	Harry Dunstan
Wed. Feb 3		To Raboul (MD,SF,KRK,TAT,GW,AEC) Lowlands Agriculture Experiment Station, Keravat	
		Ag. OIC, and Food Crop Agronomist	Meli Lolo
		Sen. Food Crop Agronomist	Andrew Leng
		Food Crop Agronomist	Louis Kurika
		FAO Roots Crop Project	Sama Gunawardhana
		Area Horticulturist	Ron Croyden
		National Crop Advisor (Cocoa)	David Kidd
		Sen. Land Util. Officer (Cocoa)	Peter Jeffery
		Cocoa Agronomist	Gady Ling
		Pathologist	Alistair McGregor
		Entomologist	John Moxon
		Area Economist	John Perkins
		Pathologist (UPNG)	Chris Prior
	p.m.	Vudal Agricultural College (KRK,TAT)	
Wed. Feb 3		JA to Lae	
	a.m.	Agric. Research Station, Bubia	Rosa Kambuou
		Poultry Research Station, Labu	Claudette Loda
	p.m.	University of Technology	
		Planning Officer	David Parry
		Agric. Economist	D.K. Das
		Associated Mills	
		Extension Agronomist	Neville Hall
		Further discussion with John Mandage Animal Production and Development, Livestock Branch	
Thurs Feb 4	a.m.	Provincial Extension Service, East New Britain (MD, SF, KRK, TAT, GW, AEC)	
		PRDO	Hosea Turbarat
		Cocoa Advisory Officer	Trevor Clark
		Subsistence, Nutrition and Conservation	Miriam Joseph

	Ag. Prov. Fisheries Officer	Sylvester Mala
	Coconut Hybrid Production	Leo Romarosa
	RDO Sericulture	Bernard Chow
	RDO Fisheries	Reinhold Dixon
	Draught buffalo	Levi Keoplan
	Training and Records	Gali Levi
		Inia Moore
		Mary Waraja
		Ignatious Jopling
p.m.	Cocoa Board	
	President	Barry Hart
	Executive Secretary	Bob Duncan
	Member Research Committee	John O'Donohue
	Member Research Committee	Leon Bridgland
	Cocoa Breeder	Yum Tan
	Consultant on research priorities	Peter Turner

Thurs Feb 4 — JA visits around Lae with Neville Hall,

	Morobe Rural Development Office	
	Extension Officer	Ian Reardon
	Livestock Dev. Officer	Greg English
	Lutheran Rice Dev. Training Farm	Camillo Toledo
	Niugini Tablebirds	
	Manager	Bob Hansen
	Cattle Research Station, Erap	
p.m.	Flew to Goroka	

Fri. Feb 5 — To Hoskins, West New Britain (MD,SF,KRK,GW,AEC)
PNG Oil Palm Research Association and Oil Palm Research Station (New Britain Palm Oil Development), Kimbe, West New Britain

a.m.	PNGOPRA	
	Director	Tremar Menendez
	Agronomist	Theo Guiking
	Asst. Agronomist	Peter Narvus
	Entomologist (DPI)	Bob Prior
	OPRS	
	Breeder (OIC)	Kees Heilingman
	Agronomist	Martin Powell
	Asst. Agronomist	Tore Ovasuru
	DPI Coordinator Oil palm Settlement Project	Philemon Tainole
	Staff Development and Training	Isaac Marum
	Area Economist	Josiah Takuru
p.m.	Visited farms in Oil Palm Settlement Project	

Fri. Feb 5 — TAT to Lae, for discussions with Faculty at University of Technology

	Vice-Chancellor	Dr. A.P. Mead
	Faculty of Agriculture	Dr. A. Gurnah
	Head Department of Fisheries Technology	Prof. C.S. Anathan

		Head Department of Chemical Technology	Prof. D.F. Stewart
		Acting Head, Dept. of Forestry	A.E.K. Tisseverasinghe
		University Librarian	S.A. Patchett
		Chairman, University Research Committee	R. Hull
Fri. Feb 5		JA to Highlands Research Station, Aiyura	
		Senior Area Economist	Bruce Carrad
		Ag. OIC and Spices Horticulturist	Kana Aburu
		Senior Horticulturist	Michael Bourke
	p.m.	Rural Dev. Office, E. Highlands Prov.	
		Area Economist	Roy Thompson
Sat. Feb 6		To Lae. (MD, SF, KRK, GW)	
		Dr. Lin joined team	
		Visited possible farm site for University of Technology, Lae, at Nadzab, with staff of Faculty of Agriculture, UPNG.(MD,SF,KRK,SSL,TAT,GW)	
		UOT Planning Officer	David Parry
		Agronomist/Physiologist	Abdul Gurnah
		Agric. Economist	D.K. Das
		Animal Husbandry	Pikah Kohur
		Agric. Engineering	Adrian Williams
		Owner Durrum Farm	Tony Bearn
Sat. Feb 6		JA to Port Moresby and Australia	
Sun. Feb 7	a.m.	University of Technology	
		Vice Chancellor	A.P. Mead
		Food Technology (DPI)	Jeff Thomas
		Head, Fisheries Technology	C.S. Ananthan
		Head, Chemical Technology	D.F. Stewart
	p.m.	Farm on Campus with Dr. Gurnah	
Mon. Feb 8		To Wau Ecology Institute (MD,GW)	
		Agronomist (Farming Systems)	Jonathan Swift
		Asst. Agronomist	G Nalu
		Agricultural Research Station, Bubia (SF,KRK,SSL,TAT,AEC)	
		OIC and Food Crop Agronomy	Rosa Kambuou
		Entomologist	John Sutherland
		Rice Breeder	Joo Moon Kap
		Coconut Breeder (Madang)	R. Brook
Tues. Feb 9	a.m.	Beef Cattle Research Center, Erap	
		Ag. Prin. Animal Production Officer	John Schottler
		Animal Production Officer	Uve Rova
		Sn. Pasture Agronomist	Graeme Tupper
		Pasture Agronomist	Frank Kamit
		Training Officer (3 mile station)	Martin Needham
		Sen. Animal Prod. Officer (Sheep)	Trevor Lyall

		OIC Poultry Research Centre, Labu	Rashad Abdelsamie
		Broiler Research	Bill Bakau
	p.m.	Travelled to Aiyura	
Wed. Feb 10	a.m.	Highlands Agricultural Experiment Station, Aiyura	
		Ag. OIC Agronomist (Spices)	Kana Aburu
		Coffee Agronomist (Coffee Board)	Roy Dingu
		Horticulturist (Fruit and Nuts)	Tevo Tarepe
		Senior Horticulturist (Food Crop Systems)	Michael Bourke
		Horticulturist (Food Crops)	Clement Tumana
	p.m.	Visit to village gardens. Travelled to Goroka	
Thurs. Feb 11		TAT left team	
		SL at Aiyura	
	a.m.	Research Department, Coffee Industry Board, Goroka (MD,SF,KRK,GW,AEC)	
		Executive Secretary, Board	Ricky Mitio
		Coffee Specialist	Don S. Meredith
		National Crop Advisor (Coffee)	Joe Nitsche
		Sen. Agric. Economist	Bruce Carrad
		Coffee Farming Systems Project	
	p.m.	Eastern Highlands Provincial Rural Development Office, Goroka	
		PRDO	Tukura Renagi
		Coffee Coordinator	Kevin Murray
		Area Economist	Roy Thompson
Fri. Feb 12	a.m.	Travelled to Kundiawa, Simbu.	
		Simbu Land Use Project	
		Team Leader, Anthropologist (away)	P.B. Wohlt (IASER)
		Nutrition Section	Phil Harvey (Institute for Medical Research)
		Agronomy Section	Swithun Goodbody (DPI)
		S. Simbu Section (Anthropologist)	Robin Hide (IASER)
		PRDO	James Koimo
		PAO	Kapa Pandan
		Area Economist	Paul Barker
	p.m.	Travelled to Mount Hagen. JA rejoined team.	
Sat. Feb 13		JA,SF visited Kuk Agricultural Research Station	Martin Gunther
		MD,SL,GW,KRK at Mt. Hagen.	
Sun. Feb 14		At Mt. Hagen - discussion.	
Mon. Feb 15	a.m.	Kuk Agricultural Research Station (MD,SL,GW,AEC)	
		OIC Agronomist (Tea)	Martin Gunther
		Entomologist	Brian Thistleton

		Nutrition (Tea)	Margaret Russell
		Field Agronomist	Ernst Groedl
		Agronomist (Pyrethrum) (OIC Tambul Station)	A. Mengge-Nang
	a.m.	Highlands Agricultural College (JA,SF,KRK)	
		Ag. Principal	Jim Hick
	p.m.	Provincial Rural Development Office (JA,MD,SF,KRK,SL,AEC)	
		PRDO	Kombamong Wak
		Nutrition Officer	Mary Bonji
Tues. Feb 16		To Wewak. Visited Agricultural Research Station, Hawain, E. Sepik Rural Development Project (MD,SF,GW,AEC)	
		Agronomist	Moses Waruba
		Sen. Agronomist	Margaret Quinn
Tues. Feb 16		To Mendi (JA,KRK,SL)	
Wed. Feb 17		Southern Highlands Rural Development Project	
		Manager	John Wallis
		Agricultural Field Trials, Studies, Extension and Monitoring Unit (AFTSEMU)	
		Leader, Nutritionist	Lyn Clarke
		Agronomist	Merle Anders
		Agronomist	Bruce French
		Asst. Agronomist	Francis Wapma
		Land Use	John Muspratt
		S. H. Provincial Development Office	
		PRDO	Foy Aiyora
		Prov. Staff Dev. Officer	Paul Fearman
		Agro Forestry (Dept. of Minerals and Energy)	Jim Tolisano
Wed. Feb 17	a.m.	Visited by plane, village gardens near Maprik (MD,SF,GW,AEC)	
		Lunch at E. Sepik Agricultural College.	
		Principal	Peter Fulwood
		Lecturer	Halley Jenning
	p.m.	Agricultural Experiment Station, Saramandi near Angoram, Project Center for Rubber and Cocoa	
		OIC Agronomist	Margaret Quinn
		Agronomist	Jimmy Risimari (absent)
		RDO	Eroan Nisie
		RDT	Caspar Sam
		RDT	Mary Slappa
Thurs. Feb 18	a.m.	E. Sepik Rural Development Project HQ in Wewak	
		Agricultural Manager	Luke Blansjaar
	p.m.	To Port Moresby (MD,SF,GW,AEC)	

Thurs. Feb 18		To Port Moresby (JA, KRK, SSL)
Fri. Feb 19	a.m.	Discussion with staff from Agricultural Branch on major impressions, findings, and tentative proposals. GW left team
Sat./Sun. Feb 20/21		Discussion.
Mon. Feb 22	a.m.	Visit with Gima Temu, Policy Secretariat (JA,MD)
	p.m.	Visit with publications officers -- Nancy Birge, Catherine Kilroy (KRK)
Tues./Wed. Feb 23/24		Discussion and Preparation of Preliminary Report for Policy Group. Visit to Planning Section Miri Setai (JA)
Thurs. Feb 25	a.m.	Meeting with Policy Group and Agricultural Branch Sections.

Secretary	Brown Bai
Asst. Sec.	Richard Doery (Chairman)
Asst. Sec.	Gima Temu
Asst. Sec	George Malynicz
	Michael Oata
NPO	David Edwardes
	Tim Kepui
Finance	Robert Clement-Jones
Educ. and Training	Harry Dunstan
	Ian Donald
Agriculture	Arthur Charles
	Fred Dori
	Jan van Greve
	David Freyne
	Sister Mary Drum
Planning Economics and Marketing	Mike Thomas

	p.m.	Discussions
Fri. Feb 26		Final discussion with A. E. Charles and Richard Doery JA departed.
Sat. Feb 27		MD,KRK,SF,SL departed Port Moresby.

ANNEX 2

Nature and Role of a National Agricultural Research System

Agricultural research is a broad term and can legitimately embrace a wide range of activities, especially in independent institutions dedicated to the pursuit of knowledge of agricultural science -- and it is up-to-date agricultural science that must be taught at degree level. However, a national agricultural research service, especially in a developing country with limited resources, must have a more restricted target: it must serve the agricultural industry to help it meet national objectives. National agricultural research is therefore essentially industrial research, often serving by far the most important industry a country has, and its objectives should be couched firmly in those terms.

Information for government: The planning and implementation of development planning in the agricultural sector in Papua New Guinea is especially important for its impact on several of the country's nine Strategic Objectives. It is one of the responsibilities of the agricultural research service to ensure that the government has the best information possible on the opportunities for successful developments, and also to warn of potential dangers and limitations in technical details of any proposed plans. This information may be based on direct experimental work; on the implications of survey data on the natural resources of the country or market potentials; or, more frequently, on the sound professional interpretation of world knowledge of agricultural science in relation to national development needs. The agricultural research service is almost always the best source of such information and should be closely linked with development planning, with a significant voice in the process. By the same token, it should be held answerable for its advice with equivalently significant responsibility.

Information to farmers: Although goverment policies and planning, and the supply services are both important in encouraging production, there will be no increase in production unless the producer, the farmer, is reasonably certain that it will be worth his while to go ahead and to satisfy his complex personal objectives without excessive risk. Mosher[1] has drawn attention to three main groups of obstacles facing the farmer:

a. there may be no practices that will increase his productivity economically and safely in face of pests, diseases and adverse environment;
b. there may be practices, but he does not know about them, or he cannot get the necessary inputs;
c. there may be practices and adequate agri-services, but not the economic incentive, because of inadequate marketing facilities and pricing policies, or social incentive in particular circumstances.

The research system can work at all three aspects, in close association with the prime movers in (b) and (c) who are the development agencies and

[1]Mosher, A.T. 1982. Some Critical Requirements for Productive Agricultural Research. The Hague, Netherlands: ISNAR.

political leaders. Research workers must be well aware of the higher and lower probabilities of change in the latter areas, but the main thrust must fall on (a) to develop and introduce new technologies that canchange the parameters in primary productivity; create new conditions for the analysis of the situation; generate new margins to get things moving; and set out more options.

The research effort must also be closely aligned with the producers' interests so that the research output is recognizably relevant to the producers' system whether this is large or small scale. Moreover, new practices must be tested under the farmers' management system to confirm that they will be feasible and profitable, or that there is need for some further adaptation to ensure they will be worthwhile to the farmer. It is noteworthy that this "adaptive" research, which is vital if farmers are going to accept changes, is usually carried out in affluent developed countries by agencies supplying inputs or by the farmers (large) themselves. (The private sector invests about $2 billion of the $4 billion spent annually on agricultural research in U.S.A.). This echelon of research has to be supplied by government in developing countries, in the absence of suppliers and with small farmers who can face little risk. But this research step remains vital, perhaps the most important step in all countries.

Agricultural research is a continuum from the most elaborate basic research on genetic engineering to adaptive research. There are several phases, given various names. One representation is illustrated in Figure 1. All of the phases require imaginative research, insight, and interpretive ability, but some phases have restrictive conditions imposed. Phase I, pre-release testing under farmers' conditions, must be done in the area of use as indicated above; and Phase II, adaptation to local conditions, should also be done locally, and indeed on farmers' fields if the economics of farmers' operations are important. Basic research, Phase V, can be done anywhere; and the application of new knowledge in applied research in Phase IV is not usually location-specific. However, the research work to develop a suitable package of technology, Phase III, is often best done nearer to the place of application, close to the reality of the problem to be overcome. At every step there should be a two-way flow of information in the system.

Figure 2, illustrating the role of the agricultural research system in supporting national development planning, brings out a second important element. Most on-going project planning is done on the basis of well established world knowledge, supplemented by critical, recently acquired information from experiment or survey. A major task of the research establishment is keeping abreast of world knowledge (including Papua New Guinea's contribution) and interpreting this in the light of national needs, and in the light of PNG's natural resources and constraints, so that new advances can be exploited as quickly as possible in terms of better development plans. Since ease of worldwide communication is increasing rapidly these days, it is worthwhile investing in this new technology that brings information on demand, and investing in developing well trained research staff to interpret the information. Each year more information will be generated from national agricultural research stations, but the increment will be small in relation to the increment in the accumulated world body of knowledge. It is therefore important that

Figure 1. Phases of agricultural research

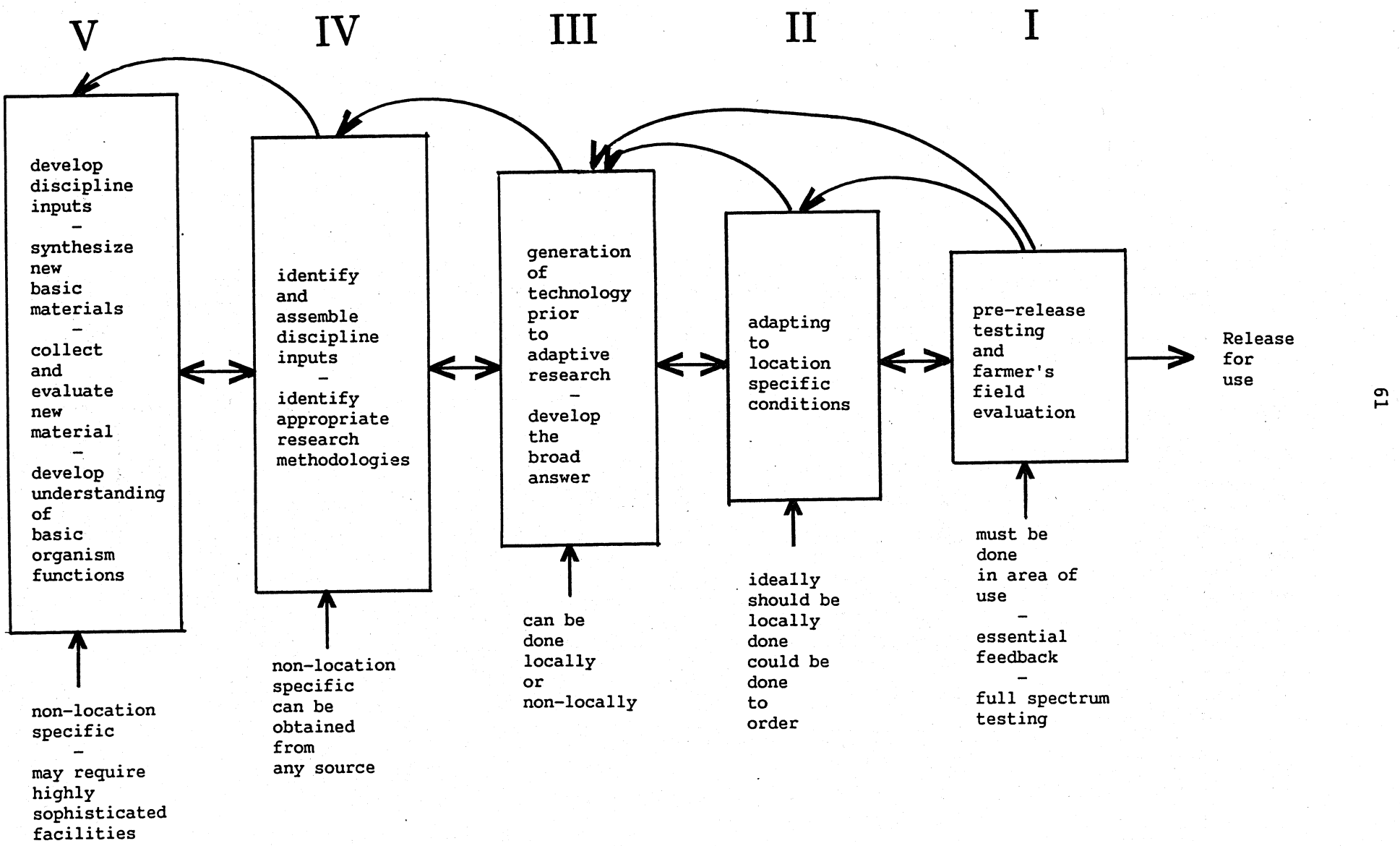
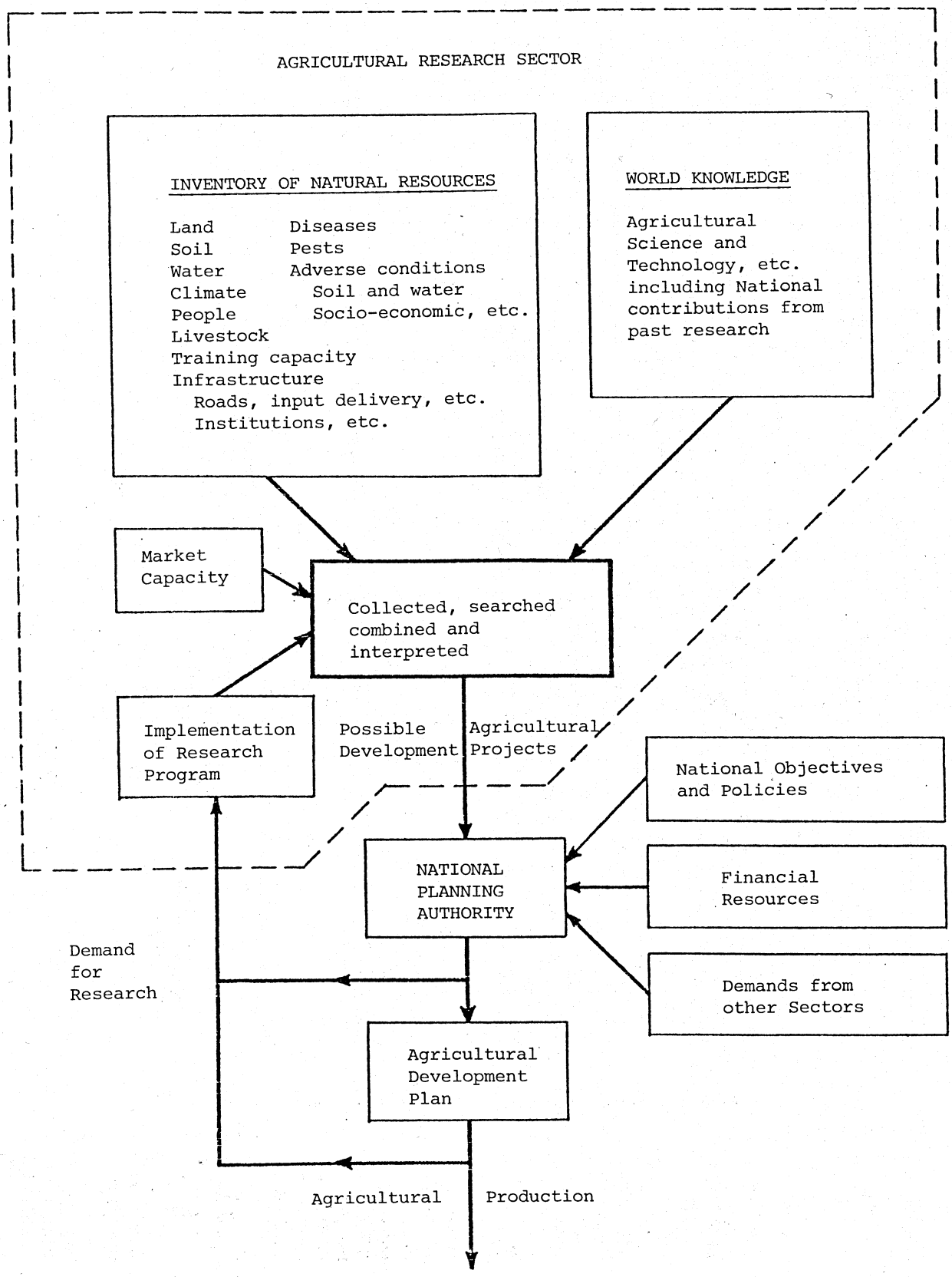


Figure 2. Establishing the national agricultural development plan.

Role of Research System



These local contributions are focused on critical gaps in the areas of knowledge and understanding that cannot be filled from elsewhere. Such contributions will be necessary to develop better descriptions of the inventory of natural resources and constraints, aspects of which are indicated in Figure 2. A separate element of the research system is the examination of the capacity of national and international markets to absorb extra production of appropriate products. Direct operational research at field stations is aimed at developing and testing new technologies to exploit the resources and to overcome the constraints. The choice of projects is wide, and the assignment of priorities must be done very carefully.

In summary, agricultural research activities should be able, in time, to

1. make available to the government, in an appropriate, interpreted form, key elements of information on which reliable agricultural development plans can be based;

2. make available to the farmers, through appropriate channels, the detailed agronomic and economic information on which to plan production of crops and stock, based soundly on adaptive research at the farmers' level;

3. develop and maintain a group of well trained, competent scientists, in the appropriate disciplines in active research positions, capable of interpreting national and international scientific advances for the benefit of national development.

Research organization

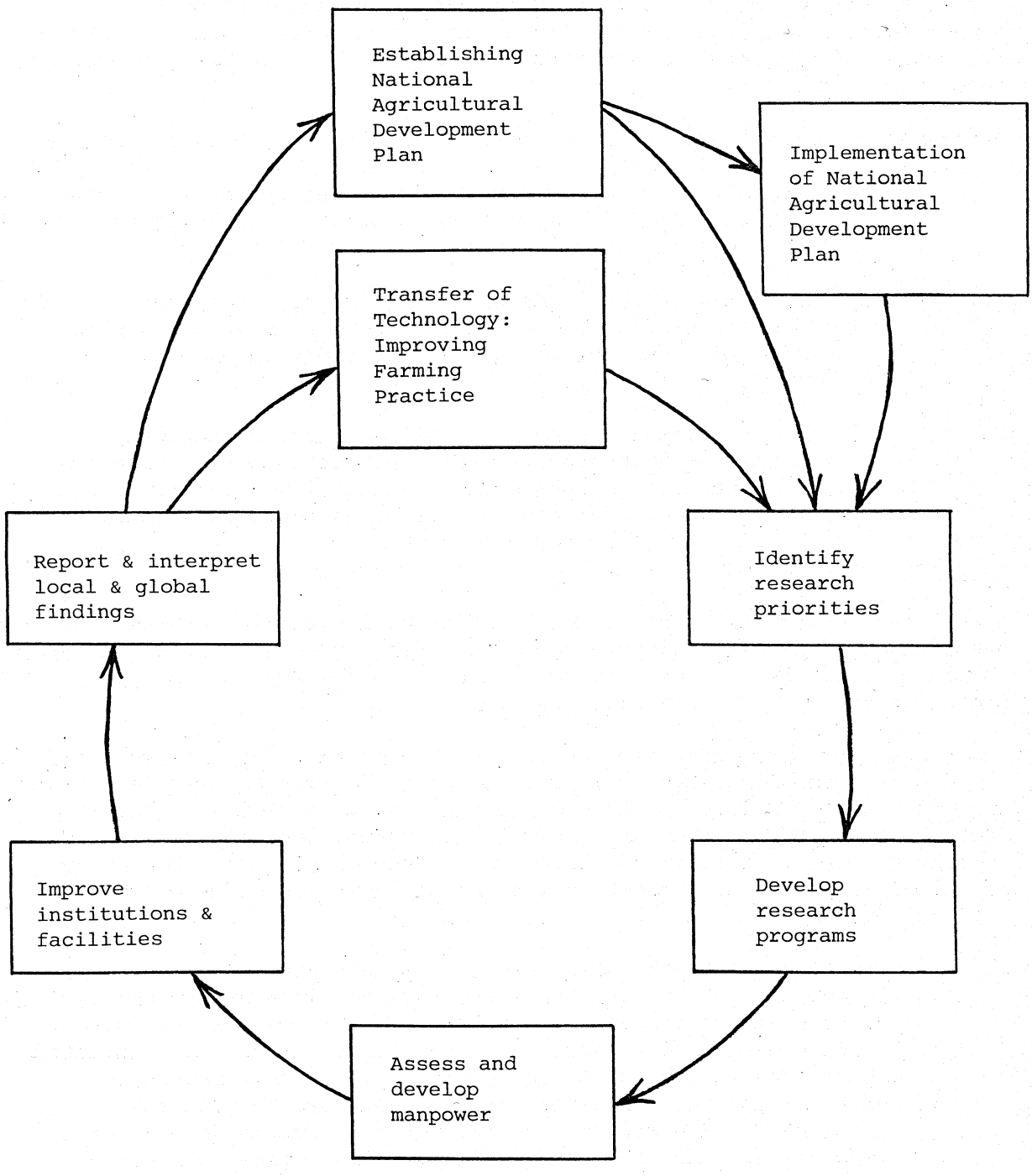
After considering what sort of contribution agricultural research should be making towards national development planning and what kind of research should be done, it is necessary to consider how the system might be organized to carry out its research task.

The system for carrying out direct national research can be represented by an expansion of the cyclical process indicated in the lower left hand part of Figure 2. This is sketched schematically in Figure 3, but it must always be recognized that the research system is made up of people, facilities, and institutions, all of which need development, backed by political resolve that agricultural research is an essential element in national development.

1. Starting at the top of Figure 3, the unknowns and uncertainties in the national agricultural development planning process (which incorporates national policies and objectives) lead to the identification of a range of topics for research. As indicated above, the selection of high priority items of research is critical for the efficiency of the whole system, and the institutional mechanism for making the selection is of central importance. The precise form is probably immaterial, but it should permit both technical and administrative inputs, and scope for suggestions to be considered from active research staff throughout the system.

2. Research programs are formulated to generate new information needed.

Figure 3. Planning for implementation of national agricultural research



3. The manpower (research capacity) needed for research programs is assessed and given special training if necessary. Training for supporting technical staff is also essential. Generally, there should be more trained support staff than research scientists, preferably three times as many.

4. Suitable research stations or other institutional arrangements and facilities are provided to enable the research capacity to operate effectively. Facilities include operational support: recurrent funding to a station for logistic support should be, in most cases, at least half that allocated for salaries.

5. Research results are assessed, communicated to all likely users in appropriate form, interpreted in relation to previous knowledge, and incorporated into new and better agricultural development project proposals.

There are several general requirements that seem to arise in all research systems. The first requirement for a productive agricultural research system is that it must be conducted by highly trained research scientists, often interacting together in interdisciplinary teams. Research at all phases is essentially a creative activity that needs a depth of training and specialist understanding that can appreciate the novel significance of national and international research findings in interpretation for national development. An individual researcher must be able to hold firm confidently to his (or her) view point in the stimulating and fruitful atmosphere of interdisciplinary discussions on findings. An interdisciplinary research team derives its special interpretive strength from the combined strength of its different components. It follows that there should be a well planned staff development program ensuring training up to the highest levels attainable by the individual to strengthen his/her contribution and to encourage novel creative activity as soon as possible.

From the importance for the special strength of interdisciplinary research, it follows that research agencies require a type of organization that encourages staff interaction. Some organizations have abolished disciplinary sections and reorganized on commodities or problem areas; others have maintained both, with funding allocated to disciplinary sections, but the research program, including staff from many sections, determined by commodity need, not by the heads of the sections. However, scientists often try to avoid the tensions of working with other disciplines and retreat to the safe comfort of their familiar disciplinary scene and values. It needs a sensitive style of administration in most research organizations where all members might be specialists. In these circumstances, it requires leadership rather than authority to mold a productive team.

In such a group of specialists, hierarchal structures and attitudes are not appropriate, and rewards should follow research contribution -- the object of employment -- rather than hierarchal administrative responsibility and authority.

The traditional civil service administration hierarchal structure, which is usually heavily weighted to the line of authority, has not usually been found to be an appropriate form of organization for an agricultural

research system. Many countries have endeavored to set up alternative organizations to escape these limitations. For instance, in the United Kingdom, the Agricultural Research Council was formed, and there is a Scientific Civil Service with its own service criteria; India has the Indian Council for Agricultural Research, again with its own cadre in the Agricultural Research Service; Kenya is considering giving operational automony to the Agricultural Research Service by placing it under the Council for Science and Technology; Nigeria has put agricultural research in a Ministry of Science and Technology, and so on. Earlier, on a smaller scale, while much of the agricultural research service in Nigeria was in the Federal Ministry of Agriculture, the Government of Northern Nigeria placed the research division of its ministry under the operational jurisdiction of the new Ahmadu Bello University, and the Faculty of Agriculture grew alongside and linked with the national agricultural research organization for the savannah area of Nigeria. This has proved a fruitful model that has subsequently been repeated elsewhere in Nigeria where it has been appropriate.

All of these particular forms have been concerned to retain policy and thrust of research in the hands of the responsible development ministry or ministries, while endeavoring to follow a coherent national science policy and to maintain an environment for research operations that is much more conducive to imaginative and creative research than is usually found in a civil service. The latter is more concerned with development targets and control of expenditure.

After reviewing the current situation with respect to agricultural research management in relation to the needs and resources for crop and farming system research, and in relation to the needs and resources of existing institutions, the team has made recommendations for changes in the agricultural research organization as set out in Annex 6.

ANNEX 3

Organization of Crops Research System in DPI in Relation to Research Functions

Formal crops research in PNG is carried out mainly by the Agricultural Branch of the DPI with important agricultural economics inputs from the former Planning, Economics and Marketing Branch. Some rural development projects incorporate research units that are linked with the DPI central research group. They carry out adaptive and survey research related to the projects. Additional research work is carried out by: industry boards for coffee, cocoa, and oil palm; the University of Papua New Guinea and the University of Technology; the independent Institute for Social and Economic Research; and private bodies such as the Wau Ecology Institute.

The bulk of the work is, however, carried out within the Agriculture Branch of DPI in the Agronomy, Agricultural Chemistry, Entomology Horticulture, Land Utilization, and Plant Pathology Sections, which have personnel posted at laboratories and offices at DPI headquarters in Konedobu and at 10 research stations strategically placed around the country.

The present organization of the agricultural services within DPI, including research, has been described well in the World Bank Review and it is not repeated here. Based on the framework of the main functions of an effective research system, as set out in Annex 2, the review here examines mechanisms currently available within DPI for carrying out these functions.

The objectives of the agricultural research system are to supply appropriate information to the government policy and planning authorities and to the producers and extension service, while building up and maintaining a well-trained body of research scientists who are in touch with advancing world knowledge. The components of the cyclical agricultural research system (set out in Figure 3 of Annex 2) are: (1) maintenance of linkages with development planning authorities; (2) identification of critical researchable problems; (3) formulation of a research program; (4) provision of appropriate research manpower to carry out the program and facilities for their efficient operation; (5) implementation of the program; and (6) the reporting of results and interpreted conclusions in an appropriate form to government policy makers and planners, as well as to producers and extension staff.

Linkage with Policy Makers and Development Planners

It is necessary for the research system to maintain close linkages with policy and development planning authorities, so as to ensure that research programs relate to top priority development problems in accordance with national policy. Those same linkages, or channels of communication, should enable the research service to report findings from its program and to make its contribution to the formulation of policy and development plans, especially in terms of expert assessment of the potential of prospective development projects.

In PNG, policy directives come ultimately from the National Executive Council. The recently established inter-ministerial body, the National Agricultural Committee (NAC), is expected to play an important role in the planning and formulation of agricultural policy. The NAC is to be serviced by the Policy Secretariat of DPI, which should serve as an efficient channel for the transmission of policy guidelines to the research group.

Currently, the spokesman for the crops research group, and the conduit for policy guidelines back to the research group, is the Assistant Secretary, Agriculture Branch, who supervises the six disciplinary research sections, quarantine, and the large development section. An Assistant Secretary may do an excellent job of transmitting technical information from the research group to the policy makers, but if he does not have technical research experience, it may be difficult for him to carry out the reverse function efficiently; there is a real need for the sense of the policy guidelines to be interpreted faithfully to the section chiefs in technical terms and with good scientific balance. Guidelines going into disciplinary groups with their own separate budgets can be implemented in a grossly unbalanced way unless there is strong direction from a leader with a sound interdisciplinary understanding of the technical problems. A means of strengthening this critical channel for identification of problems and research program formulation would be through a unified Research Division with a Director to mediate the policy guidelines to the section heads. It would be especially beneficial to the system for the director to be a member of the Policy Secretariat (or an observer). He would thus be in a position to respond promptly to technical queries and to be the direct communicator of policy to the technical heads of sections.

The channel for policy guidelines for socio-economic research leads to the separate Planning, Economics and Marketing Branch, linked across at a lower level for interaction and collaboration with the technical scientists in the Agriculture Branch. This linkage has not been strong in the past, and it remains a potential weakness in communication within the system. Formal and regular consultative arrangements should be made to ensure a base on which greater informal collaboration can grow.

The same situation exists with respect to livestock, fisheries, and forestry research. This poses a barrier to effective research on farming systems that involves several components. Similar formal channels for collaboration between researchers need to be established and maintained.

Problem Identification and Program Formulation

The second function in the research cycle is problem identification, finding the critical constraints to production that are likely to yield to research efforts. This responsibility currently rests within the individual research sections. Projects are prepared and reviewed within each discipline before being grouped to form a program for ratification at the assistant secretary level. Problems seldom occur on the basis of a single discipline; they more often have facets that require a balanced interdisciplinary outlook, even for accurate problem identification. It is not impossible to achieve this within a single discipline section, but it may be difficult. It is considered important that there be a unifying directorate to provide a guiding overview in the processes of problem

identification, project appraisal, and program formulation. A director can ensure that suitable interdisciplinary groups review project proposals and that these groups are properly informed of policy guidelines. The current process of program formulation is not clear to most research scientists in the field; some complain that policy guidelines are not passed down to them. It is, however, generally a good principle that it should be possible for project proposals to arise from research scientists at the "grass roots," close to the practical issues, rather than be imposed from above. The scientists need policy guidelines, then freedom to exercise their creativity within those guidelines -- subject to doing their part of a balanced program.

It is really important that research scientists are receiving clear guidelines from their other clients, including farmers. There are several possible channels of communication, but with small unsophisticated farmers, some systematic analysis of his constraints is necessary, preferably by a social scientist/agronomist team. A great deal can be learned for setting future research priorities from careful on-farm testing at the farmer's level of management of possible improvements in materials and practice.

The balanced program should be the responsibility of the directorate, with, for instance, the executive task being assigned to the deputy director helped by a small program unit.

Manpower Development

A research system needs appropriate manpower to carry out the research program. As has been indicated earlier, one of the objectives of the research system is to establish and maintain a body of scientists trained in the appropriate disciplines, in active research positions, capable of interpreting national and international scientific advances to the benefit of national development. The agricultural system in PNG has fallen short in this function over the past few years, often under difficult circumstances. The man-years of research experience in the service has declined seriously: in the DPI, for example, 58 research staff in 1973 had a combined total of 545 years of research experience; in 1980, 56 research staff had 359 years of experience (DPI Research Comparisons 1973-1980). At the end of the period of comparison, 25 of the research staff were nationals with relatively few years of experience, since the PNG universities did not graduate classes until the mid-1970s. There are now 28 national graduates in the research system; none have post-graduate degrees, nor is there a systematic program for formal training to upgrade their qualifications for research. In the short term, it may be necessary and possible to recruit well-qualified expatriate scientists to meet some of the shortage, but the lasting solution appears to be in building the level of qualified experience in the national research staff. It will be a slow process.

Training

The team recognized training as a major issue, recommending strongly that a systematic training program be developed to improve existing staff capability in research methodology and in depth of technical knowledge (see 4.1 and Annex 9 for details of a systematic scheme). The team has not attempted to specify disciplines, as that will depend on policy

decisions on crop priorities. More emphasis will be necessary on a socio-economic research input into technical programs to relate research impact more closely to farmers' complex needs.
Training in management practices will be necessary for some of the staff -- such as prospective research directors, officers-in-charge of stations, and station managers; the range of training will include management of physical infrastructure, administration and accounting, through personnel management and research planning.

Retention

A research system needs to retain its well-trained staff. To help ensure that, the whole environment for research should be reasonably attractive: salary levels are an important incentive, and adequate compensation, accommodation, and other material factors are necessary to withstand the usual stresses of competition. A scheme of service appropriate to the distinctive nature of their job has been shown by several studies to be a powerful stabilizing factor for research scientists -- often a stronger factor than salary. Probably the most important elements of a "research scheme of service" are that it reward effective research production and that promotion can be given in the place where the scientist's research competence and experience are relevant -- so the individual does not have to move to a vacant position where previous experience may be irrelevant. Another major factor in the research environment is that there be adequate facilities to permit fruitful research work. Some additional compensation for working in unfavorable postings would be a helpful factor, one that might prove beneficial for farmers in remote areas.

While the salary scales for agricultural scientists in PNG are reasonably competitive now, the evaluation and promotional system is still largely typical of civil service: rewards tend to go for managerial and supervisory responsibilities; promotion may sometimes be to distant vacant posts in unfamiliar technical fields. A change to a research scheme of service is strongly recommended to improve stability of service, which is extremely important in long-term research. Appropriate changes would have to be made in the institutional arrangements to administer a new scheme of service; different recruitment criteria and job specifications would be required for use by the Public Service Commission, together with appropriate criteria for promotions.

Planning Manpower for Research

If resources were unlimited, a full multidisciplinary team on each major crop commodity would be ideal. When resources are severly restricted, however, it becomes of great strategic importance to select or develop research staff with different specialized training. At the early stages of national agricultural research system development, it is necessary to have representatives of each major discipline in order to have a broad base for interpreting advances from world science. As the system grows and staff can concentrate on particular crops, allocation of personnel should be related to the ranking of crops in national policy and the urgency of production problems. Planning for research manpower can then be done on a commodity basis by an interdisciplinary group that can perceive the relative importance of gaps of knowledge in the production system. When a research system gets large, and the country can afford to

allocate a lot of time for basic research for the advancement of agricultural science for the benefit of the world, a concentration of effort within separate disciplines may again be appropriate.

The disciplinary structure of the research sections in DPI tends to weight planning considerations toward disciplinary requirements. However, the research system in PNG is well beyond the early stages but not large enough to devote much of its resources to basic research. Research planning should, therefore, be governed by requirements for crop production (as illustrated on assumed priorities in Section 5.3 and Annex 7). A desirable planning decision mechanism should be developed to involve a unified interdisciplinary research service under a director who is in close touch with policy makers.

Institutions and Facilities

An efficient agricultural research service must establish and maintain adequate facilities with which the scientists can carry out their research. Papua New Guinea is reasonably well equipped in its physical facilities and equipment, though by no means beyond improvement. Six well-sited stations, with supplementary testing stations, give a good basis for constructive research. More stations may be needed as development proceeds.

Provision for technical staff supporting the research scientists is not satisfactory, and steps are needed urgently to improve both the number and level of training of support staff. Active research staff should have the equivalent support of: about one research development officer (RDO), one research development technician (RDT), one research development assistant (RDA), and appropriate laborers. On the average there is now less than half this level of support. Funding for the research program is also inadequate, constituting a serious curb on some types of research; an example is on-farm testing, which requires a lot of transport and junior staff, in addition to guarantees of compensation for cooperating farmers.

When the level of supporting staff is raised to a satisfactory level, the physical facilities at the research stations will no longer be adequate; more investment will be required to make optimum research outputs.

There is a correlation between conditions set out in a research scheme of service and the level of support and facilities provided in the system; its potential importance should not be overlooked. If a scientist is to be judged by the quality of research performance, he or she may exert a strong demand for appropriate facilities and support staff. If facilities and support are weak, on the other hand, the introduction of a new scheme of service could frustrate the researcher and prove to be a generally backward step because he is not able to demonstrate his capabilities.

Emphasis has been placed clearly here on the need for adequately trained research and support staff. Institutions for training such staff are thus closely linked with the success of the national research system. Neither the colleges of agriculture (for support staff) nor the universities (for research staff) are currently able to serve fully the needs of the research service. Modifications to curricula at the

colleges (as proposed in the 1982 report by McKillop and Associates) should improve the quality of support staff recruited. Complex issues are involved in efforts to strengthen the small Faculty of Agriculture (10 staff) to cope better with graduate and postgraduate training. It is recommended that every effort be made to resolve the issues quickly so The universities may play their roles in upgrading of the national research staff as suggested in Annex 9. In the meantime, postgraduate training will have to be sought overseas. Close linkages should be developed between the agricultural research service of DPI and the University of Papua New Guinea, so they share in the processes of postgraduate training and national research -- to the benefit of both organizations.

It has been argued earlier that an agricultural research service will find the source of most of its advice for planners to be in research advances made elsewhere in the world; one of its major roles is that of interpreting these advances in terms of local circumstances. It follows that a substantial investment is needed to keep the research staff in contact with world agricultural research. Library facilities and documentation services are essential tools for an effective research service. The current facilities and operation deserve to be appreciably expanded in scope and intensity.

Funding

Funding is closely linked to the size and scope of facilities available to support research staff. The cyclical diagram (Figure 3) does not specify funding, but the level of investment in agricultural research is clearly an important decision for a country dependent on progress of agricultural development. The World Bank Sector Policy Paper on Agricultural Research (June 1981) has recommended tentatively a level of 2% of gross agricultural domestic product (GADP) as a suitable rate of investment in agricultural research. Government direct investment in crops research in PNG, through DPI and NPEP, is about 0.8% of GADP for crops. When the potential contribution to research from industry boards is included, the total rate is likely to be close to 1%, still well short of the World Bank recommendation (but better than that in some developing countries). At this level of overall investment, experiences documented elsewhere suggest that it is almost certain that further investment in research would offer a better return in the longrun than would investments in most development projects.

A guideline on funding for agricultural research is suggested in Section 3.4, that not more than two-thirds of the total research budget should be allocated to salaries and allowances, leaving one-third for operational support. This would provide more for operations than is the case in the present situation. However, many observers recommend that the ratio be nearer 50:50 for the efficient use of scientific staff in research in developing countries (where salaries are generally lower but costs of equipment are higher than in developed countries).

Whether overall funding is high or low, many observers believe that a most important factor for planning is that it should be consistent year to year. Within an operational year, it is essential to have adequate funding available early, so that costly land preparation and planting can be done efficiently.

Research Program Implementation

Within the limits of the serious constraints encountered by officers-in-charge and research staff, current research programs in PNG are being carried out adequately to well on the research stations and at headquarters. A model for efficient implementation would include: a research program derived from well-defined policies and carefully identified problems; with a suitable research and support staff, who are adequately trained, equipped, and funded; with responsibility for implementation placed firmly in the hands of officers-in-charge of the research stations, who answer to the Director of Research for operations. The activity was found to be relatively well understood, even if not easy to execute.

Research work off the station -- in farmers' fields and in social science aspects of farming systems research -- is less well understood as yet. But it is likely to be an increasingly important aspect of research activity. Final testing and adaptation of technologies at farmers' level of management could be notably strengthened through integrated collaborative activities conducted by provincial extension officers. Such procedures are not currently well developed in PNG.

Reporting Conclusions

A research system is generally considered to have a responsibility to report its findings and conclusions. For an agricultural research system, there are a number of potential users: government planners and agricultural development policy makers; extension services and others that work with and advise farmers; farmers themselves; fellow scientists nationally and internationally; and the national population in general.

There were many evidences that the reporting system needs strengthening. Its present performance was seen as more adequate in reporting to the scientific community than in making contributions to national development -- both in the relations with policy makers and in reaching the production systems. The situation includes numerous factors that are presently beyond the control of the DPI research group.

ANNEX 4

History of Organization of Agricultural Research in Papua New Guinea

A. E. Charles, Chief Agronomist, DPI

In the period following the 1939-45 war, PNG was administered by the Australian Government, with the formerly separate Australian Territory of Papua being administered in unison with the UN Trust Territory of New Guinea. Agriculture at the time was clearly demarcated into two sectors: the expatriate-owned plantation sector producing almost exclusively cash crops for export, and the village sector producing food for subsistence and minor quantities of export cash crops. Agricultural research was almost exclusively the responsibility of the Department of Agriculture, Stock and Fisheries which, in the early 1950's, had four divisions:

Plant Industry - responsible for crop research and technical services, plant introduction and quarantine.

Animal Industry - responsible for livestock research and veterinary services.

Fisheries - responsible for fisheries research and surveys.

Extension and Marketing - responsible for extension services to crop producers and for marketing services for export crops where these were not available through other sources.

In addition to the four divisions, there was a small administrative services section. One significant outside research input was a comprehensive series of land use surveys by the Australian Commonwealth Scientific and Industrial Research Organization carried out between 1952 and 1975.

Throughout the 1950s, when very few PNG nationals were educated beyond primary school level, all research, extension and management staff, as well as a high proportion of clerical and support staff, were expatriates. These officers were employed as permanent public servants, with salaries and conditions generally more attractive than those available in Australia. As a result, a large proportion served for long periods, resulting in a relatively stable service with most senior positions occupied by fairly experienced officers who had advanced through the service. Most new recruitment was into base-level positions in a steadily expanding service. It may be noted that, regardless of what subsequent changes have been made in organization and structure, the duty statements of the key positions of administrators, research scientists, research support staff, and extension officers remain virtually unchanged from the original descriptions in terms of expatriate skills. The qualifications for research scientists were based generally on an Australian Agricultural Science degree, and for the extension service on a diploma from an Australian agricultural college, though the extension service always employed a sprinkling of Agricultural Science graduates and of diplomates from Netherlands and UK colleges.

The Extension Division was nominally responsible for extension services to all producers. However, the magnitude of its task in reaching the village producers and the very different nature of the services required by the village sector, as against the plantation sector, led to a situation where it became tacitly accepted that the plantation sector should generally liaise directly with the Plant Industry Division, leaving the Extension Division to service indigenous producers. The Extension Division was nominally responsible for advising and assisting in food production and monitoring village gardens. However, in a situation where the extension officers were unfamiliar with village food crops and gardening systems; where the people's expressed interest was in cash crops, and Administration's emphasis was on increasing export income; it was inevitable that extension effort focussed heavily on export crops. (One major exception to this generalization was rice, which received consistent attention from researchers and extension officers, with occasional very intensive extension efforts). Consequences for crop research of these general trends were a strengthening of the innate tendency of the researchers to direct their attention to high level management systems, and for food crops research to lack clear focus and so fail to hold the most capable researchers.

Some of the most significant changes in the agricultural situation since the 1950s have been:

1. Export agriculture has diversified from a dominance by coconut products to major shares by coffee and cocoa as well as coconuts, and substantial contributions by oil palm, tea and rubber.

2. The relative importance of the village sector has greatly increased, and it is now, overall, substantially larger in terms of production than the plantation sector.

3. Food production and distribution have not kept pace with population growth and urbanization, and food imports have greatly increased.

4. Although smallholder production has steadily increased in most crops, the rate of increase has declined in the last decade. Plantation production of cocoa, copra and rubber have declined substantially since the early seventies. Contributing to this decline was the 1974 Plantation Redistribution Scheme which adversely affected maintenance and reinvestment by expatriate owners (see World Bank Report[1] Annex G, page 136-7).

5. Coffee and cocoa, which were new crops to most villagers in the 1950's, are now virtually traditional crops.

6. Since the mid 1960s, there have been substantial borrowings from World Bank, Asian Development Bank, and other institutions for rural development projects. This has introduced external influence on types of development attempted and external monitoring of the projects' progress.

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[1] World Bank (1981) PNG: Agricultural Services Review, No 3161-PNG.

7. A new sector has entered the agricultural scene, in the form of large scale joint Government/private enterprise investment in agricultural projects, usually based on nucleus estates supported by smallholder resettlement blocks. A contribution from the private enterprise investor has been overseas expertise in intensive management methods, usually coupled with technological expertise and research orientation.

Other major changes in the same period have affected agricultural research in a variety of ways. Some of the important changes were:

1. Improved educational attainment by PNG nationals has led to almost complete localization of DPI clerical, management, extension and research support positions. Increasing numbers of national scientists have entered the research service, but a high proportion of senior research posts and some junior posts are still filled by expatriates. At an early stage in the localization of the public service, a dual salary structure was introduced, with nationals receiving a lower salary than expatriates. The national salary structure is based on levels that the PNG economy can afford on a permanent basis, while expatriate salaries are related more to salary ranges in developed countries.

2. Political development culminated in self-government from 1972 and complete independence in 1975. Among the many effects on agricultural research have been greater involvement by the elected government in agricultural policy making and closer accountability of Departmental staff to the Minister responsible. A practical result of this has been increased work for headquarters senior staff in preparing briefs, etc.

3. To cope with the growing size and complexity of the Public Service and its functions, and to provide a better basis for decision-making by the elected government, more attention has been given to central planning. This has led to the setting up of the National Planning Office, the National Public Expenditure Plan, and the Budget Priorities Committee. All these provide external monitoring of DPI planning and performance.

4. The establishment of Provincial Governments and the transfer to their control of many formerly national functions has taken the agricultural extension services out of the control of central DPI. These changes have greatly weakened central DPI's power to implement national agricultural policies and plans.

5. Agricultural research has ceased to be the sole preserve of DPI. Industry organizations now have substantial involvement, as do some provincial integrated rural development projects. There are numerous other small research projects being conducted by the universities and several non-government organizations and enterprises.

6. In anticipation of localization of the Public Service, the basis of expatriate recruitment was changed to limited-period contracts in 1965. Subsequent development of localization policies, which

included the paying-off of all overseas permanent public servants at Independence, with those who remained being offered contracts no longer than three years at a time, has reduced security of expatriate employment and reduced promotional opportunities. These changes, together with changing political conditions and somewhat less attractive remuneration, have led to heavy losses of experienced expatriate staff and thus an overall reduction in the experience level of the service.

7. High prices for the main export commodities in the mid to late seventies supported expansive trends in the Public Service. Recent downturns in prices have necessitated stringent financial policies and all sectors of the Public Service have had severe limitations on staff recruitment and replacement since early 1981.

In response to such changes, as well as in recognition of deficiencies in existing organization, the Department has been reorganized several times since its post-war structure was first established. However, it should be noted that the structure described in the World Bank report is not appreciably changed from that introduced in 1975/76. Although further changes to accommodate the loss of the extension services and other post-independence needs were under active consideration, none had been implemented by 1980.

The extension division, always the largest section, has probably undergone the greatest changes. A change of attitude and scope was demonstrated in 1969 name changes of the Division to Development and Marketing and of the extension officers from Agricultural Officer to Rural Development Officer. The names accommodated not only a recognition of the developmental role of the service but also of the generalist approach covering crops, livestock and fisheries.

A major change, in 1971, was the decentralization of functions on a regional basis, with four Regional Controllers having substantial administrative autonomy and some control over activities of other branches in their region as well as full authority over all extension staff and programs. The system was generally considered fairly successful but had to be disbanded when the decision was taken at the time of Independence to decentralize more radically (both politically and administratively) to the provincial level. In taking the extension service out of central DPI, this change also truncated the Policy Review and Co-ordination Branch and the regionally-decentralized extension service, though it also handled the area of policy review and the management of Integrated Rural Development Projects.

Another name change, this time of the whole Department to Department of Primary Industry resulted from a government decision to reduce the number of departments in the Public Service. Among other amalgamations, the Department of Forests was incorporated with the Department of Agriculture, Stock and Fisheries. However, as the Office of Forests has retained a separate Director and a separate Minister, integration of the two departments has not proceeded beyond centralizing some administrative services and printing and mapping units.

A very important change was the establishing of new divisions (or branches, as they are now called) at the 1971 and 1975 reorganization. The existing Management Services section was given full branch status, but the more significant new branches were Agricultural Education and Training, and Planning, Economics and Marketing. A.E. & T. arose from expansion of major activities initiated in the former Development and Marketing Division and from development of the agricultural colleges (Popondetta 1963, Vudal 1965, Hagen 1973, Sepik 1980). P.E. & M. was upgraded from a section within the administrative service, through a growing appreciation of the economist's role in both marketing and farm management services.

After the multiplication of branches to seven, a pattern of regular meetings of branch heads was established for the purpose of discussion and coordination of activities. These meetings were formalized in 1973 as the Standing Committee on Agriculture which met monthly and included the four Regional Controllers as well as the headquarters branch heads. The Committee was the main vehicle for two-way communication between headquarters policy formulators and the implementers in the field extension service. The Standing Committee did not have executive authority but submitted recommendations to the Secretary, or through him to the Minister for decision. Although the Standing Committee was fairly effective for a period, its impact was weakened by lack of adequate secretariat services and, more severely, by the decentralization process which took away the field extension component. There had been active planning towards more effective arrangements by the time of the World Bank Mission in 1980 and the issue is taken up in their report. The recommendations of that report, in respect of Central and Provincial policy making and coordination, have been adopted in modified form, with the establishment of annual meetings of Provincial and National Ministers, and twice-yearly meetings of provincial departmental heads attended by many of the central DPI branch heads. Within central DPI, a committee similar to the headquarters component of the Standing Committee has been retitled Policy Group and a Policy Secretariat has been established to service these organizations.

This outline of the changes affecting DPI as a whole has been given as a background against which attention can be focussed on the changes affecting crop research specifically. As noted at the outset, crop research was the responsibility of the Division of Plant Industry. In 1969 the division was given a name change to Research and Surveys, mainly because of the incorporation into the branch of fisheries research activities (which rendered "plant industry" inappropriate) but partly to emphasize the importance of survey activities in both fisheries and land utilization work. Fisheries activities incorporated into the branch were under the direction of a Deputy Assistant Director (corresponding to Deputy Assistant Secretary on present nomenclature) and there was virtually no integration of fisheries and crop research other than at the directional level. At the same reorganization, fisheries development activities were incorporated into the division of Development and Marketing. At the reorganization, in 1975, the two fisheries elements were reunited to recreate a fisheries branch. It was felt that the small gain from having two sectors of research under the same direction was more than offset by the loss of direct contact between fisheries research and development activities. Such a statement is weakened, however, by

noting that the simultaneous transfer of the Agricultural Development Section from Economics and Marketing into the now-renamed Agriculture Branch cannot be said to have had any marked effect on integration of the transferred development activities with crop research activities. This is not to say the two activities do not interact, but to suggest that their interaction has not been appreciably enhanced by putting them in the same branch. The more notable effect of the transfer has been to introduce a tension between the two activities in relation to the division of branch funds.

Whether intentional or not, an effect of the reorganizations that have taken place has been a substantial weakening of the position of crop researchers in policy formulation. In the fifties, departmental policy making was by the departmental head in consultation with his divisional heads, so crop research was represented by one voice in four. In the 1981 Policy Group, the Assistant Secretary (Agriculture) has one voice, to speak for both crop research and national agricultural development projects, in a group of seven Assistant Secretaries.
Although the reorganizations have appreciably changed the status of crop research within the Department, they have not greatly affected the internal structure of the crop research system, except for the introduction of a new section, Horticulture, in 1976. Early in the fifties, the basic structure was established with sections of Agronomy, Entomology, Plant Pathology, Agricultural Chemistry, and Soil Survey (later renamed Land Utilization). Quarantine later gained the status of a section but, as its role is not research, it will not be considered further here. (The Quarantine Section comprises inspectors only; quarantine decisions are made by the Assistant Secretary (in his role as Chief Quarantine Officer (Plants)) in consultation with specialists of other sections.) The addition of the Horticulture Section was made specifically to promote greater attention to production and post-harvest handling of perishable foods, and the decision to create it arose from increasing Government concern at the increases in food imports.

Throughout the history of the crop research service, the approach has been both discipline and commodity oriented, with the former perhaps the stronger. The Agronomy Section controlled a series of experiment stations and tended to be seen as the leader in research, with the experiment station agronomist expected to become an expert in his assigned commodity, able to take an overview of crop production and problems. He would call the attention of the appropriate technical sections to pest and disease problems, and draw on the services of the Chemistry Section for soil and plant analyses associated with his field trials or for analyses to determine product quality. Soil Survey work tended to be more independent, providing land use data for development projects and serviced by the Chemistry Section for soil analyses. The leading role of Agronomy was not formalized and the different sections, according to their staffing and experience levels, have tended to varying extents to develop their own research projects, with the servicing of experiment stations sometimes becoming quite secondary. All research has been "applied", directly related to improving crop productivity or profitability, and mostly on the level of local adaptation of overseas research findings.

The disciplinary approach to research was inbuilt in a hierarchical control system. A station agronomist is responsible through any

supervisory senior agronomist to the Agronomist in Charge of his station, who is responsible through the Chief Agronomist to the Assistant Secretary and through him to the Secretary. The station Agronomist in Charge is responsible for station programs and priorities, the Chief Agronomist for coordination of programs and priorities between stations, and the Assistant Secretary for coordination between disciplines and for integration with priorities of other branches. The Secretary sets overall priorities. The system within each of the other sections is similar, but an officer posted to an agronomy station has, until recently, been responsible only administratively to the Agronomist in Charge, but responsible for his work program to the Chief of his own section. Formal integration of projects across disciplines was therefore at the level of discussion between section Chiefs or direction by the Assistant Secretary, though in practice it was often much more direct. Actual projects may be initiated at any point in the hierarchy, but probably most frequently arise from the researcher himself. There is a formal system for submission of projects for approval by the section Chief before they can be commenced, but this has not always been rigidly enforced.

At the time the Horticulture Section was established, some attention was given to perceived weaknesses in the earlier structure. Firstly, in recognition of the very poor communication between research and extension workers, a section of Field Horticulturists was included. The role of the Field Horticulturist is to liaise between the research horticulturist on the experiment station and the extension services, and to carry out demonstrations and adaptive trials in farmers' fields. Secondly, in recognition of the undesirability of further sectionalization of research activities, horticulturists were stationed at existing agronomy stations and an informal arrangement was made for Agronomy and Horticulture Chiefs to share responsibility for station oversight.

Subsequently, both these trends have been followed further. Five positions of National Crop Adviser (for coffee, cocoa, coconuts, spices, and rice) have been created within the Agricultural Development Section. Their role is primarily to encourage and seek to coordinate provincial efforts in crop development, but they also make an important contribution to research/extension liaison. Where practical, they work out of research stations. More recently it has been agreed within the Branch that all officers posted to an experiment station should be fully responsible to the Officer in Charge, and the latter title should replace Agronomist in Charge in recognition that the post could be held by a scientist from one of the other disciplines. However, although this decision has been issued as an instruction, no detailed guidelines have yet been issued for putting it into effect.

One other facet of the research structure which has contributed to the disciplinary approach has been the tendency for Chemistry, Plant Pathology and Land Utilization Sections to operate from a central base in Port Moresby rather than to decentralize to stations. For Land Utilization, and to a lesser extent the other two sections, this has related to their function in supplying services to the whole agricultural industry as well as to experiment stations, and such services can be supplied conveniently from a central location. For Chemistry and Plant Pathology the more important reason has been the cost economy of operating a single laboratory rather than several, and at a centre where at least some equipment supply and repair facilities are available.

Biometrics is an area of research support not yet mentioned. Through the fifties and sixties services were provided by a senior biometrician of CSIRO Canberra through correspondence and periodic visits to experiment stations. Difficulty was experienced in recruiting a biometrician to DPI and it was not till 1978 that an appointment was made. Installation of a mini-computer in 1981 has assisted in data processing and an assistant has been appointed but there is still a backload of trial and survey data for analysis.

ANNEX 5

Current Crop Research Capabilities at Major Research Stations in Papua New Guinea

Crop research is carried out by the Department of Primary Industry at headquarters at Port Moresby and at five major research stations.

Lowlands Agricultural Experiment Sation, Keravat;
Agricultural Research Centre, Bubia;
Highlands Agricultural Experiment Station, Aiyura;
Agricultural Research Station, Kuk;
Horticultural Research Station, Laloki.

They are supported by smaller DPI substations at Tambul (pyrethrum), Lejo (cocoa), Omuru (coconut), and Bisianumu (rubber). Supplementary work in association with DPI is being carried out by research teams that are part of rural development projects in Southern Highlands and East Sepik provinces; they are mainly concerned with adaptive research, testing recommended technologies in local environments, and with describing better those local environments and farming systems. Another group is working with similar objectives in Simbu Province, with strong participation by the Institute for Applied Social and Economic Research (IASER).

Most of the research work in agricultural economics has been carried out by staff from the former Planning, Economics and Marketing Branch of DPI. The major export crops commodity boards are also establishing research institutions for their particular crops, but only the oil palm research station at Dami has made much headway as yet. The Faculty of Agriculture and other faculties at the University of Papua New Guinea (UPNG) at Waigani and the University of Technology (UOT) at Lae have research programs that are relevant to agricultural development. In addition, independent institutes, such as the Institute for Applied Social and Economic Research and the Ecology Institute at Wau, also carry out agricultural research.

In the limited time available the team was able, through visits and discussions, to gain a reasonable impression of the facilities of the main stations and the general capacity to come to grips with the research programs outlined, but it was impossible to carry out a detailed review of all the research projects at hand. Some conversation was possible about the progress of the experimental programs with individual scientists at the time of the visits, but it was concluded that it would be inappropriate to discuss particular programs in any depth after such brief visits. Only a broad appreciation of the thrust of the research work at each station is given; a comprehensive list of crop research projects in Papua New Guinea has been prepared by R. M. Bourke, senior agronomist, and the list is included in this annex.

1.1 Lowlands Agricultural Experiment Station, Keravat

The research station at Keravat was established on a good representative site as early as 1928; it has played a major role in the testing of crop

introductions, especially for the Lowlands. It has a well-established infrastructure and experienced junior support staff. The station covers about 500 ha, and its research activities range from vegetables and spices to perennial tree crops. Most of the cultivated land is committed to tree crops, especially cocoa and coconuts. The main thrust of the resarch program is on cocoa, involving 10 research staff from five disciplines, including an economist from PEM Branch, a breeder from the Cocoa Industry Board, and a plant pathologist from UPNG. Some of those scientists also spend time on coconuts and other crops.

The other five scientists -- agronomists -- are working on a range of food crops including traditional vegetables, sweet potato, taro, xanthosoma, cassava, and maize, and on farming systems involving several of the crops. A substantial series of trials and observations on a range of nuts and spices is being carried out by a senior technician.

Laboratory and office facilities are reasonable to good, but the level of supporting technical staff (a total of 12 RDA, RDT, and RDO), although they are experienced, is still not adequate to get best value from the scientific staff.

Agricultural Research Centre, Bubia

The station at Bubia was taken over for research in 1952. It also serves the Lowlands, and it is well placed at the neck of the Markham valley to play a valuable role in good communication on the mainland with important areas of production. The total area of the station is 220 ha, but a large part of it is not suitable for experimental trials, leaving a small effective operational area. The station is conveniently placed for collaborative work with faculty from the University of Technology, where the DPI has already provided a Food Technology Laboratory.

The main research program is concerned with improving the productivity of grains and pulses, but some of the farm area is under coconuts (for observation of hybrids), cocoa, and sugar. Research work has been carried out in recent yars on maize, sorghum, and groundnuts, but staff shortages have curtailed this work. Currently one agronomist and one breeder are devoted to rice; one agronomist works on soybean, adzuki, and mung beans; and two entomologists work on a range of crops.

Crop research work at the UPNG Faculty of Agriculture group at UOT is relatively restricted by heavy teaching duties: work is mainly on taro and animal husbandry. The Food Technology Laboratory is just ready to start operations with two DPI scientists to work alongside staff from the Department of Chemical Technology of UOT.

Highlands Agricultural Experiment Station, Aiyura

The Highlands Agricultural Experiment Station is the main research center for crops for higher altitudes. The station altitude is from 1,600 to 1,850 m above sea level, with a wider range covered at experimental sites off-station. It provides an excellent environment for research in traditional food crops of the highlands and a good base for farming system studies, which constitute the major research program at present. However, in the past it has concentrated more on coffee and on pastures and livestock, which are still important. This is apparent in the

present distribution of land use, with most of the 450 ha devoted to pastures, with 30 ha to coffee and fruit and nut trees, and 10 ha to arable crops. The office and housing facilities are adequate for present operations, but the laboratory and library facilities are limited. All of the seven scientific officers are agronomists; the substantive officer-in-charge, on study leave, is in the Agronomy Section and is a coffee specialist. The rest are in the Horticulture Section: two are working with fruit and nut trees, and the other four are on aspects of describing and improving sweet potato-based farming systems in the Highlands. The distribution of technical support staff reflects earlier priorities: of 12 technical staff, 4 are for coffee, 4 for pastures and livestock (including fish), 1 for fruit and nuts, 1 for food crops, plus the station manager and field supervisor.

Two research staff from the newly created Coffee Industry Board research department and an economist from PEM Branch working on farming systems involving coffee are closely linked with the research station at Aiyura.

Kuk Agricultural Experiment Station

The Agricultural Experiment Station at Kuk, near Mt. Hagen, was set up in 1969 to serve the tea industry. It has a total area of 320 ha, of which 100 ha is cultivated. It has a total area of 320 ha, of which 100 ha is cultivated. Most of the cultivated land is under tea, with small areas for root crops, vegetables, and fruit. The station is typical of an extensive area of the Wahgi valley: the land needs drainage for good crop performance, but it is used for both tea and coffee cultivation. Past research activity has worked out suitable agronomic practices for tea production and solved establishment problems in the nursery. The major programs on hand are a long-term evaluation of clonal material started in the 1960s and nearing completion of an evaluation cycle; and the analysis of a long-term trial on tea nutrition, also nearing completion in the field. Promising material is emerging from the clonal program, and a firmer base has been established for fertilizer recommendations. It is difficult to arouse interest among planters at present, as profit margins have been severely squeezed between rising production costs and declining prices. Three research officers give part-time attention to tea research, and there is no prospect for further research effort from the depressed industry at present. However, field and nursery facilities are good for research in tea at Kuk; laboratory facilities are less adequate.

The remaining program is on food and vegetable crops. Two entomologists are concerned with a survey of pests in the South Highlands Rural Development Project and on studies for the control of important pests of vegetables. A horticulurist is mainly involved on fertilizer and variety trials of sweet potato and on maintenance for distribution of a wide range of local and introduced crops. Much of this work is done off-station.

Horticultural Experiment Station, Laloki

The Laloki Research Station was established in 1949 as a plant introduction and quarantine station. Since 1970 it has assumed a major role in food crops research, vegetable crop improvement, and seed production for the important dryer lowland area around Port Moresby. Situated 15 km from Port Moresby, the station has a total area of about

180 ha; most is poor savannah country. Field trials are restricted to about 30 ha on flat alluvial clay loams along the banks of the Laloki River, all of which can be irrigated from the river. There are about 30 current trials, ranging from agronomy to crop protection and seed production, on tomatoes, cruciferous crops, sweet potato, yams, cassava, and winged bean. The station also houses the main PNG banana varietal collection. For the range of activity and good site, the scientific staff is small: 3 horticulturists and 1 Canadian volunteer, supported by 2 RDOs, 3 RDTs and 1 RDA. The area horticulturist for the Papuan region also operates from Laloki.

Even with the current involvement of the station in some aspects of the South Coast Food Project, the full potential of the station is not realized. It could play a major role in crop production research on the special problem of providing food for the Port Moresby area.

Dami Research Station (Oil Palm Research Association)

The original research work on oil palm at the nucleus plantation development at Hoskins was done by the company, New Britain Palm Oil Development Ltd. (NBPOD), which was established in 1967. It supported a vigorous seed production program and a new and expanding industry in PNG. In 1980 the growers' association established its own Oil Palm Research Association, funded by a cess on production; several ongoing experiments at Dami and at other plantations were taken over in 1981. New laboratories have been built and occupied at Dami, and the research association has been launched with a major success -- the scientifically controlled introduction of a weevil from West Africa to pollinate flowers in place of the tedious hand-assisted method previously found necessary.

The research staff is still small, with a director, two agronomists and one entomologist (from DPI), and there is good cooperation from producers on well-managed plantations. The research staff maintains close liaison with the three NBPOD company agronomists responsible for the continuing seed production and improvement by breeding. The main research program is concerned with: studies of fertilizer and planting densities in several places; replanting methods; control of sexava pests; and monitoring the performance, and its persistence in the face of predators, of the weevil pollinator.

Crop Research Projects in Papua New Guinea[1]

Prepared by Senior Agronomist R. M. Bourke
(November 1981 -- with some subsequent modifications)

National Department of Primary Industry

Highlands Agricultural Experiment Station, Aiyura, via Kainantu, Eastern Highlands Province

Sweet Potato (W. Akus)

Variety trials of PNG and overseas varieties at sites throughout the highlands. Variety by N fertilizer interaction trials.

[1] This list is not now complete or up-to-date, since several months have passed since it was compiled.

Corn (W. Akus)
Variety trialsVegetable Species Comparison (W. Akus)
A comparison of 25 introduced and traditional vegetable species.
Fruit and Nut Agronomy (T. Tarepe)
Citrus rootstock/Scion trial
Strawberry variety trial
Observations on village fruit and nut production
Pineapple yield recording block
Apple, pecan nut, macadamia nut, peach, grapes observation plots.
Intensification of Subsistenace Agriculture (E. D'Souza/R. M. Bourke)
Location: Nembi Plateau, S.H.P. Numerous trials in village gardens on inorganic and organic fertilizer, crop rotation; fallow crops; evaluation of new varieties of existing crops and new crops.
Seasonality of Food Supply in the highlands (R. M. Bourke/E. D'Souza)
Aim: To define and find out the cause of seasonality of sweet potato and other food crops in the highlands. Techniques: Regular garden planting surveys (EHP, SHP). Regular surveys of four markets (EHP, SHP). Time of planting trials of sweet potato, rungia, winged beans and peanuts (Aiyura, Nembi Plateau).
Altitudinal Limits of Crops (R. M. Bouke)
Observations are made throughout PNG on the altitudinal limits of several hundred crops in order to define their usual and extreme upper and lower altitudinal limits.
Highland Institutional Food Production (B. Calcinai)
Aim: To upgrade food production and purchase of locally produced foods at institutions in the Highlands. Techniques: Surveys; development and running of courses for institutional farmers.
Relationship between Malnutrition and Agricultural Factors.(R.M. Bouke with colleagues in other institutions)
Aim: To understand the relationship between child malnutrition and agriculture, land use, etc. Techniques: Field surveys in areas with severe malnutrition problems.

Coffee Spacing Shade Pruning Trial (R. Dingu/J. Yogio)
Coffee Spacing Variety Trial (J. Yogio)
Coffee Renovation Trial (R. Dingu)
Dwarf Coffee Evaluation (R. Dingu)

Experiment Station, Bisianumu, Sogeri Plateau via Port Moresby

Rubber Tapping System Trial (S. Langlois)
Eight Rubber Clonal Yield and Seedling Trials (S. Langlois)

Agricultural Research Center, Bubia via Lae

Soybean (R. Kambuou)
Variety trials
Herbicide trials
Mungbean (R. Kambuou)
Variety trials
Variety and density trials
Mungbean/maize intercropping trials
Peanut Variety Trials (R. Kumbuou)
Adzuki Beans Variety Trials(R. Kambuou)

Rice (Joo Moon Kap and J. Wohuinangu)
- Variety trials (irrigated and dryland)
- Fertilizer trials (irrigated and dryland)
- Seeding rate trials
- Regional yield trials
- Weed control trials
- Milling and palatability assessment

Entomological Studies
- Studies on parasites of the green vegetable bug Nezara viriduala;
- Biology of Riportus spp (G. Young)
- Studies on beanfly, Ophiomyia phaseoli; leaf eating lady bird, Henosepilachna signatipennis; bean pod borer, Marcusa testulalis, Stichotrema dallatoreana, Segestes deoratus, Coccus viridis, Conocephalus sp, Sugarcane stemborer (G. Young)
- Studies on pests of sorghum (F. Dori)
- Aibika flea beetle study (varietal resistance, life cycle) (J. Sutherland)
- Sweet potato weevil, damage assessment methods (J. Sutherland)

Lowlands Agricultural Experiment Station, Keravat via Rabaul

Studies on Traditional Vegetables
- Comparison of annual and perennial vegetable species (M. Lolo) Aibika (Abelmoschus manihot) agronomy. Variety, organic fertilizer, method of planting and method of harvesting trials (M. Lolo).
- Survey of traditional vegetables in lowland areas (M. Lolo).
- Studies on aibika collar rot (A. McGregor) and leaf roller (M. Arura).

Studies on Sweet Potato (L. Kurika)
- Variety trials of introduced and local varieties
- Variety and fertilizer trials

Cassava Variety Trial (L. Kurika)

Banana Fertilizer Trial (L. Kurika)

Maize Variety Trial (L. Kurika)

Farming Systems Studies (A. Leng)
- Rotation trial
- Soil exhaustion trial
- Yield observation blocks

Root Crops Studies (S. Gunawardhana)
- Root crops germplasm evaluation
- Pathology survey

Swamp Taro Time to Maturity Trial(C. Kasimani)

Taro Studies (C. Kasimani)
- Variety trials
- Fertilizer trials

Xanthosoma (C. Kasimani)
- Trials on fallow period, varietal resistance, time of planting, and transmission related to the root rot problem.

Fruit and Nuts Studies (K. Aburu)
- Mangosteen problems investigation
- Ramubutan evaluation of fruit
- Avocado observation and seed splitting trials
- Evaluation of indigenous fruit and nut species

Chillie (K. Aburu/F. Aia)
- Variety and spacing trial
- Labor input/output observation

Cardamon (K. Aburu/F. Aia)
- Observation trials
- Seed germination trial
- Insecticide trials (S. Smith/K. Aburu/F. Aia)
- Clonal trial

Nutmeg (K. Aburu/F. Aia)
- Marcotting trial
- Inarching observation trial
- Correlation between radicle length and tree sex

Pepper Observation and Variety Trials (K. Aburu/F. Aia)

Cocoa-Related Studies
- Progeny testing, Trintario and Amazonian crosses (T. Sitapai/G. Ling)
- Puerto Rican introduction (T. Sitapai/G. Ling)
- Colombia 4 Introductions (T. Sitapai/G. Ling)
- Clone testing: Vascular-streak dieback selection (T. Sitapai)
- Vascular-streak dieback resistant trials (T. Sitapai/G. Ling/Mrs. Mazewin)
- Trinitario seed gardens (Mrs. Mazewin)
- Propagation trials (J. Hewitt)
- Rubber/cocoa trial (T. Sitapai)
- Seeding establishment trial (T. Sitapai/G. Ling)
- Redevelopment trials (T. Sitapai/J. Hewitt/G. Ling)
- Cocoa/eucalyptus shade observation (Mrs. Mazewin)
- Seedling spacing trial (T. Sitapai/G. Ling)
- Cutting vigor and spacing trial (T. Sitapai/G. Ling)
- Cocoa tree poisoning (G. Ling)
- Release of Baculovirus against Oryctes sp and interaction (M. Arura)
- Screening against Pantorhytes (S. Smith)
- Pantorhytes pheromone investigation (S. Smith)
- Cocoa faunal association surveys (S. Smith)
- Crazy ant/Pantorhytes study (S. Smith/M. Wanariu)
- Hand picking/shade removal on Pantorhytes (S. Smith)
- Channel paints against Pantorhytes and longicorns (S. Smith)
- Glenea biology and control (S. Smith)
- Cocoa mirid studies (S. Smith)
- Susceptibility of cocoa clones to mealy bug infestation (M. Wanariu)
- Trunk injected insecticides against Pantorhytes (S. Smith)
- Metarhizium infection of rhinoceros beatles (M. Arura/C. Prior)
- Phytophthora pod rot of cocoa -- source of infection, resistance, chemical control and surveys (A. McGregor)
- Chemical control of seedling blight of cocoa (A. McGregor)

Agricultural Research Station, Kuk via Mt. Hagen

Tea Studies (M. Gunther/B. Karisa)
- Trials on: clonal selection, breeding, Japanese tea, fertilizer, time of fertilizer application, form of fertilizer, fertilizer placement, spacing, nursery shading, multi-node cuttings, herbicides

Entomology Studies (B. Thistleton)
- Black diamond moth of cabbage (Plutella xylostella), Crocidolomia binotalis, potato aphid, potato tuber moth, taro beetle, corn earworm, Oribius spp., cassava, taro, tea and citrus insect pests, and fruit fly

Sweet potato Fertilizer and Variety Trials (E. Groedl)

Onion Variety and Fertilizer Trial (E. Groedl and M. Russell)

Orange Fertilizer Trial (M. Russell/E. Groedl)

Horticultural Experiment Station, Laloki via Port Moresby

Sweet Potato
- Variety trials (G. King)
- Fertilizer trials (G. King)
- Weevil resistance and insecticides (G. King/B. Thistleton)

Vegetable Variety Trials -- tomatoes, cucumber, cabbage, and other introduced and traditional vegetables (P. Bull)
Legumes Selection for Drought Tolerance (P. Bull)
Cassava Variety Trials (G. King)
Banana Variety Trials (G. King)
Selection of Superior Types of Citrus for Multiplication (A. Rogers)

Lejo Research Centre via Popondetta

Cocoa (M. Areori)
- Propagation of clonal cocoa
- Rehabilitation trial
- Re-establishment trial

Omaru via Madang

Hybrid Coconuts (R. Brook)
- Nursery fertilizer trial
- Seednut germination trial
- Variety-by-spacing trials at Bubia and Keravat
- Demonstration plots in 14 provinces
- Fertilizer trials at Omuru, Manus, and Bubia

Popondetta

Entomology -- Biocontrol of Pantorhytes

High Altitude Experiment Station, Tambul via Mt. Hagen

Pyrethrum (A. Mengge-Nang)
- Clonal selections and yield trials
- Polycross evaluation trial

Chemistry Section, DPI Headquarters

Soil Fertility and Plant Nutrition
- Soil fertility levels in relation to sweet potato yield (K.J. Velayutham/S. Pondrilei)
- Nutrient requirements of tomato (K.J. Velayutham/S. Pondrilei)
- Evolution of methods of soil analysis used in plant nutrition diagnosis (K.J. Velayutham).

General Chemistry of Natural Products
- Evaluation of the commercial value of cardamon and chille (T. Piper)
- Estimation of protein content of sweet potato cultivars (N. Toreu)
- Assessment of pyrethrin content in pyrethrum clones (T. Piper)
- Analysis of sandalwood oil to evaluate the commercial value of the components (T. Piper)
- Investigation of sources of environmental contaminants (N. Toreu)
- Analysis, classification, and grading of natural rubber (T. Piper)

Plant Pathology Section, DPI Headquarters

Disease and pathogen identification (G. Kula/D. Clarkson/B. N. Muthappa/D. Tomlinson)
Studies on fungicides and nematicide (D. Clarkson/G. Kula)
Studies on bacterial wilt of tomatoes and potatoes (D. Tomlinson)
Effect of nematicides on nodulation (D. Clarkson)
Studies on coffee disease and aibika collar rot (B. N. Muthappa)

Entomology Section, DPI Headquarters

Studies on stored-product insects (J. van Greve)
Entomological taxomony (J. Ismay)

Land Use Section, DPI Headquarters

Land use/population study of PNG (in conjunction with CSIRO Division of Land Use)
Soil conservation study in Simbu Province (G. Humphreys)
Land use potential studies in Milne Bay, Manus and Western Provinces
Semi-detailed land use potential surveys: West New Britain, Gulf Province, and Vanimo timber purchase area
Rapid reconnaissance studies in various provinces

Post-Harvest Handling, DPI, Port Moresby

Studies on storage of fruits and vegetables -- sweet potato, bananas, seasonal greens, pumpkin, pineapples, and tomatoes; processing of tomato and pineapple (M. Drum)

Food Processing Section, DPI, Lae

Food processing studies on sweet potato, passionfruit, pineapple, banana, tomato, pumpkin, and mung bean (G. Thomas/M. Akia)

Goroka

Coffee/food crops farming system studies (B. Carrad)

Bulolo

Plant pathology studies on various pathogens including Phytophtora colocasiae (J. Simpson)

Universities

University of Papua New Guinea

Winged bean agronomy (V. Kesavan, Agriculture)
Traditional vegetable agronomy (V. Kesavan, Agriculture)
Winged bean chemistry (A. Claydon, Science)
Organic fertilizer trials (K. Thiagalingam, Agriculture)
Economic entomology, especially of citrus (E. Brough, Science)
Virus studies, especially on taro (M. Pearson, Science)

Land use/subsistence agriculture on Manus Island (W. Rooney, Geography)
Land use/subsistence agriculture, Waghi Valley (W. Heaney, Anthropology)
Subsistence agriculture study, Central Province (D. Vaaly, History of Sciences and Technology)
Land use/subsistence study, Tari Basin (A. Wood, Geography)
Physiology of winged beans (G. Browning, Agriculture)
Yam agonomy (E. Pais)
History of agriculture (D. Denoon)
Economics of subsistence agriculture (D. Story)

University of Technology

Soil conservation studies (A. William, Agriculture)
Economics of vegetable production (D. K. Das, Agriculture)
Agronomy and physiology of taro (A. Gurnah, Agriculture)

Other organizations

Oil Palm Research Association, Dami, West New Britain

Agronomic and fertilizer studies on oil palm (T. Menendez/T. Guiking/P. Narvus)
Pollination of oil palm by weevils (R. Prior)
Control of insect pests (R. Prior)

New Britain Palm Oil Development Ltd.

Agronomic and breeding studies on oil palm (C. Heilingman/M. Powell/T. Ovasuru)

Ramu Sugar Limited Plantation

Agronomic studies on sugarcane (J. Gallagher)

Saramandi Research Station, via Angoram, ESP/Hawaian Research Station via Wewak

Agronomic studies on sago, farming systems, yams, taro, sweet potato, traditional and introduced vegetables, bananas (M. Quinn/M. Woruba/J. Risimeri)

Wau Ecology Institute, Wau, Morobe Province

Study of local subsistence gardens (J. Swift)
Leucaena/sweet potato intercropping trial (J. Swift)
Agro-forestry observation block (J. Swift)
Sweet potato/cassava intercropping trial (J. Swift)
Study of nitrogen-fixing trees (J. Swift)

Institute of Medical Research, Madang

Land use, nutrition, and subsistence agriculture study in Usino area (T. Spencer)

Office of Environment and Conservation

Land use studies of subsistence agriculture in various parts of PNG (B. Allen)

Atzara Range Project Council

Farming system study of food/fuel systems (B. Siki)

Simbu Land Use Project

Integrated land use, subsistence agriculture, soil erosion, and human nutrition studies (S. Goodbody, A. Goie, P. Harvey, R. Hide, G. Humphries, P. Wohlt, and R. Wohlt)

Rural Development Project, Southern Highlands Province

Sweet potato variety trials (M. Anders)
Sweet potato time of planting trials (M. Anders/F. Wapma)
Sweet potato density of planting trials (F. Wapma)
Studies on nematode and frost damage to sweet potato (M. Anders)
Area studies of subsistence farming systems (B. French/M. Anders/J. Muspratt)
Tomato bacterial wilt resistance trial (M. Anders/F. Wapma)
Land use studies (J.S. Muspratt)
Tea fertilizer trial (M. Anders)

Department of Minerals and Energy

Cassava variety trials: various locations (B. Holmes, in Goroka)
Nipa palm yield and tapping techniques

Sonoma Adventist College, East New Britain Province

Variety and fertilizer trials on temperate climate vegetables (K. Denver)

DPI, East New Britain

Soil erosion study (K. Carman)

Davy Agro (Cassava alcohol project) Baiyer River, WHP

Yield observations in cassava cultivars (P. Andreoli)

Australian National University, Canberra, Australia

Prehistory in the Waghi Valley (J. Golson/J. Burton)
Taro cultivation in highlands (T. Bayliss-Smith)
Economics of subsistence agriculture, Nembi Plateau (R. Critterden)
Food intake studies, Nembi Plateau (J. Baines)

Division of Land Use, CSIRO, Canberra and Land Use Section, DPI

Assessment of the potential resources of PNG for subsistence agriculture, smallholder cash cropping, and population growth. (J. McAlpine/P. Bleeker/D. Freyne/G. King)

Germplasm Maintenance

In addition to the research listed above, germplasm collections are maintained at most research stations. The main collections are:

Aiyura: Sweet potato, taro, yams, sugar cane, rungia and oenanthe
Bubia: Rice, sugarcane, soybean
Keravat: Sweet potato, taro, cassava, other aroids, aibika (abelmoschus manihot), banana, fruit and nut species.
Kuk: Sweet potato, taro, traditional vegetables
Laloki: Bananas, sweet potato, cassava
Saramandi/Hawaian: Yams, sago, aibika, bananas, taro
Sepik Agricultural College: Yam, taro, banana, sweet potato, cassava, winged bean, and others
Tambul: Nut pandanus
UPNG, Lae: Bananas
UPNG, Waigani: Winged bean, aibika

Seed distribution

Seed and planting material is distributed from most research stations. This is a major activity at Keravat, Laloki and Aiyura. UPNG Faculty of Agriculture distributes winged bean seed. National DPI has a full time staff member (E. Duncan) working on seed distribution.

ANNEX 6

Organization of Crops Research

Research on agriculture in Papua New Guinea is carried out by a variety of agencies including: the Department of Primary Industries; other ministries such as Mines and Energy; universities; in Rural Development Projects (linked with DPI); and by boards of major cash crops. However, the bulk of the agricultural research work in support of the agricultural industry in PNG is carried out within DPI, or in close association with the Department.

Within DPI, research activities are spread over a number of different Branches and Sections within Branches (see Annex 3). Those relating to crop research are mainly in the Agriculture Branch under the disciplinary sections of Agricultural Chemistry, Agronomy, Entomology, Horticulture, Land Utilization, and Plant Pathology; but an important social science component of crop research is provided from the Economics and Statistics Section in the (formerly) Planning, Economics and Marketing Branch (PEM).

The Agricultural Branch also contains the large Agriculture Development Section and Quarantine Section in addition to the disciplinary groups. An Assistant Secretary presides over these disparate sections and has the responsibility of presenting the combined viewpoint at meetings of the Policy Group, etc. The management system is that generally associated with the civil service, with line authority descending hierarchically, through section heads to disciplinary research staff posted at research stations. A frequent complaint on stations was that there was little consultation between disciplinary elements in planning research programs as the formal lines of communication all went back separately to headquarters. There was also a general feeling that the agriculture research group was not understood or consulted by the main planning bodies in the country, or even in the Department.

The agricultural research system should be organized to interact efficiently with external institutions, and also to maintain an efficient internal system of management.

A. External

Part of what is considered efficient depends on the role envisaged for the organization. It was pointed out in Annex 2 that a national agriculture research service should have as its target:

1. to make available to the government in an appropriately interpreted form, key elements of information on which reliable agricultural plans can be based.
2. to make available to the producers through appropriate channels, and in a comprehensible form, the detailed agronomic and economic information on which to plan production of crops and stock, based soundly on adaptive research at the farmers' level of management.

3. to develop and maintain a group of well trained, competent scientists in active research positions, capable of interpreting national and international scientific advances for the benefit of national development.

The means and modes of communications with government and producers, and the development of appropriate research programs are discussed elsewhere, but for the basic pattern of organization it is stressed that the research service is concerned with imaginative creation and delivery of new information that can change existing planning situations. It is not concerned with the control of people, or property, or with the allocation or expenditure of funds for large scale developments which are the more usual public service duties. It is not suited to a classic civil service hierarchical system of authoritative control and management, but should have a system of management that encourages leadership of a team of more closely equal, independent, but cooperating, scientists, and a reward system based on efficient contributions of useful information.

As a minimum, therefore, the team strongly endorses the suggestion in the World Bank Review that Crops Research should be separated from actual development and extension sections so that it can be perceived clearly in its role as the generator and supplier of new technical information, as distinct from an operational position of the implementation of development projects - which does require a mangerial structure

Furthermore, within the separated division, there should be a "research scheme of service" which could relate to scientific service patterns elsewhere, (e.g. university) and where cases for promotion would rest on effective research activity, the nature of the job, rather than solely on managerial responsibility. It should be possible for an agricultural research officer to proceed from the lowest position in the scale to normal career expectancy solely on the value of his research and interpretive contributions, without necessarily having managerial or adminstrative responsibility. This is the pattern of research service adopted by many countries in one form or another, and if it is possible to introduce such a pattern within a Crop Research Division in DPI, it would be extremey valuable in creating an appropriate environment for encouraging good research performance.

An even more efficient and attractive option would be to establish the Crops Research Division as a semi-autonomous institute within the DPI but with its own budgetary system, although with the budget still controlled by Mangement Services through an officer placed by Management Services in the management of the Institute. This arrangement would ensure government standards of control, but greater flexibility of operations in practice.

B. Internal

The World Bank Review stressed the disruptive effect of having the research function dispersed amongst several distinct disciplinary sections, and this was echoed by research scientists on stations. The structure militates against cooperation with colleagues while, on the contrary, the basic organization should facilitate an interdisciplinary team approach to identifying priority problems and their solution.

The team, therefore, endorses the World Bank Review recommendations that there should be, under a Deputy Secretary, an overall Director of the Crops Research Division who can provide technical leadership to the various heads of disciplinary sections (not necessarily at headquarters) and can preent a balanced view of technical aspects of developmental issues to planning authorities, and in reverse, convey policy directives interpreted in appropriate technical objectives to the research staff.

There should also be a Deputy Director to assist the Director and stand in when he is away; in addition he would be the head of a research programming unit, which would develop and operate an effective consultative system for determining long-term research strategy and shorter term research programs -- and in general be responsible for generating and maintaining a flow of information within the research organization. The Deputy Director and the unit should in particular be responsible for ensuring that the research staff are kept in close touch with international research developments. There should also be an Executive Officer with an administrative cell to keep as much routine administrative load as possible off the shoulders of the Director.

Research Stations

The DPI maintains 10 agricultural experiment stations in addition to research laboratories at headquaters (see annex 5). Five of these stations currently have only one or no graduates in residence and are, therefore, essentially testing or monitoring sites, but of considerable importance because of their position or specific crop suitability.

The main research effort is concentrated on the remaining five well sited stations, with those at Keravat and Bubia serving the Lowlands area and those at Aiyura and Kuk serving the Highlands area. The experiment station at Laloki serves the special environment near Port Moresby and acts as a center for plant introductions.

The team considered that the research facilities at these main stations were good and that, given adequate funds for travel, could serve their designated areas satisfactorily. To maintain a reasonable sized core of interacting scientists, the team recommends that the numbers of staff at each station should certainly not be reduced further by opening any new stations; indeed, the size of each research group should be increased to utilize better the facilities available and to develop a few strong interdisciplinary teams focussed on specific high priority tree and food crops (see 4.3 and Annex 7).

An important recent development in research activity is the establishment of formal research organizations funded by the crop commodity boards for oil palm, cocoa and coffee. The Oil Palm Research Association has its research station at Dami, near Kimbe, and has developed from a station operated by New Britain Oil Palm Development Limited. DPI supplies one entomologist and participates in the Research Advisory Committee. It is a suitable site for oil palm research.

The Cocoa and Coffee Boards are just starting similar research activities and should work in close cooperation with the DPI establishment, with joint teams under unified leadership. Many details of the working arrangements between DPI and the research groups of the commodity boards are yet to be worked out.

To consolidate research effort into reasonably good sized teams it is proposed that the functions of the main research stations should be regrouped as follows:

Cocoa and Coconut Research Program	centered at Keravat
Coffee and Tea Research Program	centered at Kuk
(Oil Palm Research Program	centered at Dami)
Highlands Food Crop Research Program	centered at Aiyura
Lowlands Food Crop Research Program	centered at Bubia
Port Moresby Food Supply Research Program	centered at Laloki

More details of how the research programs might be organized is given in Annex 7. The officers-in-charge of the Food Crops Research Stations should have a greater degree of autonomy than at present, and each major multidisciplinary research team from a cropping system or commodity group should have a leader who would be responsible to the Director for the progress of the research program throughout the country. A similar arrangement might be possible for the Tree Crop Research Stations.

Testing Stations

Adaptive research -- testing recommended practices in new areas or on farmers' fields at farmers' level of management -- is an essential part of the research system activity. Currently, valuable adaptive research is being carried out at farm sites off the main research stations, and also in the Rural Development Projects (e.g. at Mendi in S. Highlands and at Saramandi and Hawain in E. Sepik).

A more widespread network would be desirable. But there is a limit as to how many such testing stations the central research service can or should maintain directly. Ideally, and indeed in practicable terms, adaptive research and testing stations should in due course be maintained and operated by provincial services, in close collaboration and consultation with staff from the main Central Research stations. Currently, this is not yet possible as Provincial extension personnel have not received adequate training in experimental research methodology. If the proposals embodied in the McKillop report are accepted and put into practice, even if some years away, it should be possible for some Provincial Rural Development staff to receive special in-service training in reseach techniques and experiment methodology to enable them to run such testing stations.

It should be re-emphasized that this is an essential, perhaps the most essential, stage of the research process of developing new appropriate technology for small farmers, and it is fully a part of the national research system. But such adaptive testing is of little use in the development and selection of technology to test: this is the job of the main research stations, and the staff at testing status cannot hope to take over this role. The final testing programme at provincial level should be done in conjunction and collaboration with the main stations. This may also prove to be an important way of forging formal links between research and extension.

ANNEX 7

Size and Structure of the National Agricultural Research System: Research Program Planning

In December 1981 there were 69 senior members of DPI staff listed in the Crops Research Sections of Agronomy, Horticulture, Plant Pathology, Entomology, Agricultural Chemistry and Land Use Sections. To gain an impression of what research effort was being expended on different crops, research staff were requested to estimate how much of their time was being spent on research on different crops, administration, extension, etc. Meanwhile, a preliminary estimate was made on the basis of visits and the list of current research projects prepared by Bourke (Annex 5). The result of the preliminary analysis is shown in Table 1; a later analysis based on actual returns from research staff on stations is given in Table 1a. They show similar pictures, with dangerously low research support for many important crops, such as only 1.5 man years from DPI on coffee, 0.5 man years on pulse crops, etc. Some of the staff indicated are currently on training courses and therefore not currently directly involved in research activities. The major difference between the two estimates (Tables 1 and 1a) is that the research staff indicated much more time spent on administration, supervision, and extension than was assumed, on reasonable grounds, in the preliminary estimate. This may well indicate an unhealthily large amount of time is being spent on administration and routine management by research scientists (as indeed they claim).

Table 1 also includes an estimate of agricultural research effort made by other organizations or projects not included in the recurrent DPI Agriculture Branch (and Horticulture (Food Crop) NPEP). This includes the Cocoa Industry Company, the Coffee Board Research Department, Oil Palm Research Association and New Britain Palm Oil Development, Ramu Sugar Company, the University of Papua New Guinea, AFTSEMU in the Southern Highlands Rural Development Project, the Simbu Research Project, the East Sepic Rural Development Project, Wau Ecology Institute, and the Economics and Statistics Section of Planning, Economics and Marketing Branch of DPI. These do not pretend to be very precise figures and are probably too generous on time allocated to research by scientists in these groups. More intensive analysis will undoubtedly give more refined estimates, but the overall picture is unlikely to change much.

It is a remarkably varied picture. For the major export crops, while DPI maintains a modest research team of 5.5 man years (following Table 1) in a range of disciplines to protect and improve the production of cocoa, only 1.5 and 1.0 man years each are allocated to coffee and oil palm respectively. However, research capacity on these crops has been strengthened recently by research staff supported by the industry itself. No such support is yet available for coconut or tea, which look rather vulnerable at only 1.25 and 2.25 man years per year respectively. The Cocoa Board has recently hired a consultant to advise on research priorities for cocoa. Among other suggestions, he considered a minimum level of staffing for cocoa research to be about 12 scientists, including agronomists, breeders, entomologists, pathologists, physiologists and a soil scientist (but no economist who might look to the small farmer

Table 1. Allocation of Agricultural Research Manpower Resources in PNG in Man Years/Year Based on Estimates of Division of Time Spent on Research and Administration Collected on Visits to Research Stations.

Table 1a. Allocation of Agricultural Research Manpower Resources in PNG in Man Years/Year Based on Estimates from Agriculture Branch Staff of Division of Time Spent on Research, Administration and Extension/Development February 1982.

Crop Activity	Table 1 Agricultural Branch DPI	Other Research Groups	Total	Table 1a Agricultural Branch DPI
Cocoa	5.5	2.5	8.0	2.50
Coffee	1.5	2.75	4.25	0.75
Coconut	1.25		1.25	1.70
Oil Palm	1.0	5.25	6.25	1.05
Tea	2.25		2.25	2.00
Rubber	0.25	0.5	0.75	0.75
Pyrethrum	1.25		1.25	1.0
Sub-total	13.0	11.0	24.0	9.75
Sweet Potato	4.67	2.0	6.67	3.15
Taro (aroids) and Yams	0.5	2.0	2.5	1.55
Vegetables	4.25	0.25	4.5	1.50
Rice	2.0		2.0	1.70
Pulses	0.5	0.25	0.75	0.50
Bananas/Cassava	0.83		0.83	0.80
Feed	0.5		0.5	0.55
Fruit-nuts, spices	3.75		3.75	1.45
Sugar	0.25	2.0	2.25	0.20
Flowers	2.0		2.0	2.0
Farming system	2.17	4.83	7.0	2.40
Sub-total	21.42	11.33	32.75	15.8
Storage/Processing	2.0		2.0	2.0
Pathology Services	3.75	0.25	4.0	2.85
Entomology Services	1.0		1.0	1.0
Soil & Plant Analysis	5.67		5.67	3.22
Land Use Services	7.5	3.0	10.5	8.5
Biometrics	2.0		2.0	1.20
Sub-total	21.92	3.25	25.17	18.77
Extension/Liaison	5.0		5.0	8.65
Administration	7.5		7.5	16.03
Sub-total	12.5		12.5	24.68
TOTAL	69.0	23.75	92.5	69.0

system and the farmers' economic view of less than perfect maintenance of the crop). Even for cocoa, which is the best served by research of all the crops, the existing allocation of manpower at 8 man years, falls short of the above, not excessive, target. Coffee, the most important export crop, and grown by over 250,000 small holders, is supported by only 4.25 man years of research effort per year. It is hardly surprising that the Provincial Rural Development Officers do not expect much to come from the research system, despite their felt need for better understanding of the crop and advice for small holders.

In Food Crops research, most of which is of relatively recent origin, there has been a valuable beginning to the investigation of traditional farming systems, much of it outside the formal DPI research system (see Table 1). There is also increasing attention to research on the main staple food crop, sweet potato, with more than 6 man years per year. However, on examination, this is spread over as many as seven centers, involving part-time activity of 15 people in relatively early exploratory variety trials. No other food crop receives so much research attention; the range of vegetables covered by 4.5 man years of effort is very wide. The research staff at headquarters provides a variety of valuable research services that are difficult to group. In addition to control, advisory, and monitoring services, they provide a focus for survey research on the national natural resource base, which is an essential function of any research service that is never adequately fulfilled. The largest group is in Land Utilization Section, but the coordination of surveys of pest and disease incidence is also important.

Interpretive core

It is clear that most of the crops in the country cannot be provided more than cursory attention from the modest research system. It is, therefore, all the more important to maintain a constant monitoring of what research advances are being made elsewhere in the world so that new opportunities can be exploited quickly. This requires a minimum core of experienced research specialists to be built up to be able to interpret new findings elsewhere in the light of PNG conditions.

Research Teams

However, some crops are critical for the well being of the country and deserve much more intensive attention than mere monitoring. The choice of these key crops and mode of production is a matter of long term national policy (and the team would certainly not presume to make those choices). But once the choices are made, there should be a deliberate concentration of research resources into focussed interdisciplinary teams with strong leadership to support those crops, rather than to have research resources spread thinly over a wide range of crops with leadership and organization on a disciplinary basis rather than on a crop or farming system basis. To have a chance of making a significant impact, a team must have a "critical mass" of interacting scientists: the actual number will vary with crops and circumstances, (but probably should not be less than six). Especially where smallholder farming systems are concerned, it is very important to have a professional socio-economic research input into the team, preferably from an economist, if only one place can be spared.

Under stringent conditions of limited funding for research staff, the development of minimally adequate teams to focus on a few key crops and their associated systems inevitably means that other less critically important crops must be denied much research support. Such hard decisions must be taken deliberately on the basis of a long range plan, if precious research resources are not to be dispersed ineffectively over a wide spectrum of crops and systems.

Illustrative Research Program Plan

In the absence of clearly defined crop research priorities, some assumptions have been made about possible priority choices as a basis for an illustrative exercise for recasting the existing research staff complement into a research program based on an interdisciplinary team approach. Clearly the pattern and numbers of staff allocated would change completely if different decisions were taken as priorities, but the planning approach should be similar.

It is assumed therefore, for the sake of the exercise, that a crop research policy would allocate resources to provide some research support for the important tree cash crops, and for the food crops that sustain the nutritional status of the people. Assumptions about which crops and how much support are implicit in the discussion. The illustrative recasting of the research program is done under the constraint of keeping within the current numbers of senior research staff at DPI. This is not to imply that this is desirable: it will be very evident that large and important areas of crop production will be left with very little research support when they really deserve more attention.

Tree Crops

There is much evidence that there is a solid base for the production of plantation cash crops based on sound interpretation of world knowledge and good oriented research backed by central disciplinary service and research laboratories. However, these crops, so essential to the national export earnings and small holder income, are currently backed by very slender research teams to protect the great investment already made and to provide some insurance against surprise attack from pests and diseases. The tree crops are relatively young, but the maintenance of soil fertility to meet plant nutrition requirements over the long run is important, and such investigations should be an integral part of a long term protection program.

Moreover, most of the industry is based on smallholder coffee production and there is not a great deal of understanding of the smallholder system of cultivation, which is rarely single crop and includes the cash crop as part of the total agricultural enterprise. It may well be not in the grower's interests to practice perfect plantation management, but currently this is all the extension officer can reliably advise: there is little researched evidence of the sensitivity of production to departures from perfection of management. More research effort, mainly by agronomists with an input from economists and perhaps other social scientists, is needed into understanding and improving the smallholder system, so that better information can be supplied for extension advice.

These elements of protection, long term fertility, and improvement of cash crop production in the small farmer system are of central research

importance for the well being of almost all of the tree crops, and can only be carried out in PNG. Knowledge and advances from elsewhere are not particularly relevant to these aspects, although useful clues and guidance for experiements could be gleaned from world literature and experience.

Thus a desirable minimum team for each cash crop should include:

Team Leader (coordinator and spokesman)
For maintenance of existing potential of plants

Plant Protection 1 Pathologist
1 Entomologist
1 Agronomist (weeds)

Long Term Fertility 1 Soil Scientist

For increase of potential from small holder system

Cropping System and adaptive research for understanding and improving the system: 2 Agronomists, 1 Economist, Anthropologist (part time) (plus strong junior support staff and travel facilities)

(A Breeder would be a very useful addition for collecting, selecting and generating material for better potential yield, and for incorporating disease and pest resistance if necessary, and a physiologist would be valuable if a program of improvement, rather than maintenance of plant potential, was contemplated.)

It is very important that the team be together at one station so as to encourage a strong interdisciplinary approach, and that there be a designated leader to draw the specialists together and focus their separate skills to practical interdisciplinary problems. If no serious pest or disease is ravaging the crop, and the protection research phase is one of monitoring, then the pathologist, entomologist, and soil scientist could be shared with another crop, if the other research center was nearby (e.g. coffee and tea, if both at Kuk; cocoa and coconut, if both at Keravat), but it must be recognized that any serious outbreak would need the full time attention of a specialist (and that in any case half a man cannot do as much as a whole man). If a very serious attack broke out, the station would serve as a ready base from which an increased team could operate on an emergency basis.

The cropping system and adaptive research would have to be carried out at several sites, which would impose a heavy travel schedule on the agronomists servicing the sites: at least two should be involved in operating and interpreting these complex trials. The economist and anthropologist, given adequate supporting junior staff, could almost certainly be shared with other crops and systems research.

This scenario looks towards a minimum number of scientific staff of 9 per tree crop at one research centre (and 11 with breeder and physiologist). If a research center covered two tree crops (as proposed coffee and tea; cocoa and coconuts), then the leader, pathologist, entomologist, soil scientist, economist and anthropologist could be shared, to give a total of 12 man years for a center for two tree crops. Oil palm and rubber seem destined to stand alone.

The total number of scientists indicated, 42 man years (or 54 with no sharing), is large compared with the current allocation in the country of 23 man years for the six tree crops, but perhaps not excessive as insurance and for prospects of improved performance in crops worth K276 million (US$414 million) in 1979. It is recognized that such an allocation is unlikely in the near future.

Industrial Support

The cocoa, coffee and oil palm industries currently contribute about half of the research manpower for those crops (with some additional contribution from the Economics and Statistics Section of PEM). The World Bank Report on Support Services recommends that the industries be encouraged to assume more responsibility for the resarch effort. The team firmly endorses this recommendation with the proviso that the DPI at least maintains a strong voice on the Research Advisory Committee (and Board) to ensure that adequate research effort is directed towards the smallholder situation. In all of the crops, more than half of the production is from smallholders, who will, therefore, through a cess system of payment, be contributing more than half of the support costs of research. The research activity should be directed to generate recommendations that are beneficial and applicable in small farmers' conditions as well as in well managed plantations.

At present the two part time research economists working on coffee and cocoa are contributed from the PEM Branch. It is desirable for that contribution to continue to be from the Economics and Statistics Section so as to provide a strong and secure disciplinary base from which to engage in the interdisciplinary research work in the field.

The DPI Agriculture Branch should also provide some of the other research staff, but it is suggested not more than two each for these three crops.

For the other tree crops -- coconut, rubber, and tea -- it is unlikely that it will be possible for the Agriculture Branch to mount even approximately adequate research teams, and nothing is forthcoming from the industry as yet. Some supplementary benefit may be obtained if the center for coconut was on the same station as cocoa, and tea with coffee, but it would appear improbable that more than two scientist could be allocated to each of these crops, putting them on a low intensity research basis, with the scientists being responsible for keeping up-to-date with advances in research elsewhere that might give new opportunity in PNG.

Thus a research establishment that would provide a minimal protection (insurance) cover, information on soil fertility trends and management, and active improvement of potential in smallholder farms for coffee, cocoa, and oil palm plus simple monitoring and maintenance for coconut, tea, and rubber, would be:

Coffee	2 scientists from Agriculture Branch DPI
	1 economist from PEM
	6 scientists from Coffee Industry Board

Cocoa	2 scientists from Agriculture Branch 1 economist from PEM 6 scientists from Cocoa Board
Oil Palm	2 scientists from Agriculture Branch 1 economist from PEM 6 scientists from Oil Palm Research Association
Coconut	2 scientists from Agriculture Branch
Rubber	2 scientists from Agriculture Branch
Tea	2 scientists from Agriculture Branch

This suggests a total of 12 full time scientists from Agriculture Research Branch and 3 economists from PEM Branch. A contribution of 18 scientists from the industries is contemplated, compared with about 8.5 man years at present.

These numbers are intended to be illustrative of what might be required for the total research system to carry out the assumed policy. Clearly the numbers required could change drastically if decisions were taken to adopt a more aggressive policy for improvement of these crops.

Food Crops

As in most tropical developing countries with an economy heavily based on agriculture, PNG has emphasized research on cash crops for export, while tending to neglect the food crops consumed locally. Rice, an increasingly important import, has commanded research attention intermittently for over 50 years, but the net conclusions are still negative: that at the prices prevailing, the likely return to small farmers for their labor is low compared to that from other crops. Research on other food crops, especially traditional root crops, is more recent and has been intensified after recognition of appreciable malnutrition in some areas of the country. The research program was reinforced after the declaration of a Food and Nutrition Policy for Papua New Guinea (February 1978)

Currently, the policy for increasing food production is not very clear, and it is difficult to formulate a research program with any definition. However, the Horticulture Section lays considerable stress on research on staple food crop production, and the sweet potato research program has more time allocated to it than any other food program (Table 1). Much of the Farming Systems research program is also devoted to sweet potato based systems. Furthermore, several rural development projects are also allocating research resources to understanding and improving sweet potato based farming systems.

There is considerable justification for this emphasis in addition to the improvement of nutrition for poorer families. Subsistence agriculture forms the largest sector of agriculture and is based largely on root crops and bananas, which at a national marketed value would compare with that of coffee exports. By developing a more efficient food crop production system, more land and especially labor would be available for increasing cash crop production. Meanwhile a higher return to effort and

reduced drudgery in producing staple food crops is intrinsically attractive. Finally, improvement of traditional staple food production would increase self reliance and would reduce dependence on imported food stuffs, the prices of which -- and the prices of commodities sold to buy them -- are beyond the control of PNG.

Major problems remain in the storage and marketing of traditional root crops on an extensive scale. Locally produced rice has difficulty in competing in price with cheap imported rice. Rice has had the benefit of thousands of man years of intensive research devoted to it; root crops, especially sweet potato, have had very little research indeed, and there is considerable room for improvement in production practices and post harvest handling.

On the assumption that a firm choice was made that top priority should go to boosting the productivity of traditional food crops, with special emphasis for instance in the Highlands on sweet potato based-farming system, and in the Lowlands on taro-based systems, then there is a large role for research to play in improving these crops and their associated production systems. For sweet potato there is little world technology available for direct introduction into production in PNG. The major international research centers working on sweet potato, IITA and AVRDC, do have improved, high yielding cultivars but they are unlikely to embody the quality characteristics desired in PNG. Improved yield with acceptable qualities will have to be incorporated by breeding programs related to the appropriate production systems within the country.

The current research effort on sweet potato, is scattered, mostly involving single disciplines on relatively early-phase variety trials, with some studies on fertilizer response, spacing, time of planting, and resistance to weevil and some important studies on time of planting in relation to reducing the seasonal shortage of food known as "taim hangri". But to make rapid strides towards improved material and practice that is clearly much better than that used by better farmers at present, a much more intensive interdisciplinary team approach must be adopted with concentration of resources at one center under unified national leadership.

Aiyura, in the Highlands, would make a suitable national center for sweet potato research, with a subcenter at Bubia for the Lowlands and preliminary testing sites at Kuk and Tambul. The crop improvement program must be carried out in conditions equivalent to realistic farming systems. An appropriate minimal team at Aiyura as a Highlands Food Research Center would be:

Officer-in-Charge*
Team Leader* improvement of sweet potato-based farmingsystems

Farming Systems Improvement	Crop Improvement (Sweet potato breeding)
1 Horticulturist	1 Breeder
1 Economist	1 Entomologist
1 Soil Scientist	1 Pathologist
	1 Physiologist

* Also expected to be active research scientist in any of the relevant disciplines in the team, but each supported by a junior scientist in team position.

1 Horticulturist (pulses, vegetables, potato, spices)	plus sub center in Lowlands 1 Breeder 1 Horticulturist and testing center at Kuk 1 Horticulturist

It would be essential that all of the main team be based at one center to permit frequent consultation and interaction. The systems group would help define realistically appropriate selection criteria for the breeders, and devise new systems for exploiting the potential of new varieties created. Such interaction is essential if new varieties are to effect the economy significantly. Too frequently plant breeding research in the tropics has had little effect on subsistence and small farmer production because the varieties were not developed to perform well in farmers' systems.

It should be stressed that for traditional food crops only material and technology with very clear advantages over local practice have much chance of being introduced successfully by extension staff to experienced farmers.

Lowlands Food Crop Research Center:

Bubia is suggested as the most suitable center for food crop research in the lowlands. Sweet potato is not the dominant food crop in the lowland, but it is important enough to merit a sub-center as indicated above. The major thrust should be on another lowlands crop within the main farming systems. It is assumed that the choice has fallen on taro (although of course banana is the second most important food crop in terms of production). Taro has been shown to flower freely at the University of Technology farm at Lae, so a breeding program should not be difficult. The main problems with taro are diseases and pests, and resistance to the major pathogens would be the main aim of the program. Advantage should be taken of advances that might be achieved elsewhere with mutation breeding and other sophisticated techniques.

An appropriate team for the Lowlands Food Crop research at Bubia might therefore be

Officer in Charge*
Team leader* for improvement of taro based farming systems

Farming System Improvement	Crop Improvement (Taro breeding)
1 Horticulturist	1 Breeder, taro
1 Economist	1 Pathologist
1 Soil Scientist	1 Physiologist

* Expected to be active research scientists in any of the relevant disciplines in the team.

1 Horticulturist, (feed grains,
pulses, bananas)

(Sweet Potato Sub-center
(1 Breeder)
(1 Horticulturist)
(sweet potato and cassava)

Only one horticulturist to provide research support for such important and potentially important lowland crops as bananas, feed grains and pulses is indeed not really adequate, but the overall constraint on numbers of staff is severe and only one major thrust is possible. There would be some (small) extra support from the entomologist, pathologist, and economist; perhaps the sweet potato horticulturist could spare some time for another crop such as cassava. (In the future, if more mechanized farming systems develop, it may be important to add at least one agricultural engineer to the research team at Bubia).

The Research Station, Laloki would serve as an important substation of the Lowlands Food Crops Research Station. It would continue to concentrate on the special problem of food supply to the Port Moresby urban area, with additional responsibilities towards the introduction of breeding material through quarantine. A possible staffing pattern might be:

Officer in Charge* Leader*	improved farming systems for urban food supply
1 Horticulturist	vegetables
1 Horticulturist	bananas, other food crops, ornamentals
1 Pathologist	(shared with HQ - identification and Quarantine)
1 Entomologist	(shared with HQ - identification and Quarantine)
Economist (part time)	based in Economics and Statistics Section).

The Research Station at Keravat would also serve as a testing station for the Lowlands Food Crop Research program with

1 Horticulturist	(spices, food crops)

with perhaps major responsibility for spices research and evaluation, and for supervising testing of food crop components of local farming systems. (He would require strong junior support staff).

Other Research Stations

The pyrethrum research program should be, at least, continued at the high altitude station at Tambul with

1 Horticulturist	(pyrethrum)

Rice is so important a crop in the economy of the country that, even if the major thrust was to be made on traditional crops, it would still be essential to allocate at least

2 Agronomists

to continue evaluating and improving new rice materials and to monitor progress of the 50 ha Pilot Mechanized Rice Project, presumably located in due course at the project site.

Post harvest handling of many crops, and especially sweet potato and taro, is critically important for their potential as commercial food crops over moderate distances. The Research Laboratory recently established by DPI in the University of Technology in close association with the Department of Chemical Technology would appear to be the most suitable center for combined work in post harvest handling of all crops. Because of its importance the staff strength should be increased (from at present three scientists) to

4 Research Scientists with strong supporting staff.

Headquarters, Port Moresby

Assuming the unification of the Crop Research group into a Research Division with its own Director, a minimal senior staff for the Research Division at headquarters, Port Moresby would be:

1 Director
1 Deputy Director
2 Scientists in programming unit
1 Executive Officer
3 Biometricians (for improved service)
7 Chemists in Agricultural Chemistry analytical laboratories
7 Scientists in Land Use Section

The entomologist and pathologist linked with Laloki would provide central identification services for pests and diseases, but it is proposed that the other crop protection staff should be located with research teams for more effective interaction.

The Land Use Section provides a very valuable and necessary service for defining better the land resource available in Papua New Guinea. However, in looking to the future trend in land capability, it is suggested that two positions be allocated as soil scientists at the main food crops research stations for the Highlands and Lowlands for studies of changes in fertility with management. (There is also a need for a research input into the farming systems programs for a soil conservation engineer, which could most appropriately be made from the Land Use research group.)

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* Expected to be active in any of the relevant disciplines.

The Agricultural Chemistry analytical laboratories deserve special mention. Much of the present farming practices among overall farmers are concerned with maintenance of soil fertility; this is also an abiding long-term concern of any farming operation and a vital objective of responsible agricultural research studies. A good soil analytical service is essential for studies of changes in soil fertility with management. At present, the reasonably well equipped DPI analytical laboratories cannot offer to carry out soil analysis, as its existing staff capacity is fully committed to other routine services. Soil analysis can only be obtained, at high cost, by sending soil samples to an agency in New Zealand or from the National Analysis Laboratory at the University of Technology. The latter is not geared, at present, for a large throughput of soil samples, and almost all soil samples are going to New Zealand. For such an important analytical service to agricultural research and development, it would seem salutary to improve the internal capacity for service either at DPI headquarters or at the University of Technology.

The major difficulty would appear to be a shortage of staff at the technical assistant level, and this shortcoming should be rectified as soon as possible. The costly alternative of equipping each research team with capacity to carry out routine soil analyses is not recommended.

Staff distribution

In this assumed scenario, the broad distribution of senior staff from the Crop Research Divisions would be (with an additional 6 Economists from P.E.M. and 18 scientists from the cocoa, coffee, and oil palm industries):

Tree crop research	12
Food crop research (plus pyrethrum and ornamentals	35
Headquarters and services	22
	69

Other research programs that are being carried out in projects consist essentially of survey and adaptive research and should be closely linked with the main station programs.

Making due allowance for time spent on administrative and extension activity, a time distribution of senior staff time by crop research or service might be as in Table 2 (which may be compared with Tables 1 and 1a).

It can be seen that reorganization does not greatly change the existing total allocation of manpower from DPI to the cash crops, but it would imply a substantial shift in emphasis.

The move to interdisciplinary teams with leadership focussed on the main traditional highland and lowland food crops would mean that some other crops and services would have very little support under the constraint of no expansion of total staff. For instance, very little research work could be done on fruit, nuts, and spices, and the positions of the group of "field horticulturists" have been absorbed into the research program.

Also, very little research could be done on pulses which, in light of a growing interest on pulses in the Highlands and its importance for improved nutrition, really deserves more research attention. If a different decision had been taken to boost pulse production, or if extra positions were available, it would be desirable to have a grain legume research team of:

2 Breeders	(high and low altitudes)
2 Horticulturists	(high and low altitudes)
1 Pathologist	
1 Entomologist	
1 Economist	

If an alternative decision was that highest priority for food crop research is to replace imports, then the major thrust of research would have to be again on rice production, despite past experiences. Substantial teams would have to be mounted to work on both irrigated and rainfed rice systems, with a minimum of 13 senior research staff for a serious effort:

a. Irrigated Rice:	1 Leader for Rice Research Team
	1 Breeder
	2 Agronomists
	1 Pathologist
	1 Entomologist
	1 Agricultural Engineer
	1 Economist
b. Rainfed Rice:	1 Breeder
	2 Agronomists
	1 Soil Scientist

In such circumstances, maximum advantage should be taken of the great progress made at the International Rice Research Institute over the last five years on improved technology and research methodology for rainfed rice production.

Table 2. Hypothetical Allocation of Agricultural Research Manpower in DPI Crop Research Division in Man-Years per Year. Based on Assumed Priorities for Protecting the Potential of Cash Crops and Boosting Production of Traditional Food Crops.

	Revised Crop Research Division	Industry Boards	Other Research Groups	Total
Cocoa	1.5	4.5	0.7	6.7
Coffee	1.5	4.5	0.7	6.7
Coconut	1.3			1.3
Oil palm	1.5	4.5	2.7	8.4
Tea	1.3			1.3
Rubber	1.3		0.5	1.8
Pyrethrum	0.6			0.6
Subtotal	9.0	13.5	4.6	27.1
Sweet potato	5.4		2.0	7.4
Taro (aroids) and yams	3.8		2.0	5.8
Vegetables	2.3		0.25	2.55
Rice	1.6			1.6
Pulses	1.0		0.25	1.25
Bananas/cassava	2.1			2.1
Feed	0.4			0.4
Fruit-nuts, spices	0.8			0.8
Sugar	0		2.0	2.0
Flowers	0.2			0.2
Farming systems	5.6		4.83	10.43
Subtotal	23.2		11.33	34.53
Storage/ Processing	2.7			2.7
Pathology Services	0.3		0.25	0.55
Entomology Services	0.3			0.3
Soil and Plant analysis	4.0			4.0
Land use Services	6.5		3.0	9.5
Biometrics	2.6			2.6
Subtotal	16.4		3.25	19.65
Extension/liaison	4.1	2.0		6.1
Administration	16.3	2.5		18.8
Subtotal	20.4	4.5		24.9
TOTAL	69.0	18.0	19.18	106.18

ANNEX 8

Manpower and Training

The strength, responsiveness, and productivity of a national agricultural research system, in a developing country like Papua New Guine (PNG) -- in relation to national goals and objectives -- depend not only on the choice, organization, and management of appropriate research programs, but also on the adequacy and stability of trained manpower for the execution of the programs. In recognition of the importance of manpower and training components in agricultural research, the terms of reference of the ISNAR review of PNG's agricultural research system provide for an assessment of "the need for training and professional development programs for research scientists, research administrators, farm managers and supporting staff". Such an assessment is expected to be made in the context of the human and other resources required for an agricultural research service appropriate to the national development plans and the overall agricultural development of PNG.

The government of PNG and, in particular, the Department of Primary Industry (DPI) and the National Planning Office (NPO) have been aware of manpower and training issues in the agricultural development plans of the country for some time. In September 1979, the National Planning Committee requested the NPO to prepare a comprehensive manpower plan and a planning framework which would enable trends in the labor market and in the country's manpower needs to be monitored on a regular basis. The National Manpower Assessment 1979-1990 (Colclough Report) resulting from this decision presented a description and analysis of the employment position in the formal sector of PNG's economy, projections of requirements for skilled workers in the 1980s, and analyses with implications for policies in education, training, and localization.

The World Bank Report (1981), in discussing performance and problems in the agricultural sector, drew attention to the manpower, planning and budgeting problems. These problems result in part from the loss, of experienced staff following independence and decentralization and the difficulties facing inexperienced public servants to efficiently carry out their reponsibilities. The report suggested a manpower and training review to assess the needs for trained personnel, the measures to fill these needs, and the implications of doing so. Such a review would require: an assessment of existing manpower; estimates of effective manpower demand; an assessment of the country's present capacity to supply manpower; and detailed, quantified assessment of measures needed to close the gap between projected effective demand and expected output.

The DPI, in recognition of the importance of effective manpower and training policies in development planning, and in accepting the recommendation of the World Bank Report, appointed the consulting firm of McKillop, Williamson & Associates Pty Ltd, of Sydney, Australia, with Mr. R.F. McKillop as team leader, to undertake the review. The consultants were required to investigate and report on the interrelated areas of manpower requirements, financial and statistical information, productivity of existing manpower, and pre-service and in-service training. The requirements of the review largely conform to the

specifications in the four components of the manpower and training review envisaged in the World Bank Report. The study was undertaken in PNG during the period September 14 to December 20, 1981. The provisional report of the consultants made available (in draft form) to the ISNAR review team proved extremely useful to the team in the tackling of its Terms of Reference in relation to PNG's agricultural research system.

Although the McKillop report anticipated the further examination of some of the problems it identified by the ISNAR review of agricultural research, the comments and observations on the major conclusions and recommendations of that report are made only in relation to the ISNAR team's Terms of Reference and within the limits of the scope of its visit and study.

Several of the issues raised in the McKillop report will require a balanced examination of the present situation, the capacity and commitment of PNG for agricultural research and development, and the potential support from internal and external sources for agricultural growth and development in the years ahead. Furthermore, McKillop examined the training and manpower development in the Colleges of Agriculture; these colleges, and the agricultural industry training centres (AITCs) expected to replace one or more of them, will provide intermediate manpower and supporting staff for agricultural research. The major scientific and technical manpower for leadership in and execution of agricultural research programs will have to come from the higher institutions (universities and equivalent institutions) locally in PNG and overseas. Manpower and training at these latter levels have received attention in the current study.

Present Manpower in relation to crop research activities

Five major features characterize the present manpower situation in relation to research activities. These are: the inadequacy of the number of research staff in relation to the coverage and spread of crop research activities (but there is an early limit to the number of staff the country is likely to afford); the inadequacy of research-oriented training among the research staff that is available (most serious among national staff); the shortage of suitably trained research support staff to enhance the performance of the existing research staff; the rapid turnover among the few national graduate staff; and the strictly discipline orientation within departments of both the expatriate and national research staff.

An examination of the current research manpower indicates that of the total 69 research staff, 41 are expatriates, and of the 28 national staff none has research-oriented training beyond the first degree level. Table 1 gives a summary of the qualifications of current expatriate and national staff. Furthermore, many of the expatriates are on short-term contracts, and a fair proportion have had only very limited experience in PNG agriculture. This high proportion of expatriates and the rapid rate of turnover within this group (as well as among the national research staff) indicate that valuable experience and continuity can hardly be maintained within the research service, a feature that is deleterious to the stability and possible impact of the problem-oriented research programs.

Table 1. Summary of the Qualifications of the Crops Research Manpower in DPI (December 1981)

Category of Staff	Ph.D./ D.Sc.	M.Sc. or equivalent	B.Sc./ B.Agric.	Diploma	
National staff	-	-	27	1	
Expatriate staff	8	11	18	4	
TOTAL	8	11	45	5	69

The suggested reorganization of the research programs envisages a better utilization of the existing research staff on a limited number of high priority research programs. A stable program implies a modest growth of research staff with more intensive training and/or retraining of staff for the next 10 years and beyond. A growth of about 3.7% per year over the next 10 years is proposed to ensure that program stability and research staff training can be maintained. Provisions made for the replacement of expatriate staff that are likely to leave the service during the period.

Manpower for Agricultural Research

Considerations for manpower development for agricultural research in PNG must address the question of agricultural education as an integrated human resource development in the whole country. Agricultural research manpower (research scientists, technicians, station managers, and various levels of research support staff) is a product of the total educational system. The foundations are laid in the high schools, where the teaching of science and agriculture are directly relevant to future careers in agricultural research. There is the need for the basic strengthening of the pre-college and pre-university training in the sciences and agriculture. It has been suggested that, apart from the provision of increasing numbers of qualified science teachers, equipment, and materials for science teaching, the teaching of agricultural science in the high schools should be strengthened; The possibility of introducing a graded national examination in this subject explored.

Research Assistants

The second level in the manpower development for agricultural research are the colleges of agriculture, the proposed AITCS, and the technician training programs in universities and technical colleges. McKillop has made comprehensive recommendations for the reform and strengthening of these levels of training. The team's investigations and discussions largely supported his conclusions and recommendations.

The reformed system proposed should be able to provide qualified research support personnel as well as managers and innovators required for the country's agricultural industry . For research specifically, provision should be made for the training (formal and in-service) of experiment station managers and the inclusion of additional specialized training areas such as experimental techniques, extension education, and soil/water conservation in post-certificate courses.

The DPI has four agricultural colleges, one forestry and one fisheries college. The colleges started with three-year diploma programs in 1965, but following the Wilson Report, these were discontinued in 1979 and replaced by the two-year certificate program. The agricultural colleges offer general training in agriculture, and most of their products serve as RDTs in central and provincial DPI. At the time of the visit, the Vudal Agricultural College had 85 students in the first year, 55 in the second and 20 in the diploma program (one additional year after the certificate and some years' field experience). Mt. Hagen had an intake of about 90 students per year. The agricultural colleges produce a total of about 200 certificate graduates per year. About 40 to 60% of these go into the DPI, 20% into the private sector, and in recent times there have been increasing difficulties in placing the remaining 20 to 40% in the public or private sector. This appears to be an artificial glut since decentralization and greater intensive extension activities in the provinces should in fact have generated increasing demands for these graduates. The artificially set ceilings of staff numbers imposed at the central and provincial DPI seem to prevent the full utilization of these trained agriculturists in the research and extension services. There is the need to address the question of the full utilization of these graduates, especially in the context of the reforms proposed in the McKillop report.

Reference has been made in Chapter 3 of this Report to the observed deficiencies in the curricula for these colleges and the tendency to cover too many courses and subject areas (up to 76 courses) superficially during a two-year certificate training program. The recommendations of the McKillop report and other reforms should sharpen the focus of these training programs and ensure that graduates have sound basic training in scientific agriculture and in-depth technical knowledge in special subject areas. These training programs will in most cases have to be supplemented by on-the-job training and exposure, and scientific officers should be encouraged to undertake this consciously and consistently as an activity that will benefit and extend their work as well as create competence and experience for the research service.
Although a substantial part of the training of research support staff such as laboratory technicians and technologists will be done in service, the facilities of the universities and the technical colleges should be recognized and utilized for formal aspects of the training. In particular, departments such as the Department of Chemical Technology of the UOT at Lae, with programs in analytical chemistry, food science and technology and minerals technology will have an important role to play in such programs. It is noted that UOT has a vigorous and comprehensive training and staff development program covering postgraduate studies overseas, training and study tours, in-country in-service training, cadetships and sponsorships, technicians training, part-time studies, secretarial training and work/study attachments. There will be great

value in the expansion of the relevant programs to cater for the training and supply of qualified research support staff for the agricultural service.

Research Scientists.

The most important area of shortage of manpower in agricultural research is the area of qualified scientific officers. The third tier of agricultural education -- the University system -- is expected to play a major, though not exclusive, role in the production of this level of manpower. Historically, agricultural training in a university culminating in a first degree, honours degree and, in some cases, postgraduate diploma had been considered adequate training for research. But a detailed examination of such programs and the performance of officers who have gone through them indicate that at best they provide only a minor foundation for research and do not prepare personnel adequately in areas such as definition of research programs, research methodology, and analytical research. It has been necessary to back up the first degree with a relatively long period of supervision in the field by a senior officer experienced in research methodology and in the nature of local conditions. It is very difficult to provide that experienced supervision today, and even if skilled research personnel are available, they do not always prove to be good and willing teachers. Moreover, short term contract expatriate research officers understandily have to be concerned with their scientific reputations to secure future jobs in their developed countries: their criteria for appropriate research tend therefore to be those of the developed country. Rarely are these the appropriate criteria for most effective research in the developing country -- therefore some can prove to be misleading, teaching an inappropriate research philosophy.

Today it is usually required that personnel for agricultural research be formally trained and prepared in the basic and applied scientific disciplines also in research and agricultural experimentation methodology. This almost invariably means formal and rapid training at least to the Master's and, in some cases, to the Ph.D level by university professional staff skilled in the business of education as well as research. Research scientists so trained will have the capacity to link in with, adapt, and utilize knowledge from the worldwide scientific community and be in a position to initiate and execute relevant research programs with minimum supervision.

The University of Papua New Guinea is the main in-country institution that can be responsible for the training of graduate manpower for the scientific officer level, for the provincial extension services, and the agricultural industry in general. The university offers a four-year Bachelor of Agriculture degree. Although the Faculty of Agriculture was established in 1975, it has remained relatively undeveloped with only one academic department and 10 academic staff, including only one national with a Master's degree. The teaching program is undesirably split between Port Moresby and Lae. The first three years of the degree program, including one science foundation year, is undertaken in Port Moresby because of facilities for supplementary teaching from the other seven other faculties (notably science and social sciences). The final year is at the University of Technology in Lae, where better facilities

exist for training in mechanized agriculture and animal husbandry, including exposure to agricultural problems and practice in lowlands, highlands and island agriculture which are all within easy access.

The Faculty has produced 115 B.Agric. graduates, 9 Honours (one additional year after B.Agric. and after some field experience) and 7 Masters graduates since its inception: 108 of these (about 82%) were initially employed in central and provincial DPIs. There is some dissatisfaction in DPI about the technical knowledge, competence and performance of UPNG graduates in agriculture. This may arise from several conditions: the fact that the curriculum as presented and taught at present appears to be a compromise curriculum which depends on the teaching of more than 50% of the courses by staff outside the Faculty; the fact that the teaching program is split between Port Moresby and Lae; and the fact that perhaps far more than should be expected from first degree holders is being expected from these graduates, especially in research and in extension and communication. There is also a debate as to whether the Faculty should produce agricultural scientists or agricultural technologists. The Faculty and the DPI have set up a joint committee to look into this problem. This seems to be a sterile debate, since research scientists developing and applying technologies must be well grounded in scientific agriculture. It is, however, important to point out that if the Faculty is to meet the increasing demands of the centralized agricultural research system and the decentralized agricultural extension services, in quantity and quality, priority should be accorded to the strengthening of the Faculty teaching and research, the provision of unified and adequate facilities for both activities, and the development of postgraduate training as soon as possible.

It is recommended that major technical assistance be sought to strengthen the PNG University system in the integration and reform of its degree program in agriculture. The program of strengthening should emphasize the provision of additional qualified academic staff; indigenous staff development; curriculum review and reform to provide for stronger scientific and technological training in agriculture during the four-year degree program (including adequate and relevant practical training and orientation); adequate teaching and research farm facilities and exposure to a representative range of practical PNG agriculture; and the modification of the first degree to be an adequate basis for the future development of Master's programs in agriculture. The University system should be able to provide the country's major degree manpower requirements by approaching its projected quota of 46 intake per year and possible production of about 40 graduates per year (assuming a 13% loss) during the next 10 years.

It is estimated that about 400 graduates in agriculture will be required in the 10 years between now and 1992. These graduates will be expected to go into agricultural research services, agricultural colleges, provincial DPIs, the private sector, and management and policy positions, including the development banks. The breakdown of these requirements is shown in Table 2. This estimate is much higher than the projected figure of 145 graduates in agriculture for the period 1979-1989 (Coclough Report) which appears to be a serious underestimate of the requirements for a progressive research and development program in agriculture.

Table 2. Estimates of Requirements for Agricultural Graduates in the Agricultural Sector in PNG for the next 10 Years.

1.	DPI Research and Services (including Livestock, Forestry and Fisheries)		120
2.	University Teaching in Agriculture (possible creation of Departments of Plant Science, Annual Science and Agricultural Economics and Extension by 1990)		30
3.	Agricultural Colleges (greater use of graduate teachers)	(2 colleges)	20
4.	Provincial Extension Officers (19 provinces - 6 per province)		115
5.	Private Sector (Research and Development - Cocoa, Oil Palm, Coffee, Tea, Coconut)		45
6.	Graduate Teachers (National and other High Schools)		20
7.	Management and Policy positions (including the Development Banks)		30
8.	Miscellaneous (Public and Private Sectors)		20
	TOTAL		400

An indicative plan for agricultural research manpower would suggest the requirements for the agricultural research service will reach a figure of 150 by the year 2002. The recommendations for the strengthening of intermediate level training in colleges, agricultural industry training centers, and of technicians in universities and technical colleges should meet the requirements for research support staff during this period.

With the recognition of at least the Master's degree (or equivalent) as a basic requirement for a career in agricultural research, there will be the need to train increasing numbers of graduates to the Master's and Ph.D. levels abroad during the next five years, while developing and consolidating the postgraduate training facilities in the country. This has been taken into consideration in preparing a draft Manpower Development Plan for the PNG agricultural research service.

Manpower Plan. (A strategy for training and indigenization of agricultural research manpower)

In order to achieve the objective of a strong stable, responsive and productive research system, a strategy for training and indigenization of the research service should be developed for the next 10 years and on an indicative basis to the year 2002. This will be in the form of a National Agricultural Research Manpower Development Plan and should envisage yearly allocations of training positions and fellowships that would enable the present research staff and the additional staff to be recruited to be systematically trained progressively during the next 15 years. It is recommended that emphasis should initially be given to the training of the present national staff to at least the Master's level and some to the Ph.D. level. In addition, provision should be made for a net growth of about 3.7% in research staff positions (equivalent to three staff positions) per year and for the training of these staff. The Manpower Development Plan phased over a 15-year period is illustrated in Figure 1, which shows that staff research positions would increase modestly and progressively from 69 in 1982 to about 100 in 1992. An indicative increase to about 150 is suggested by AD 2002, depending on research program expansion and development, the further diversification of the agricultural economy, and the concentration of expertise on specific problems of increased productivity. The plan will require a total of 220 fellowship person-years (based on estimates of 2.5 and 3 years for Master's and Ph.D. programs respectively) and can be phased to provide for 6, 13, 20, 21 and 23 fellowship person years in the first, second, third, fourth, and fifth years of the training program, with a peak in 1989 and 1990 when 26 fellowship person years (16 Master's and 10 Ph.D.) will be required.

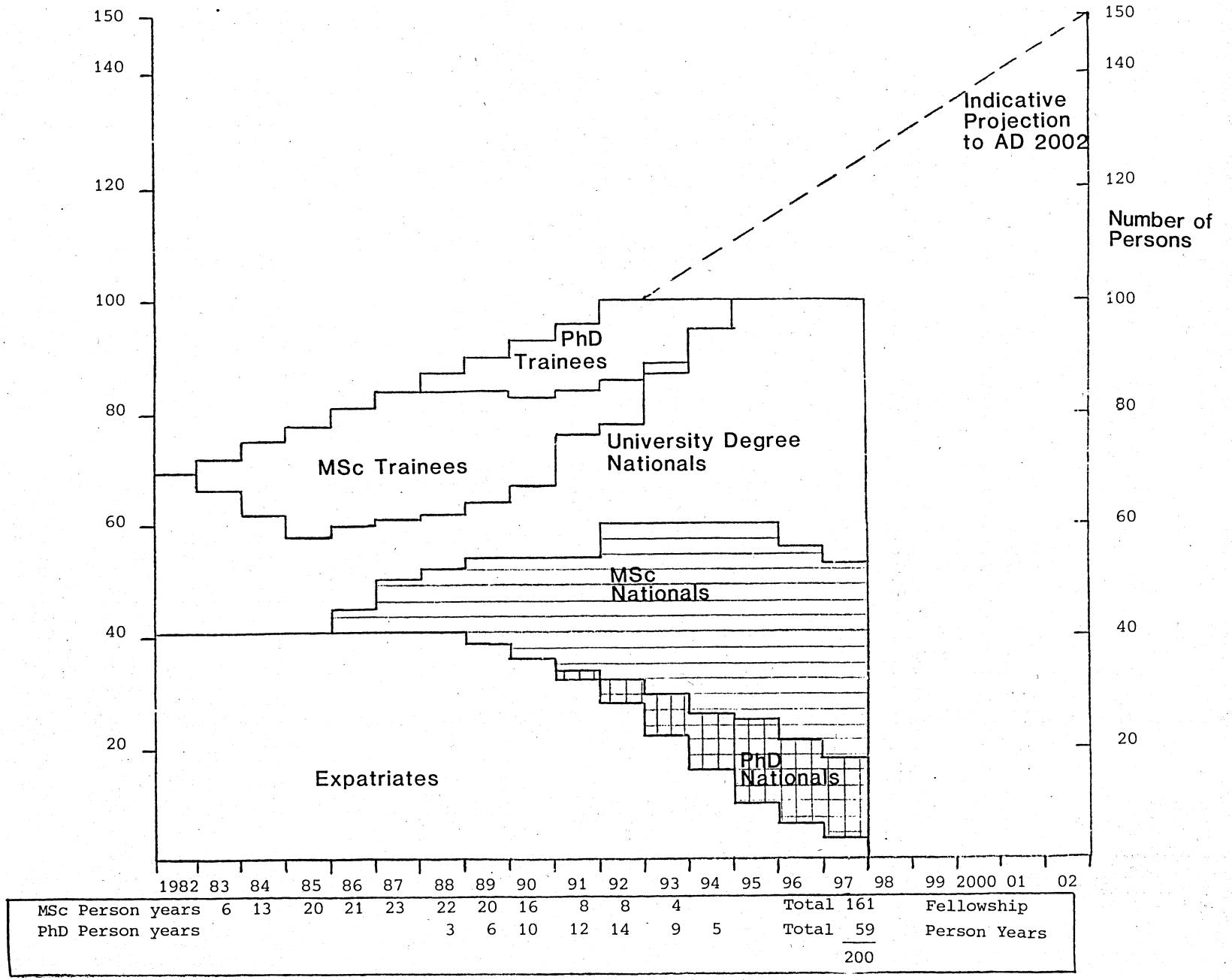
The plan will train a total of 64 national staff, 28 (44%) of whom will be from the present national staff in DPI. Under these conditions, agricultural research activities could be effectively undertaken and directed by national staff, which, by 1995, would include 50 with advanced research-oriented training (15 with Ph.D. and 35 with Master's). A concommitant requirement for this development plan, the maintenance of continuity and stability in the research programs, and the retention of valuable experience during the next 6 to 8 years is the retention of the present level of expatriate staff at least until 1988. They could then be replaced progressively by trained national staff, as indicated in Figure 1 from 1989.

There will be the need to identify a variety of institutions and places where some of the present national research staff could undertake postgraduate training and strengthen their basic training simultaneously by auditing relevant courses. Most of the training will have to be undertaken in appropriate university institutions outside the country until such a time that the Faculty of Agriculture can provide the staff and resources to mount a range of postgraduate programs locally.

A Manpower Development Plan of this nature would require planning, management, and monitoring. It is suggested that this should be handled by an officer designated as a Training Officer in the Directorate of Research. He would be expected, in consultation with the Director, Deputy-Director, and the research program leaders, to identify, place, and supervise suitable candidates in the training programs relevant to the needs of the research service. It is recommended that external funding be sought through technical assistance for a 10-year Staff Development Project (or two 5-year plans) through NPEP.

A second major issue which is likely to affect the manpower development plan, the build-up of staff positions, and the releasing for training of existing staff initially and new staff later in the program, is the establishment ceiling for DPI. It is recommended that policy provisions be made for the creation of supernumerary or training positions which would initially be funded through the fellowships program and progressively absorbed into the establishment on a planned basis (See Figure 1.). It should be pointed out that many other developing countries, which have had to develop indigenous research manpower to establish and develop viable and responsive agricultural research systems and to progressively replace expatriate research staff, have almost invariably had to create supernumerary positions during this phase. PNG is in this phase of development at present, and it is considered important that it should give high priority to this approach in order to ensure the stability and continuing productivity of the research service.

Figure 1. Plan for developing research scientist manpower, Crops Research, Department of Primary Industry.



ANNEX 9

Agricultural Economics in the PNG Agricultural Research System

Present Situation

The existing and prospective situation of agricultural economics (broadly defined) in the Department of Primary Industry (DPI) epitomizes many of the more general difficulties faced by DPI. Three more or less related factors have contributed to the present inadequate position, namely:

* dispersal of resources, especially of area economists to the provinces, but also to other branches, such as livestock;

* premature localization, especially in terms of numbers of appropriately trained and experienced national staff;

* staff numbers squeezed by ceilings, especially reducing the force of effective experienced research personnel.

Difficulties have been compounded by delayed attention, especially through shortage of suitable national staff, to appropriate local training and counterpart arrangements, perhaps reflecting an unanticipatedly rapid exodus of experienced expatriate staff since about 1977. In the interim, some of the functions logically best executed in the Planning, Economics and Marketing Branch (PEM) have been taken over by the National Planning Office (NPO). However, with the progressive departure from the NPO of the people best qualified to substitute in these functions, it is becoming more urgent that DPI act to replace these key experienced positions in economics and the related areas of planning, marketing, and statistics.

Solutions to these difficulties will not come easily and may be politically awkward. The Government may have to recognize that it will take more time than implicitly has been allowed to enable transfer of professional skills and responsibilities to national staff. Worse still, for economists in particular, is the competitive national and international market for these professionals; this makes for added challenge in attracting people with advanced training and experience to DPI. The present classification (as Clerks rather than as Scientific Officers or Economists) and structure of levels do not make the DPI a very attractive employer -- witness the lack of interest by B. Econ. graduates from UPNG, and by experienced expatriate graduates, for the few positions which have come up recently.

There has been a tendency for responsibilities of the PEM economists to become excessively regional in orientation, whereas a sectoral orientation would seem more appropriate. Particularly among the area economists, there has also been an absence of coordinated direction and professional leadership from headquarters senior staff. This is especially problematic when the staff concerned are rather inexperienced, and has been recognized by the branch as a whole in the past few Annual Branch Conferences and is well documented in Heydon (1980 a,b). Various suggested alleviations such as new communication channels like a Branch

Newsletter have not been implemented, apparently because of staff shortages and associated work pressures.

The "memory" for economics work in the past relied, as it has for other disciplinary work in DPI, greatly on informal contact between research and extension staff, combined with documentation 'on file' which now is often effectively lost. With recent staff loss and turnover, much of the previously known and shared information is apparently gone forever. For example, there seems no ready compendium of basic farm management data on crop yields and inputs, assembled in standard-form gross-margin budgets (on both land- and labor-unit bases) that lend themselves to ready updating with contemporary and prospective prices. A newly graduated extension-oriented economist must presumably rediscover such information as best he can across the challenging gaps between the disciplines and personalities involved. Such a compendium should be a key element of the kitbag of provincial planners and extension staff generally, but it will take time and effort to develop and maintain.

Apart from such planning data, the descriptive statistical base for the agricultural sector is remarkably thin and dated. It must be admitted that the communications difficulties and costs are rather daunting but the importance of a strong data base, that goes beyond mere counts of export crop trees and levels of production etc. to nutritional and economic aspects of household and subclan welfare over time, should be recognized as a necessary early step towards more rational policy implementation, be it by national, provincial or local governments.

Present staffing levels are low by any standards. It is recognized that the Public Service Commission (PSC) and NPO regard "establishment" figures as purely historical accidents. As of January 1, 1983, all presently "approved" positions (approximately those filled) will become the new "establishment." Accordingly, perhaps not too much should be made of comparisons between present and establishment positions, although it does facilitate a contrast with a situation (in 1977) that was regarded as desirable and did work well. The following table summarizes the position for areas most relevanct to agricultural economics research.

Table 1. Professional Staffing (excluding clerical and typing support and study leave).

	Economics		Statistics		Planning	
Classification (Approximate equivalents)	E	P	E	P	E	P
L1						
CC10, SO5	1	(1)			1	(1)
CC9, SO4	9*	4*	1	1	1	1
CC7, SO3	7	5	4	3	3	2
CC5, SO2	4	2	1	1	4	0
CC4, Gr5			2	(2)	2	1
CC2, Gr 3,4			2	0	2	1
Total	21	12	10	7	13	6

E is historical establishment; P is number in post, February 1982
* Two NPEP non-establishment appointments are included
( ) indicates number in acting positions

Of 44 professional (nominal) positions, just over half are presently occupied. Further, at least three additional resignations (of expatriate staff) are in hand, but approval has so far been given for refilling only one of these (the Chief Agricultural Economist, CAE).

Good research management is essential for high levels of achievement, relevance, and efficiency. A better management will require decisive, experienced, and skilled people in positions of authority at Headquarters and on key stations. More people per se are not required -- but better, more productive, more priority-oriented people. Such people may need safer tenure to operate effectively and enthusiastically.

Counterpart training is crucial, but it should not proceed too rapidly. The local ultimate managers need more experience, both in research practice and in the diverse regions. It will take time, especially if performance is not to suffer in the transition.

Shifting further to project (and program) work through NPEP (outside normal headquarters core work and ad hoc work) seems desirable if enough skilled people can be recruited to identify researchable problems and draft viable projects. A multidisciplinary, systems view seems essential if projects are to be relevant to the complex needs of the rural population. Involving regional and headquarters economists in such work should contribute relevance and provide stimulus, purpose, and motivation for these staff.

The lack of professional guidance of rather inexperienced people placed in the field, often in a remote part of the country, is unproductive and wasteful. The problems are being exacerbated by increasingly restricted travel funds.

Headquarters: Structural Considerations

The importance of linkages between policy (especially economic policy on price interventions) and markets in the interplay between agricultural research and the sequence of investment, development, and growth is not ideally reflected in the present DPI research management and implementation. Examples of a "cheap rice" policy resulting in poor rice development or of a high beef/feedgrain price ratio discouraging commercial grain development epitomize the need for strong linkages.

Research and development managers should thus have the benefit of high quality economic advice, and such advice should identify incompatabilities or inconsistencies between research and development goals. Operationally, a well trained and developmentally experienced economist could provide this advice. He could perhaps be designated Chief Policy Economist and located within the Economics Section or the new Policy Section (but at a level at least equivalent to the Chief Agricultural Economist). He should have direct access to the Secretary and the Director of Research and the Chief Planner, as well as representation on the Policy Group and its working parties. Incidentally, working parties may provide the most effective means of

pooling experience and diverse perspectives on potential research projects, and could assemble the materials required for NPEP draft proposals. They have already been used effectively.

With the advent of a Chief Policy Economist, the Chief Agricultural Economist (CAE) could be "protected" from the "fire-fighting" roles of heavy involvement in policy development and implementation. It is hope that he can avoid the seductions of too active an involvement in urgent policy work, and he can then get on with the main task of directing, coordinating, and advising the farming systems, marketing, and other economic researchers responsible to him. Particularly for the first of these functions, there would be some advantage in the CAE having special competence and experience in production economics.

To attract good people, these and other senior economics research people should be designated as Economists and should attract benefits parallel those of the other comparable senior scientific staff.

A large change was due to take place March 1, 1982 when the Branch was to (a) be divested of Development Engineering, (b) retain the direct marketing activities and the produce inspection regulatory roles, and (c) lose to a revised Policy, Review and Coordination Branch to be called Policy, Planning and Coordination the sections concerned with Economics, Statistics and Planning. Since Planning and Policy per se seem to be activities falling somewhat beyond the "research" terms of reference of ISNAR, planning activities and resources are only mentioned here insofar as they impact on research functions. This is not to deny the crucial importance of this applied economics work in the development of PNG.

It is presumed, for instance, that Planning will develop, retain and refine a capacity to polish NPEP submissions for research projects in DPI. Beyond this, in the general development context, national DPI must maintain the capacity to inspire, direct, and advise the area economists assigned to provincial DPIs. Whether these economists/planners are recruited by national DPI or directly by the provinces, at least one for each province will be required eventually. Plans to develop a "Manpower Training Project for the Planning, Implementation and Control of Rural Development" should thus receive every encouragement to help to fill this important void. Meanwhile, the idea of allocating available resources to assist the least developed provinces first should be pursued. With these provisos, attention is now returned to staffing in the Economics Section.

To revitalize the section after its recent decline in staff, there would be much merit in appointing a group of skilled energetic people who can work synergistically. The following structure for the Economics Section features several effective fillings of presently vacant positions. In nominating several positions at relatively high levels, the thought is to seek competent, experienced applied research economists with diverse sectoral interests.

Seven senior or special economists (CC9 or scientific equivalent) should be responsible to the CAE, covering the areas of:

1.	Coffee and Tea Economics	(production, marketing and outlook)
2.	Cocoa, Copra and Oil Palm Economics	(production, marketing and outlook)
3.	Food and Farming Systems Economics	(systems research and food crops production, marketing and outlook)
4.	Training	(also to engage in research and inter-branch inter-institution liaison)
5.	Economic and Policy Analysis	(intersectoral research and agricultural - macroeconomic relationships)
6.	Livestock Economics	(previously in the Livestock Branch)
7.	Fisheries Economics	(presently in the Fisheries Branch)

Given the levels and responsibilities, it seems that, in the first instance, these positions will probably have to be filled by expatriate appointments. However, every such appointment must be matched by at least one national understudy, whether by linking more junior (say CC5-7) positions or by special supernumerary arrangements. In fact, several understudies may be desirable since, if the system works effectively, the people trained will find ready employment (through promotion "out") in other departments and organizations. Thus the in-house apprenticeship arrangements will doubtless have to accommodate some slippage to other areas of government and to industry.

To summarize the suggestions for headquarters economic services, there is an enhancement of policy advice and research-specific coverage of major sectors with research in production economics, marketing efficiency, and outlook predictions and a freeing of senior resources for direction and training of staff, especially those staff not located at headquarters, and of other mainstream economic research activities such as development of data collection priorities and specific wider economic research projects such as, for example, building a policy/agricultural research oriented model of the PNG rural sector.

Production Research

With regional research economists working on a project basis in cross-disciplinary teams with a concrete problem-solving objective, the role of the economist will be particularly to grapple with inter-relationships between production and household consumption, and market linkages and prospects. In addition, working jointly with agronomists, agricultural economists can play an invaluable role in helping define technical research problems that stand very high in the farmer's value system because of socio-economic factors.

Other aspects of farming systems research that must be the particular concern of the economist are, for example: (a) the impact of risk and risk aversion on choice of technique and enterprise combination and (b), especially given the high costs of labor in PNG (both legislated minimum wages and the "reservation" wages, particularly of men), careful attention to measuring labor productivity and accounting for it in systems evaluation. Recommendations prepared in recognition of these special circumstances may well differ between smallholders and larger commercial farmers.

Ignorance of intercropped production systems used in traditional and smallholder farming seems profound -- for the "good" reason that they are very complex (intrinsically, and to investigate) and the "bad" reason that relatively little attention has been addressed explicitly to them -- by agronomists preferring the "simpler life" of monoculture. It is to be hoped that these complexities can be addressed more enthusiastically in the problem-oriented farming systems studies foreshadowed above.

Needless to say, systems work is demanding and, if staff available for the work are not well trained or experienced, good direction, leadership and on-the-job training will be required of the supervisory staff at headquarters (especially if the CAE and the Training Economist are chosen for complementary skills) and in the project team itself.

It is envisaged that (a) the Area Economists be transferred to the Planning Section to reflect their regional planning responsibilities in the Provinces and their logical linkage to Headquarters planners and (b) some outposted economists be designated as Research Economists or preferably as Farming Systems Economists attached to research stations. The latter may involve only two or three positions, in the first instance, with the results carefully monitored to aid further possible extension of this essentially new role. (The numbers should rise to meet the needs of research Teams as indicated in Annex 7.) The Farming Systems Economists will be generally responsible to the CAE (especially for professional advice and leadership) but, for their project/team work, will report in the first instance to the designated team leaders. Their work may well take them into marketing issues as often as production economics.

There are several models that have been used in cross-disciplinary research. The one that seems most applicable for PNG farming systems research seems somewhere between "multidisciplinary" (wherein individuals pursue their disciplinary interests within an agreed general objective and approach) and "interdisciplinary" (wherein there is a more pervasive common view and unified end product of recommendations). Cross-disciplinary teams should best have a sharp problem-oriented focus, even if the research "problem" is not itself simple and well structured. Experience with economists in cross-disciplinary teams has not been universally happy, usually because of occasional communications difficulties between economists and biologists (which has obvious implications for the types of people recruited to such work), but sometimes because of the narrow perspective some economists have on the boundaries of economics, particularly regarding non-monetary goals of farmers.

Perhaps reflecting the relative salary and peer recognition, the main encouraging experience in cross-disciplinary research resides in the strongly mission-oriented international agricultural research centers e.g.,

IRRI, IITA, etc.). However, several countries in the region (notably Indonesia, Philippines, and Thailand) have recently reorganized to highlight economics contributions to a farming systems approach. The success of this reoriented work will depend on many factors (as well as the mentioned salary and peer recognition), including careful staffing, outside peer monitoring, and (more difficult in times of shrinking research budgets) strong financial support of such work which may well (through being field-based) be more expensive (albeit more relevant) than analogous research on research stations. After staff have reached higher levels of educational attainment and extended their PNG professional experience, there will be merit in attaching national research staff for sabbatical periods in relevant international centers.

National Recruitment and Training

The reality of seeking mainly B.Agric. graduates and tropical agriculture diplomates into the economics positions of DPI may be explicable in terms of ultimate retention of staff, given a career structure unattractive relative to some other departments and a desire that staff should be familiar with the fundamentals of modern agriculture. However, the policy seems too parochial in not seeking more vigorously B.Econ. graduates who are much better trained in economics and, particularly for commodities, price analysis, and outlook work and probably also project analysis, are more prepared for active research work. More effort in B.Econ. recruitment seems justified, even though the "problem" of B.Econ. graduate's high career expectations persists.

The scope for postgraduate training in PNG is very limited. Some might pursue B.Econ. (Hons) with merit. Fewer might tackle B.Agric. (Hons Ag. Econ.) because of the extremely limited staffing of the area in PNG. The previous training economist recommended that, after a year or two of experience, national graduates take a one-year postgraduate Dip.Ag.Econ. course at the University of New England, Australia. There may be other such suitable remedial/bridging courses elsewhere. After a further period (say two years) of work experience, such diplomates who have demonstrated aptitude and ability could be sent out for Master's degree training, with a view to staffing the higher level positions in the economics, statistics, and planning areas. This desirable state of affairs seems to be at least six years hence, if all goes well, which is virtually two cycles of the normal expatriate contracts.

Statistics

These remarks on agricultural economics in DPI cannot be closed without further brief mention of the work on Rural Statistics. A much enhanced broad socio-economic (including nutritional status indicators such as weight-for-height measures of young children) and farm structure data base is a necessary condition for major advances in applied economic research. Present staffing of the Statistics Section is inadequate to the tasks faced. Working out priorities for the most urgent policy- and research-needed data collections should be one of the pressing tasks for a revamped Economics Section. Eventual staffing of the Statistics Section with qualified statisticians and in-training national staff up to at least the previous establishment seems mandatory. In the interim, subject to budget limitations, there may be scope for commissioning some specific data collections through the Institute for Applied Social and Economic Research.

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International Service for National Agricultural Research

Headquarters
Oranje Buitensingel 6
2511 VE The Hague
Netherlands

Correspondence
P.O. Box 93375
2509 AJ, The Hague
Netherlands

Communications
Telephone: 070-472991
Telex: 33746
Cable: ISNAR