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REPORT TO THE GOVERNMENT OF

THE COOPERATIVE REPUBLIC OF GUYANA

A Review of The Agricultural Research System of GUYANA

isnar

International Service for National Agricultural Research

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March 1982

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The Hague, Netherlands

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Introduction

After informal discussions between Dr. W. K. Gamble, Director General of the International Service for National Agricultural Research (ISNAR), and Mr. Joseph A. Tyndall, the Minister of Agriculture of the Cooperative Republic of Guyana, in Novisad during the World Food Council Meeting, the Minister formally requested ISNAR to review the agricultural research activities in Guyana and to recommend measures for their strengthening and improvement.

A short visit was paid by one ISNAR staff officer to Guyana at the end of August 1981 and, after discussions with the minister and senior officers of the Ministry of Agriculture, the terms of reference for a full review mission were established. A team of six persons (four ISNAR staff officers and two consultants, names in Annex 12) carried out the review from 15 January to 6 February 1982. Since there are a number of regional organizations working in the agricultural research field in the Caribbean and in Central America, discussions were held with the acting dean of the Faculty of Agriculture of the University of The West Indies (UWI) in Trinidad, with the executive secretary of the Caribbean Agricultural Research and Development Institute (CARDI), also based in Trinidad, and with the Guyana country representative of the Inter-American Institute for Cooperation on Agriculture (IICA) together with the officer in charge of the Caribbean Council for Science and Technology (CCST).

Terms of Reference

The specific terms of reference, as proposed by the government during the first visit to Guyana and jointly approved with minor changes in wording by the Minister of Agriculture and the Director General of ISNAR, were:

- to identify a research philosophy that is oriented toward the practical production problems of farmers;

- to assist in the development of a policy strategy for a national research system with specific emphasis on organizational structure, physical facilities, training, and staff development;

- to examine the present and potential national research institutions with a view to ensuring the most effective arrangements that would facilitate coordination and cooperation toward common objectives;

- to examine the links with research and extension, and to recommend arrangements that would strengthen such links to facilitate flow of information from research scientists to farmers and vice versa;

- to identify the functional link between the national research system and international centers and programs;

- to identify conditions that may be conducive to the generation and adoption of effective and efficient technology;

- to examine the present administrative system for the funding of research and to advise on a possible alternative system.

In the context of this review, agriculture was defined to include inland fisheries and forestry.

The Report

The results of the review are presented in four sections. In the first section, the overall approach (or philosophy) to agricultural research in the Guyana context is considered, having regard to the specific objectives laid down by the Minister of Agriculture and his senior staff. He emphasized in all discussions the need to orient research activities toward agricultural production and to work within the overall resources which the country could provide.

The second section of the report analyzes the present situation. Since the overall agricultural effort in the country has been described recently in substantial documents which are readily available, there appeared to be no reason to repeat the description. However, some relatively minor updating of the information was required. The analysis sets out the strengths and weaknesses of the present situation and some of the reasons for the current low level of research activity, and endeavours to derive a basic philosophy on which to base future action.

The third section discusses a number of alternatives. It does not give a strong recommendation to any one of these alternatives, since there are advantages and disadvantages attached to each.

In the last section the main conclusions of the mission are presented, and the likely courses for future action are discussed further. Emphasis is placed on the functions rather than on the particular structures of the organizations proposed. A number of specific items have also been identified, which could effect some preliminary strengthening of the research base before the full suggested reorganization is carried out. It seems important to draw attention to one or two areas where immediate action is needed (sugar and rice), counseling against hastily made minor adjustments which will not deal with the major issues but which might aggravate the situation.

An Approach to the Development of a Research Philosophy and Strategy

The basis for the approach presented in this section is the search for answers to a series of questions:

Why is research needed?
What kind of research needs to be done?
How, by whom, and where is the work best carried out?
What resources are required for effective action.

Why Is Research Needed?

All forms of agricultural activity involve the use of land to grow non-climax vegetation. This means that certain measures are necessary to displace the natural vegetation in favor of those crops which man wishes to have.

However primitive a land-use system may appear to be, it has usually evolved by trial and error, often over a long period of time. Few systems are static; most make use of the resources available at a given time to stabilize output and to minimize risks.

In a simple system which has a small resource base, the output may be stabilized at a low level, with little risk. To increase the output from such a system, additional inputs are needed (in this context, new knowledge or information is an input), and the risk situation may be changed in the process.

The system coming nearest to using the climax vegetation in a relatively unchanged form is that of pastoral activities where herds of various animals are moved from one place to another. Even in this, however, fire is often used as a means of removing indigestible material and promoting the growth of younger, more palatable and digestible shoots.

In shifting cultivation, natural regeneration of vegetation is used to restore soil fertility after specific crops have been grown. This is adequate for subsistence agriculture, provided that the population is small, land is available to allow for the appropriate length of time between successive uses for arable crops, and the climate-soil situation is conducive to forest regeneration.

This form of cultivation has been further modified to provide arable systems in which a proportion of the land is left fallow each year, or on which a crop is grown to provide roots and green manure for regenerating the soil. The old rotations developed in Europe relied heavily on a relatively low net removal of nutrients by their main crops and on a resting period under either fallow or leguminous crops. The advent of fertilizers and mechanical and chemical weed control methods has enabled soil fertility to be maintained in temperate areas without resorting to resting periods, provided that reasonable crop rotations are followed. Systems of continuous cultivation, using short duration or annual crops in the much more difficult environmental conditions of the humid tropics, are being developed with the help of modern inputs (especially at the International Institute for Tropical Agriculture (IITA)). These show considerable promise on certain soil types.

In each type of agriculture there is some specific interference with the climax vegetation. This interference and the attempt to maintain a balance always in favor of the desired plants, has brought with it a number of major problems. In addition to the need to maintain soil fertility, a major problem is the control of pests and diseases, which tend to build up to damaging proportions in continuous cultivation systems.

In traditional systems of agriculture the rate of change was usually slow, probably because the population was increasing slowly. Informal systems of research (trial and error) were adequate to support the production of enough food and fiber for the people, while fuel wood was abundant in the areas not used for cultivation. As the demand for agricultural produce began to increase, it became necessary to speed up the rate of change in various production systems. More inputs were needed and, in the temperate countries, the amount of investigational (research) effort was increased to define these inputs and how to use them effectively. This brought about a change from an informal research system at the production level to a more formalized research system involving specially trained persons working in specialized institutions. Research was needed to increase rates of change in agricultural production systems, as well as to protect those systems which had already resulted in high levels of productivity.

In established production situations, research has at least two components. One is the maintenance or protection of what already exists, and the other is the provision of the bases for changes in existing practices or systems to increase the total output. Research is, therefore, one component of the agricultural development process. While it is essential in that it provides the knowledge and materials which allow changes to take place, it does not of itself provide the whole framework within which increases in production can be made. Many other factors must be in balance -- cost and availability of inputs, access to markets, remunerative prices, and so on -- before the research information and materials can be used effectively in agricultural production systems.

The basic philosophy of research in agriculture (itself an applied science) is, therefore, that of providing continually changing technology as <u>one</u> of the essential components for agricultural development. It is a highly complex component and involves both technical and socio-economic fields.

What Kind of Research?

While the basic philosophy for agricultural research may vary relatively little from country to country, the strategies adopted to define specific objectives within the overall goal in a particular country will be influenced by many factors. The most important of these appear to be the significance of the agricultural sector in the general development of the country, the stage of development of the sector and of the national agricultural research system, and the extent of the information available from outside the country.

Before discussing a possible strategy for agricultural research in Guyana, it seems important to outline what a good research system can (and, equally important, cannot) be expected to provide.

In Guyana, as in most countries, there are competing demands on the resources available for national development. Agriculture is considered to have a major role, but agricultural research must gain support by being able to give convincing answers to a number of pressing questions:

— What can agricultural research do and what sorts of results can be provided?

— How long will it take for the results to be effective in increasing output (this may be measured in several ways besides gross yields)?

— What resources are needed to allow the work to be done effectively?

— How much will it cost?

(The last two items are discussed later in this section.)

Research is a process of systematic investigation which, however complex the procedures involved, produces only information (with an estimate of its reliability) and new materials with specific and defined characteristics (varieties, breeds, chemicals, equipment).

More specifically research activities should be able to:

— make available to the government, in an appropriate form, some of the information on which the agricultural development plans of the country can be based, for example:

- medium and long-range market forecasting, both local and worldwide;

- the suitability of different agroclimatic zones for the production of the commodities and livestock required in competition with other forms and land use;
- detailed technical information about storage, transport, and handling of produce to minimize post-harvest losses;
- estimates of the national resources of land, capital, labor and expendable items (agronomic inputs, fertilizers, insecticides, improved seeds, etc.) needed to carry out the national plans while maintaining or improving the national land capital, especially its productive capacity.

-- make available to the farmers through appropriate channels the detailed agronomic and economic information on which to base the production of crops and stock. This includes the maintenance of existing production in the face of hazards, as well as possible changes in production based on new technology.

While pressing the need for active research services, the research administrators should be conscious also of what research alone cannot do. National agricultural development plans often contain objectives which can only be achieved through major social reforms. Alleviation of poverty and the achievement of more equitable income distributions in rural communities are not realistic objectives of agricultural research per se. Overstatement of what agricultural research can realistically contribute to development could lead to a lack of effectiveness of research administrators when dealing with budget offices, legislative committees, and special interests. Also, the latter groups should appreciate that there are some problems which cannot necessarily be overcome economically, even by the best research. An example of this is the growing of crops having high and specific nutrient requirements on inherently infertile soils. In many instances production is technically feasible but only at high cost, so that only valuable crops can be considered at these high input levels.

The identification of problems and opportunities at the farm level and the setting up of relevant research programs to develop new technologies are well understood and generally accepted in most governments as essential functions of the agricultural research system. The role that the system should have in providing one of the major technical inputs into national agricultural development plans or into the planning of individual projects is less well understood.

Of all the types of information that can be made available from research activities, the critical question is what part of the information needed to support agricultural development in Guyana should be generated within the national research system.

On a global basis there is a substantial total research effort being made in tropical areas and on tropical crops. The question is to what extent the results of work outside Guyana can be adapted for use there, and what investigations must be done within the country.

If the national research effort is viewed as a component within a wider international framework, the answer to what kind of research becomes somewhat simplified. However, a detailed definition of national agricultural objectives is necessary for an accurate assessment of what information is needed. Planning in Guyana has not yet reached the level where the identification of precise objectives is possible, so there is an element of uncertainty in the following argument.

The stated policy objectives emphasize increasing the net foreign exchange earnings of the agricultural sector by increasing exports and decreasing imports (or a combination of both), and of becoming self-sufficient in as many foodstuffs and fibers as possible. Considering both this and the country's difficult financial situation, a realistic goal for the research system is to develop the capacity to:

— maintain the production of sugar and rice at present levels;

— improve the knowledge base to permit improvements in the yields of sugar (not necessarily of cane) and rice per unit area and to decrease unit costs of production;

— make the fullest use of the world information base to assist in developing simple adaptive trials on the crops necessary to meet the national objective of self-sufficiency in all major items of food (it should be noted that most of these crops would occupy relatively small areas of land, which raises the difficult question as to how much research effort can be applied to any one of them);

— provide multidisciplinary teams of research workers to develop improved land-use systems in the already highly developed areas of the coastal plain and in other areas which are currently undeveloped but appear to offer some potential;

— establish effective working linkages with farmers through those possible extension channels which have adequate numbers of personnel located at the subdistrict or village level.

A framework within which a system may be developed to address the above objectives was put forward recently by Steppler[1]. His paper divides the agricultural research spectrum (which is essentially continuous) into five major activities (phases) described as follows;

— pre-release testing and farmer field evaluation;

— adaptation to local specific conditions;

— generation of technology prior to adaptive research;

— identification and assembly of individual disciplinary inputs and of appropriate research methodologies;

— development of disciplinary inputs, synthesis of new materials, collection and evaluation of new materials, and establishment of the understanding of basic organisms and functions.

The spectrum ranges from adaptive research at the field end (Phase 1) to basic research (Phase 5) at the other. It is clear that all of the stages may need to be brought to bear on any one problem; the main question is how and where the work should ideally be done.

The work in Phase 1 must be done in the area of use and has two objectives: (1) final testing of ideas, materials, and methods which are expected to be of value, based on prior testing in similar situations elsewhere; and (2) the feedback of the findings and of problems identified during the course of the work to the appropriate stage of the research process. In the case of a country which can only afford a research effort of modest size and which produces crops which occupy small areas of land, work at Phase 1 may be all that is realistically possible.

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[1] Steppler, H. 1981. Agricultural research systems. Unpublished paper.

Research work in Phase 2 should be done in the area of use, possibly at the district or regional level. Work in Phase 3, which is concerned mainly with the generation of technology for particular crops or situations, can be done wherever the particular situation exists and the crop is grown on a sufficient scale.

Research activities at Phases 4 and 5, except in the broadest sense, are essentially nonlocation-specific . The activities of the international agricultural research centers cover aspects of work in Phases 3, 4, and 5 although a considerable part of the research needed in Phase 5 is done in specialist institutions.

Relating these concepts to the Guyana situation, there is clearly a need for an effective research presence at Phase 1 in all major crops, livestock, and aquaculture.

For sugar, rice, the more important group of minor crops (possibly grain legumes, sorghum, oil seed crops), pastures, and livestock, it seems realistic to suggest the need for research capacity at Phase 2. For rice and sugar, some research activities may be needed in specific aspects covered by Phases 3 and 4 and in direct association with specialist institutions at the regional or international level.

In addition there is a need to examine whether specific technologies can be developed for use in certain difficult agro-ecological conditions -- for example, the coastal clay areas and the poor soils of the intermediate savannahs.

These relatively modest objectives have been taken as a guide to define what kind of research could form the core of the activities in Guyana.

How, by Whom, and Where Can the Work Best Be Done?

Phase 1 research needs to be done at many sites and in on-farm situations. This means that an adequate number of trained personnel must be available at this level to do the necessary trials. The two main functions of these persons would be to test methods and materials from the earlier phases of research, and to identify and refer to the appropriate unit those problems and opportunities which may need further research.

The performance of these tasks also requires a thorough knowledge of the situation within which the farmers are working and of the production systems. The requirement in terms of professional skills is, therefore, wide and includes the social sciences as well as the more usually accepted biological sciences.

Further, for the research scientists at other phases of the work to be able to interpret existing knowledge in the light of local needs, the ecological characteristics of each area need to be thoroughly documented and their significance understood. Personnel posted at the subdistrict level would also be involved in the compilation of these data. However, the interpretation of the data and the more specialized aspects of socio-economic research at this level would be the responsibility of others.

The structure of government in Guyana has recently been regionalized; a considerable degree of authority and responsibility has been delegated to regional chairmen and executive officers. While research services are excluded from regionalization, extension services are not. It was necessary, therefore, to pay particular attention to the lines of communication and authority within these services, particularly in technical areas with which administrative staff at regional level cannot be expected to be well acquainted. It is self-evident that it is extremely important to try to ensure a free and rapid flow of information within the farmer-extension-research system.

Ways in which the new structure of government may be used to best advantage are considered in later sections of this report.

The professional input needed at Phase 1 can be divided into two parts: interpretative and deductive on the one hand, and the performance of large numbers of simple trials on the other. The latter part is essentially a task for skilled technicians and shrewd, trained observers; the former part calls for a much higher level of scientific training and wide experience. The problem is how to provide both types of input at the right place and time.

Much of the work needed at Phase 2, and in the few aspects which may be needed at Phase 3, can often be done most effectively within multidisciplinary programs. These programs require a certain level of specialized facilities, usually found only in research stations or substations, and teams of persons having specialized training and experience.

What Resources Are Needed for Effective Action?

At Phases 2 and 3 there is still a large measure of locational specificity in some of the components (for example, incidence of a specific disease in different locations within a much larger area), and the selection of appropriate locations for research stations is sometimes difficult to make. In multidisciplinary, multipurpose stations, or where the number of stations which can be afforded is severely restricted, a compromise is often needed between the requirements of the individual research programs and the need to ensure that the stations can function effectively and that staff can work happily at them.

In the analysis of any situation it is necessary to have certain criteria to guide the course of the analysis and against which the results of the analysis can be assessed. The criteria often used when analyzing research systems and stations are subjective, but there is a reasonable consensus among experienced research workers on some of the main ones. Some of these may be set out as follows:

-- a critical mass of trained research workers concentrated to ensure interaction between persons trained in different subjects, preferably in multidisciplinary programs;

-- a congenial atmosphere in which to work; this implies reasonable rewards, but more particularly a situation which allows the job to be done efficiently and satisfaction to be derived from it;

-- access to information on a worldwide basis and interaction with the production situation within which the work is to be done, in order to develop purposeful research programs and to avoid repetition of work already done elsewhere;

-- adequate basic facilities of buildings, equipment, transport, and experimental areas or farms;

-- good support services (administrative and technical) to promote rather than control the research activities and to keep the facilities fully operational;

-- assured financing especially of recurrent costs other than salaries;

-- means of dissemination of results to different groups of users; and

-- some recognition by policy-makers that research is a slow process, and the outcome is often unpredictable, but that much is already known which could, if properly interpreted, be of considerable value in the agricultural planning process.

The two key issues are undoubtedly an adequate number of trained personnel -- researchers, support staff (administrative, technical -- both laboratory and technical, and extension workers with whom to interact) and an assured level of funding. These issues will loom large in the following sections.

Analysis of the Current Situation

National agricultural development policy was interpreted in this review to provide a definition of the objectives for the development of research programs and of the functional needs of a research organization. The analysis given in this section endeavors to relate the existing research effort to that which is considered to be the essential minimum to support the national agricultural development plans, and on this basis to identify strengths and weaknesses in the present research work. The current situation is described only in sufficient detail to support the analysis which is being presented. Detailed evaluation of individual programs is not attempted.

The methodology adopted here had three objectives. The first was to make some assessment of the natural resource base (soils, vegetation, climate, and their interaction), and from that base to recognize and define the problems to be overcome in developing specific areas, such as the intermediate and Rupununi savannahs. The second aim was to assess the programmatic, resource (personnel and financial), and organizational aspects of research on the major crops, minor crops (in the sense of area of production), livestock, fisheries, and forestry. Finally, the methodology was to allow a presentation of the findings as a basis for suggestions for changes to strengthen the present research system. Summaries of the information used in making this analysis are given in Annexes 1 through 8; this section presents mainly interpretations and comments based on the data in the relevant annexes.

The Natural Resource Base (Annexes 1a, 1b, 1c, and 2)

A major program of soil surveys (Annex 1a) was completed in 1966, with support from a United Nations Food and Agricultural Organization (FAO) project; an operationally effective soil survey unit was established. Since that time it appears that only localized surveys for specific purposes have been done. The soil survey unit is now small and not able to do detailed surveys except on small areas. The main survey confirmed that, apart from the relatively fertile soils of the coastal plain, most of the soils of the rest of the country were of low fertility, had poor physical properties (fragile when exposed), and were generally not suitable for arable agriculture. Some potential was foreseen for improved pasture and for tree crops. There appear to be large areas of soils in the extreme south of Guyana which may be of moderate to high fertility. Research to assess their potentials is not proposed, because of problems of accessibility, but some further survey work there should be considered.

The agrometeorological data are sparse except from stations in the coastal plain. Records at all stations are mainly confined to rainfall and temperature; there are only eight synoptic stations in the whole country (Annex 1b). The records were adequate to indicate a high total rainfall, which is so erratic that it presents serious constraints to the development of arable systems in many areas. The lack of predictability of rainfall patterns renders virtually impossible the establishment of reasonably reliable crop calenders for annual crops.

A large part of the country is still under forest, but the soils on which the forests are growing are for the most part extremely poor. Natural regeneration after timber extraction, which is beginning on an organized and large-scale basis, cannot be taken for granted (Annex 2). Virtually no work has been done on which to base systematic extraction of the marketable species at sustainable yields, so apart from the possibilities of soil degradation, there is also a danger of adverse changes in species composition and the value of the forests.

On the basis of the main soil survey results, the intermediate savannah areas (Annex 1c) were chosen as representing a possible location for the large-scale mechanized production of annual crops and for the development of improved pastures for the beef industry. The difficulties of using these soils were underestimated at the start of the project. Nevertheless, progress has been made in the pasture development work and, to a much lesser extent, in working out how to grow annual crops. There are localized differences in the soils of the savannahs which could be important.

These four points are presented to demonstrate the importance of developing and maintaining the capacity to record and characterize soils, agrometeorological conditions, and vegetation characteristics under different types of management, in order to develop a sound data base from which to formulate agricultural research programs in support of development activities.

Overall, the resources deployed at present are weak and in need of appreciable strengthening. In program and resource terms, requirements are outlined in the annexes to which reference is made (it being assumed that the existing soil survey unit will be brought back to full strength when suitably trained staff can be recruited). Modest additional programs are proposed in agrometeorology and in forestry, while possible ways in which research might develop on the savannah areas are discussed in more detail in Annex 1c. The essential features of the suggestions are (1) the need to integrate research on crops and livestock (pasture development) into a farming systems approach, and (2) to use more fully the results and materials now becoming available from the Centro Internacional de Agricultura Tropical (CIAT) programs in similar ecological areas. In the integrated approach much more attention should be paid to minimum tillage techniques, both to prevent erosion and to assist in the retention of the expensive nutrients.

Resource Base for Agricultural Research (Annexes 3, 4, and 5)

This is considered in three parts: organizational structure and its implications, physical facilities, and manpower and financial support.

Organizational Structure (Annex 3)

Responsibility for research on the country's two main crops - sugar cane and rice - rests with the Guyana Sugar Corporation (Guysuco) and the Guyana Rice Board (GRB) respectively. The Ministry of Agriculture has responsibility for all other crops, livestock, and, through the Ministry of Fisheries, for fisheries. The Ministry of Forestry in the Ministry for National Development has responsibility for silvicultural and forest products and research, while work on agrometeorology is located in the hydrometeorological division of the Ministry of Works.

The main features of the organizational structures of the government, the Ministry of Agriculture, Guysuco, and GRB, as they relate to research and extension activities, are given in Annex 3. Within the Ministry of Agriculture, three main divisions are responsible for work on crops, soils, and livestock (veterinary and production), respectively. The crops and soils divisions appear to be divided into rather large numbers of subunits. The officers also have a wide range of duties in addition to research, and there do not appear to be any posts designated specifically as research officers in the ministry as a whole. There is very little provision for research in the veterinary and livestock division.

In Guysuco, there is a well-established and successful research unit, although depleted in staff at present and facing new problems which require additional resources of personnel and equipment. This unit works closely with the production managers. Because of this close integration of the research and production units, there is a good mechanism for research program formulation and for the evaluation and rapid field application of research results (Annex 6a).

The GRB research program is a service function to the rice growers, since GRB is not directly involved in production except on its own seed production farms. The research program is under the manager (research and agricultural services) who, because of his many nonresearch duties, can devote only a small part of his time to the research program (Annex 6b).

The Ministry of Fisheries does not have a specific research section. However, the senior fisheries officer is responsible for a research program on freshwater fish production, part of which is conducted by Guysuco on its estates.

In the Ministry of Works, the agrometeorological unit is in the hydrology division, and is not at present geared to the needs of crop production.

Many development projects have staff involved in adaptive research; perhaps the most important are the Mahaica-Mahaicony-Abary Agricultural Development Authority (MMA) -- rice and cattle, the Livestock Development Company (LIDCO) -- livestock, and the Guyana National Service (GNS) -- cotton).

The National Science Research Council (NSRC) has a mandate to coordinate the total scientific research activities in the country, but this mechanism is not necessarily appropriate for developing a program within a sector.

There seems to have been no attempt until very recently (within the planning division of the Ministry of Agriculture) to formulate a national agricultural plan on which a research program could be based. This is in contrast to the several proposals that have been put forward for the

organization of a national agricultural research service. The Downer proposal (1977), Sacid report (1980), and IICA-sponsored workshop (1982) seem to be the most important.

Since there is no effective mechanism except in the sugar industry for formulating a national agricultural research policy, a program for allocating resources on a priority basis is not possible. Until there is some clearly defined research unit with overall operational responsibility for agricultural research (excluding that on sugar cane) this situation appears likely to continue.

Research cannot be considered in isolation from the extension services, even though this analysis does not extend to the latter in detail. The 10 regions into which the country has recently been divided have been given a large measure of autonomy. Staff of the extension service within a region, while depending on the headquarters staff for program formulation and technical support, will come under the regional authorities, staff of the research services will not. To make use of the advantages which these arrangements offer, careful attention must be paid at the regional level, to the establishment of an effective working liaison between regional extension workers and the centrally controlled extension and education service, and the sources of research information. This is necessary to ensure both the relevance of research programs to regional needs, and the rapid dissemination of research results to farmers.

Physical Facilities (Annex 4)

An inventory of physical resources available for use in the agricultural research program was prepared so that an estimate could be made of the size and scope of the research program which could be accommodated, as well as an estimate of additional resources that might be needed in the near and medium-term future, should the research program be extended. A summary of the resources at each of the major institutions visited is given in Annex 2.

The facilities available may be grouped as follows:

Ministry of Agriculture	:	mainly at the Central Agriculture Station at Mon Repos; small out-stations for some adaptive trials.
Guysuco	:	Guyana Sugar Experiment Station and central analytical laboratory;
Guyana Rice Board	:	Mahaica/Abary Rice Development Scheme (MARDS), Research Station
Institute of Applied Science and Technology	:	laboratory at headquarters on the campus of the University of Guyana;
Guyana School of Agriculture	:	for teaching purposes, but some facilities in food processing;
Guyana Pharmaceutical Corporation	:	facilities for small-scale food processing;
Veterinary Diagnostic Laboratory	:	new facilities almost complete.

The Central Agricultural Experiment Station at Mon Repos currently accommodates the divisions of crop science, soil science, and veterinary and livestock, although very little research work has been done at Mon Repos in the latter division. The soil science unit also houses the soil survey and routine soil and plant analytical laboratory.

On the basis of the estimate of space in the main administration and laboratory building and the space in the new veterinary diagnostic laboratory, the present facilities could accommodate from 10 to 12 senior researchers and about 20 technicians, provided that the facilities were to be used only for research.

There is a reasonable amount of basic equipment at the station, but some is in need of repair (spare parts can take up to two years to obtain!). Nevertheless, if used cooperatively, there is enough here to permit a start on several major multidisciplinary research programs. The facilities in microbiology are especially good. The soil laboratory, though modestly equipped, appeared to be managed well and was working efficiently in spite of many difficulties.

Expansion of the program in plant protection and plant breeding would require additional equipment, especially microscopes, insect rearing facilities, and insect-proof screen or glasshouses.

For work outside the station, transport facilities are seriously inadequate and maintenance services are poor.

The modest facilities at the Guyana Sugar Experiment Station were generally adequate for the past research program, which was largely devoted to varietal improvement and general agronomy. The central analytical laboratory in Georgetown gives service support to the whole research program. Additional requirements of buildings and equipment to meet the changing research needs are discussed in Annex 5a.

The MARDS station of the Guyana Rice Board was found to have good laboratory and field facilities, which are at present seriously underused. A shortage was noted of some essential pieces of equipment.

Research is not a feature of the work of the Guyana School of Agriculture, but the school has a pilot plant for food processing which could be used for some research in this field if the need arose. Small-scale facilities for food processing are available at the Guyana Pharmaceutical Corporation's food section. The facilities of these two organizations taken together should be adequate to meet immediate and near-future needs.

New buildings are planned (to be paid for by a grant from European Economic Committee (EEC)) for the Faculty of Agriculture of the University of Guyana (UG). It is not intended that the faculty should have a large research program and, in any event, the well-equipped but underused laboratories of the Institute of Applied Science and Technology on the university campus could accommodate several University of Guyana research projects.

The basic question of whether there are adequate facilities available in Guyana to accommodate an agricultural research program must be answered with a qualified "yes." The facilities are, however, dispersed and under different administrations. Some facilities may be needed in areas not presently served. Lack of buildings does not seem to be a major

constraint. The supply and maintenance of equipment and transport appear to present serious problems, even though the total extent of additional requirements appears to be quite modest.

Manpower and Financial Support (Annex 5)

Manpower. Annex 5 gives a detailed assessment of the availability of trained personnel in the research field in the various organizations involved and the potential output from the relevant educational units. Two general levels of research activity need to be differentiated: adaptive research in the on-farm situation; and the backup applied research (or research specialists) necessary to service the adaptive trials.

The two levels of the sugar industry (Annex 6a) are effectively combined within the one research organization in Guysuco. Applied research is done in the central research unit, and the adaptive work is done on the estates. There is a research group of sufficient size to develop and maintain a good research program, but additional staff are needed for urgent additional research on the diseases that are still menaces to the crop and to intensify the promising work on aspects of the biological control of insect pests. With rice (Annex 6b), however, the position is less satisfactory. Despite an adequate research establishment, there are many vacancies, and the manager in charge of research has so many other duties that he can devote only a small part of his time to research activities.

In general, the total supply of scientific manpower at senior levels is reasonable, but few of the persons in active research positions have qualifications at the Ph.D. level, although some have good postgraduate training, proven research ability, and several years of research experience. The spread over the different scientific fields is also good. Unfortunately most of the best qualified persons are in administrative or managerial positions not directly connected with research activities,

although some of those in individual agencies and corporations are involved in adaptive research at the farm level. This is particularly true in rice, and to a lesser extent in pasture development.

The most serious problem is in middle and early career categories of staff in both research and management. The major shortage of personnel in these groups has several important consequences. Promotion from the lower levels to comparatively senior positions is rapid, so that these staff do not have adequate opportunities to remain in research or production long enough to make contributions and to gain experience from working with senior colleagues and with one another. They are promoted before they have been trained as administrators, and have had little experience as scientists. Second, there is no middle-career working group of scientists to train new recruits and to provide the program leaders with whom the younger scientists would work -- and from whom they would learn. Neither is there an effective pool from which staff may be drawn to service special projects or programs. Fourth, and potentially the most serious of all, is that there is no active program of training at the middle levels to provide a supply of well-qualified staff for the senior posts.

At the graduate intake level, the position is reasonable but not good. Only at the diploma and certificate level of the Guyana School of Agriculture are there substantial numbers of persons with some amount of practical training in agriculture.

There appear to be several reasons for the present situation. In 1971, there was a dispersal of research staff to lead "accelerated production drives" as production managers. This appears to have been based on the assumption that persons having a sound knowledge of technology can be effective production managers. This assumption is unfortunately rarely valid. Subsequently, a number of major development schemes and projects have been implemented, some of which have had adaptive research components included and financed from external sources. Staff have been drawn into these projects, mainly away from the Ministry of Agriculture, because of the better rewards offered and the more congenial working environment (houses, medical insurance, transport). In addition, the duties and responsibilities of the remaining personnel of the Ministry of Agriculture have been broadened, causing the research effort to become progressively diluted.

Due to this dispersion and dilution, the research effort has been reduced to its present low level, and individual research workers have had no effective control over this decline.

In relation to the objectives set out in this report, measures are needed to re-establish a sound applied research and adaptive research support unit at a central location and to develop a numerically adequate technical presence in the rural areas.

For the central unit, some concentration of manpower resources appears to be the first requirement. To achieve this, career structures need to be developed which will have adequate flexibility to meet the needs of the work program rather than conventional establishment norms. The restricted recruitment base (only graduates in agriculture and veterinary science can be recruited to posts in the Ministry of Agriculture) needs to be widened to include at least some natural scientists and socio-economists. Other organizational requirements are secondary to the main need to recruit, train, and retain qualified staff in research rather than managerial and administrative positions. It cannot be emphasized too strongly that research in any field is a job for well-trained professionals, it cannot be done adequately by anyone else.

The second major need is for the central unit to be designated a <u>research</u> unit and for it to be allowed to concentrate on this one component of production.

In the rural areas, however, there are very few technically trained staff either in extension or research. Before a program of on-farm trials can be carried out on a countrywide basis, numbers need to be increased or use made of qualified staff in other organizations (schools, for example).

<u>Financial support</u>. The total financial support for research is impossible to estimate accurately, since there are no components specifically for research in the budgets of the Ministry of Agriculture or in the main corporations (except for the Guyana Sugar Experiment Station of Guysuco).

The annual budget for the Guyana Sugar Experiment Station is about GY$500,000 (US$170,000), and for the research component of GRB at the MARDS station it is about GY$200,000 (US$70,000) -- because of the depleted complement of staff. An extra small amount needs to be added for work on the Guysuco estates plus an appreciable amount to cover adaptive research under the MMA, Blackbush, and Tapakuma projects. The total is still much

below 0.5 percent of the value of the output; it must be considered inadequate to support the two major agricultural industries.

Within the Ministry of Agriculture, the cost of the Central Agricultural Station is about GY$500,000 (US$170,000) per annum, but since little research work is in progress it would not be reasonable to include this sum as a research expenditure. In 1981 the budget for the crops and soils divisions was about GY$1,480,000 (US$490,000), but it is not possible to assess how much of this was spent on research.

The point was made, however, that the lack of staff and of a well-defined research program, rather than a shortage of funds, has been the main constraint. This is supported by the total allocation made to the Mon Repos station in all its divisions in 1981 and the contributions made to CARDI (GY$400,000 -- US$130,000) and to the Caribbean Food Program under Caricom. In addition, it has been difficult to maintain a steady supply of equipment and chemicals because of the delays in obtaining the necessary foreign exchange, even when this cost is being met from externally provided funds.

The importance of an assured source of funds and the availability of these funds when needed cannot be overemphasized, but it is difficult to see how these provisions can be made under the annual budgeting procedures of a unit in the public service. Some changes have recently been introduced into the budgetary procedures, both with regard to staffing and other costs, but it is not clear how much flexibility these changes have introduced.

There is much more freedom of action in some of the state corporations which are allowed to use revenue funds directly to finance expenditures, thus removing many of the delays which can arise when funds are not released on time, or when available funds are tied to specific line items and cannot be used for other needs.

Possible alternative methods of financing research activities are considered in more detail in the third section of this report.

The comments above refer essentially to staff and recurrent costs, since over the past few years virtually all capital and equipment costs have been met from the funds provided by various aid agencies; the expenditures do not appear to have promoted the development of a strong research system. Some of the problems associated with the project approach to funding are appreciated by the government and by the donor agencies. However, the team's tentative proposal for consortium financing of the research system (against some well-defined programs) and for including the funding of some incremental costs (salaries and recurrent expenses) was not enthusiastically received by representatives of the main donors (with one exception).

Crops (Annex 6)

Because of the importance of sugar cane and rice in the national economy, research on these crops is given prominence in this discussion.

Sugar Cane (Annex 6a)

There is a long history of research on sugar cane in Guyana. As in other countries of the Caribbean, this has been financed almost entirely by the industry itself. A small research group of five to seven scientists (an effective critical mass) has been maintained for many years, although this group is depleted at present.

The established research program on the breeding and selection has been able to provide a sufficient number of alternative varieties to replace those destroyed by disease during the past seven years, enabling the industry to overcome a potentially disastrous situation. The varietal improvement program is carried out as part of a cooperative network involving several countries of the Caribbean and the Central Cane Breeding Station in Barbados (financed by the participating countries themselves). This varietal improvement network has also been of great value in other countries of the region where the cane crop has been attacked by the same range of diseases.

The major feature of the organization of research on sugar cane in Guyana is the close linkage of the research program and the needs of the estates, with considerable cooperation between production and research staff in doing the field work. It is important to emphasize that research staff are not involved in the management of crop production, but they work closely with the production managers to ensure both optimal application of new technology and the identification of problems and opportunities which may need further research investigation. Since the manager (agronomy) is responsible both for the research program and all technical aspects of production, the maintenance of this close linkage between research and production is greatly facilitated.

Prior to 1974 the main emphasis of research was on varietal improvement and general agronomy, including the use of fertilizers to try to produce good quality cane under the difficult conditions in Guyana. Relatively modest facilities were needed for these programs, which were provided at the Guyana Sugar Experiment Station (GSES) on LBI Estate. Because the nature of the work program has changed to cope with the severe disease and potentially severe insect problems which have developed during the past few years, there is an urgent need for some extension of the buildings at GSES, and for the re-equipping of some of the existing laboratories (Annex 6a). An exciting recent finding, which could lead to the use of fungal pathogens to control important pests of cane and other crops, is delayed because of the lack of suitable laboratory equipment with which the needed work can be done.

Rice (Annex 6b)

Currently research on rice is the responsibility of GRB, which maintains a small but adequate research station at MARDS. In addition, there is provision for an agronomist to do adaptive trials in each of the three main rice-growing regions.

GRB is, however, primarily a marketing and service organization. It is the sole buyer of rice, and it supplies inputs (seeds, fertilizers, pesticides), machinery services, and credit to farmers. The management problems of these main enterprises are immense.

In the past there was a strong rice research group and some good work was done. The staff is now depleted (only three out of eleven technical posts are filled) and only a small amount of work (well-conducted) is being done.

For the industry as a whole,. there is an appreciable amount of adaptive research in progress in the Blackbush Polder (the USAID team), MMA, and to a lesser extent in the Tapakuma project on the Essequibo coast. This adaptive work has already demonstrated the need for better backup research from the rice research station and a need to extend systematically the measurement of

agrometeorological parameters in the rice-growing areas. There is concern about the narrow varietal base for the industry, particularly in relation to the susceptibility of the present varieties to rice blast, Pyricularia oryzae, and possibly also to sheath blight, Corticium sasakii -- although the latter is not a serious problem at present.

From the institutional viewpoint, there would seem to be no great advantage in locating rice research within GRB. Although the Board has a national responsibility for the rice industry as a whole, it does not have a producer interest which would make it an interested client for research results and hence a keen promoter of research and extension efforts. In this it differs from the other main agricultural corporation, Guysuco, in which the agricultural director is responsible both for research and production, and is thus aware of the value of a small but effective and continuous research effort. While there can be no doubt that sugar cane research should continue to be organized as it is at present (with strengthening of some components), it would appear more appropriate to transfer the responsibility for rice research to a multidisciplinary research unit which would include all crops, livestock, and possibly inland fisheries. This would permit the rice research to be intensified. In addition, work could be done on farming systems based on rice and including livestock (livestock seems to be an essential part of the farming system in most of the rice-growing areas). This proposition will be included in the consideration of alternative organizational structures later in the report.

Other Crops (Annex 6c)

The stated policy of the government, that Guyana should aim to produce all of the food and fiber necessary for both its people and for the livestock industry, has important implications for agricultural research.

A large number of crops can be grown in Guyana, but there is a major difference between growing a crop on a small scale as part of a subsistence system or backyard cultivation and growing the same crop on a large scale at a reasonable cost and at an acceptable level of risk. For small-scale production, yield and cost are often less important than security of production. This security is itself often achieved by growing a range of crops (individually or in mixtures) so that at least some will grow satisfactorily in every season. For larger-scale production, especially where this is to be mechanized and use other purchased inputs, it is essential to have a sound technological base and a system of production which is secure and reliable. This major difference is often overlooked, and large-scale production activities are started without prior establishment of a sufficient technological base. There are several examples where this has happened in Guyana. When serious problems arise because of undue haste in attempting large-scale production activities, research workers are called upon to solve them. A better procedure is to ask the researchers for objective assessments of the likely success (on technological grounds) of the proposed systems before the large-scale activities are initiated.

Overall, the agro-ecological situation in Guyana is not favorable for the growth of annual-seeded crops. On the heavy clays of the coastal plain (where drainage is difficult, slow, and costly) it is almost impossible to produce the fine soil tilth needed to ensure good germination of seeded crops. Even when this has been achieved by expensive mechanical means, the

tilth has been unstable, collapsing after the first heavy rains. Since the rainfall patterns are so unpredictable that it is not possible to plan the crop sequence to ensure ripening under dry conditions, losses must be expected at harvest time in a proportion of seasons.

On the soils of the intermediate savannahs the problems are no less severe. Although easier to cultivate, these soils are fragile, they contain few nutrients, have high levels of toxic aluminium, and hold little water. Although many of these adverse factors can be overcome at a cost, the rainfall pattern cannot be changed. Irrigation can provide water in times of drought, but the adverse effects of wet weather at harvest cannot be fully overcome.

Under these difficult conditions, much more consideration needs to be given to the appropriate choice of crops for any diversification and self-sufficiency program. A great deal is already known about the basic physiological and field requirements for most of the major crops. These requirements impose limitations as to where these crops can be grown with reasonable prospects of success, and they also indicate the inputs that are likely to be needed. It is within this context that the research efforts on crops other than sugar cane and rice should be evaluated.

Tree crops. The production of coconuts, coffee, citrus, and some other fruits has long been established on selected soils of the coastal plain. Cultivation of these crops has not expanded beyond the confines of these mainly coastal soils, riverain terraces, and peat soils (for coffee only); it is reasonable to suppose that the remaining soils of the coastal plain are unsuitable for these crops. The cultivation of oil palm is more recent and, although it can be grown on the riverain terraces given good water management, it is better suited to the more freely drained soils of the gently rolling foothills in the northwest. The four main tree crops (actual or potential) have been studied by various groups, and development proposals have been made. The position with regard to coconuts, oil palm, and coffee is reviewed in Annex 6c. A possible citrus development project, supported by EEC funds, is being studied. This would be located on riverain terraces of the East Berbice River. This is not reviewed in this report. The probability is, however, that some research effort will be needed on some aspects of each of these crops on a more or less continuous basis. It would seem reasonable to propose that one well-trained agronomist per crop could handle all the field aspects, provided that adequate specialist support could be supplied from a central unit within well-defined research programs -- not on an ad hoc basis. Apart from coconuts, where undercropping or grazing can sometimes be introduced to increase total returns, the other tree crops are essentially monoculture crops. There is less scope for them to be included in the farm-systems approach which could be applicable to the production of coconut and of annual crops.

Annual crops. Considerable research effort has been made over many years to establish the production of several annual crops. Principal among these are maize, soybeans, groundnuts, black-eyed peas (*Vigna unguiculata*), cotton, cassava, and other root crops. Some work has been done in an unsystematic way on many other crops, including a range of vegetables. These efforts have been unsuccessful; none of the crops has been developed to the point of regular and reliable production at even modest levels of output and cost.

There are several reasons for this state of affairs. The most important seems to be a lack of appreciation of the limitations imposed by difficult

environmental conditions and by the basic physiological requirements, which affect what crops can be grown, and what yields may reasonably be expected. In addition, the lack of clearly defined research thrusts has allowed efforts to be spread over a range of largely unrelated crops and topics. This situation is made even worse by the intermittent nature of the research effort and by the fact that few researchers have worked on particular problems long enough to make progress.

This unsatisfactory situation emphasizes the need for an effective mechanism for the planning of a research program with a few clearly defined goals, with estimated budget needs, with a time scale for completion or review, and with indications of expected benefits.

In spite of all the problems, there are some positive individual findings on which to base potentially useful research programs. There is a large amount of knowledge available from elsewhere which can be drawn upon to help. The concept of total productivity or profitability of a farm system, rather than of isolated crops, seems worth developing (see Annex 1c for suggestions for the intermediate savannahs) since yields obtained from available varieties of maize, sorghum, black-eyed and other cowpeas, and soybeans have not been unduly low when weather conditions have been reasonably favorable. Some improvement of yields and of other attributes may be possible by breeding and selection. Fertility maintenance problems and the provision of good soil conditions may be improved in a ley farming operation that combines crops and livestock.

Summaries of some of the work done on individual crops are given in Annex 6c. These results give indications of potentials rather than average yields over time since, although many failures have been reported in individual years, the proportion of crops lost or damaged over a period of years does not seem to have been recorded.

Livestock (Annex 7)

Apart from the work by LIDCO (based on the results of earlier research on soils, crops, and livestock within the Ministry of Agriculture on the development of improved pastures in its beef and milk production units), there is little research work currently in progress on livestock or on livestock production systems. Some well-documented feeding trials have been done with cattle in the past by Guysuco on the use of sugar cane, molasses, minerals, and urea. There is ample information on this topic derived from extensive work at several locations within the Caribbean.

In Guyana the livestock industry can conveniently be considered in two parts: (1) components that depend on a supply of good quality concentrated feeds, and (2) components that primarily make use of pasture, whether natural or improved. The latter require only supplementary quantities of specific concentrates, including minerals.

The poultry, pig, and to some extent milk production components are in the first group. For poultry and pigs, the bulk of the feed needed is imported and represents a high cost in foreign exchange. In addition, everything required for hatching eggs and chicks is imported. To date, efforts have been unsuccessful to produce maize and soybeans locally to replace a substantial part of the imports. This is discussed in Annex 7 and also in Annex 6c. It is suggested that greater consideration should be given first

to crops which seem more likely to succeed in the difficult environmental conditions in Guyana and then, having learned how to grow them, attention can be given to find out how best to use them to replace the costly imports. Some locally produced feed ingredients will become available in greater quantities after 1982 (fishmeal and extracted rice bran), and some increase may also take place in the supply of coconut meal when the coconut rehabilitation project is in operation. The main research requirements in this sector are in crop production and some feeding trials.

In the ruminant livestock sector, the supply of suitable feeds, mainly pasture, dominates the research situation. But the position is complex, since the two main areas where ruminant livestock developments are planned -- the coastal plain and the intermediate savannahs -- present different problems. The fertile soils of the coastal plain, which are in demand for crop production, could produce good forage crops. However, the crops could not be grazed without causing serious damage to the soil surface. Priority should be given to farm-systems studies in these areas, in order to maximize the production of crops and stock. This would improve the incomes of the farmers, most of whom grow rice, the profitability of which is still low despite the recent rise in the paddy price. Stall feeding of intensively produced forages could be useful in this area.

Soils on the intermediate savannahs are of low fertility and have a fragile physical structure. Some also contain toxic quantities of aluminium. The erratic rainfall pattern in these areas often produces considerable runoff during intense showers. At the other extreme, drought stress occurs after relatively short periods of dry weather, since the waterholding capacities of the soils are low. Substantial progress has already been made in the development of improved pastures on these soils and, when the essential supplementary minerals are supplied to the animals, the pastures have been productive. A more detailed analysis of the problems and potentials of these soils is given in Annex 1c. A major proposition put forward is for research into a combined livestock and crop production system, using the stability which can be developed under pasture as the basis for traditional or novel methods of minimum tillage or sod-seeding.

This proposition has implications for the organization of the research needed, which must cut across traditional divisional boundaries. A multidisciplinary system approach is proposed; the consequences of this so far as research organization is concerned are examined in the next section of this report.

The immediate research emphasis should undoubtedly be placed on the production of feeds and on feeding systems, but some consideration should be given to whether the presently used breeds can thrive on feeds which can be produced in Guyana. An extreme example may make this clear. Under poor conditions and on poor feeds, water buffalo will survive but oxen may not. Under moderately good conditions, but on feed of low digestibility, water buffalo have been shown to outgrow and outyield oxen -- and to present fewer management problems. The superiority of the selected breeds of oxen under good management and on feeds of high energy and digestibility is not questioned. What deserves reflection is whether the overall value of highly developed stock (oxen), which is undoubtedly of high productivity under ideal conditions of feed supply and management, is sufficient to merit the effort needed to meet these requirements. Or would breeds and strains which can tolerate less than ideal conditions and moderate management, and which produce well on locally available feeds, have an advantage in the Guyana context of aiming at self-sufficiency and the minimization of import costs?

In general terms this subject is important, but of second priority to that of feed production.

Fishery Resources (Annex 8)

Guyana has both marine and freshwater fishery resources. Although the marine resources -- especially shrimp -- are known to be large, there has been virtually no work on the dynamics of the fish and shrimp populations. Little has been done to arrive at estimates of the sustainable catch levels at different seasons. Projects are being developed to increase the amount of by-catch landed and processed. Among other things, these should lead to the production of fish meal for livestock feeding -- the plant will have a capacity of 2,000 tons of meal per annum. However, it seems likely that it will be a long time before enough waste fish is landed to produce this quantity of meal.

Aquaculture projects with external support have demonstrated the potential of this form of production. Yields of Tilapia, in specially constructed ponds with supplementary feeding, produced about 2.5 t/ha in from 6 to 8 months at a cost which allowed the fish to be sold at approximately 40 percent of that of broiler chickens. The import cost of the food was not given. The most likely value of this work would be for protein production in areas away from the coast, although the price of Tilapia is appreciably less than that of sea fish and there seems to be no consumer resistance to be overcome.

Other possibilities for aquaculture developments are in the many drainage and irrigation canals, in flood-fallowed sugar cane fields and, to a lesser extent, in some rice fields. The major problem is that of theft of immature and mature stocks, a problem which besets many farm enterprises in Guyana.

Policy Choices

The analysis so far has focused on four main themes: (1) the appropriate subjects (and levels) for research, (2) the organization of research, (3) research personnel, and (4) research finances. The conclusions to this point, stated briefly, are as follows.

— Small countries cannot afford full-fledged programs on all subjects, so they must plan their research programs with care. The following considerations determine what kind of program Guyana might devote to any given commodity or subject:

- Current economic importance of the commodity to the country. For Guyana, sugar and rice are clearly at the top of most lists based on this criterion.

- Projected economic and social benefits to the country. For Guyana, strong candidates for inclusion on this list include integrated livestock/pastures, fisheries, and forestry.

- The prospect of good markets. Farmers will not produce commodities on which they cannot expect a reasonable return. Their considerations are therefore apt to be input-supply requirements, input-supply costs, labor requirements, and market prices.

- The probability of making progress within available resources.

- Availability of results from research programs outside the country. Guyana can benefit from work on rice being done at the International Rice Research Institute (IRRI), on cassava at CIAT, and on cowpeas at IITA. The challenge is to design local programs which make full use of such international knowledge.

Research activity in Guyana is now dispersed among a wide variety of institutions. Research priorities are unclear, there is some duplication of effort, and the critical mass of working scientists necessary for a vigorous program is lacking. (An exception to this generalization is the Guysuco sugar research program.)

A broad consensus seems to exist within Guyana that this situation should be rationalized. Research could be "concentrated" to a much greater extent than it is now. The questions are where, with what resources, and with what mandate?

-- Considerable scientific manpower exists within Guyanese agricultural research. The problem is that it is not being used to its full potential. Younger scientists have often been promoted into senior management positions, with the result that both science and management have suffered. The solution to this problem lies in two related types of action:

- Development of a management cadre within the Ministry of Agriculture. Members of this cadre would be responsible for provision of many of the support services which now divert scientists from research. Examples include the procurement of supplies, the organization of transport, and the administration of routine financial matters.

  Senior scientists would remain in charge of research programs, but the management of many nonscientific activities could be left to others. This management cadre should contain some graduates, although many of its members could be GSA diploma-holders. The latter particularly would have to be provided with good career prospects.

- Support for the development of a strong in-career management training program within Guyana. Since most entrants to the above cadre would have had no formal training in management, they would have to acquire their skills on the job.

There are some gaps in scientific manpower which must be filled. Most are at the middle level, since the young graduate now has little chance to develop his professional skills before he is promoted. His on-the-job training is minimal, because the people who might give it to him (senior-level scientists) are preoccupied with managerial tasks. Actions such as those described immediately above could contribute to solving both problems. In addition, Guyanese now in training abroad can be expected to fill some middle-level scientific positions, if conditions of service are improved within the agricultural research program.

-- Research requires stable resources. Agricultural research in particular must usually be planned on a multi-season or multi-year basis. The research scientist needs to have some certainty that he will be able to finish a project once he has begun it.

Three main alternatives exist for the funding of agricultural research in Guyana.

- The annual budget. This option is almost certainly the least desirable of the three, since it makes even a modest degree of multi-year planning difficult. The current policy of restraint in government spending is a weak base on which to build a strengthened agricultural research program.

- Production enterprises. The issue here is whether a research program with limited personnel resources can afford to spend time on nonresearch activities (for example, seed production). A major constraint on Guyanese agricultural research to date has been the fact that senior research managers have had to be involved in such enterprises.

Two actions will be necessary if such a funding alternative is to be developed. The first is the development of the management cadre: these professional managers would then have responsibility for revenue-raising ventures connected with research, leaving scientists to concentrate on new production-relevant technologies. Second, revenue-raising ventures must be separated from research: senior scientists should have responsibility for research alone, so that research programs can be well directed and so that the scientists can train younger scientists on the job.

A special tax. Several research programs outside Guyana have such a reserved revenue base. Examples include a fixed percent (for example, 0.5% or 0.25%) on one or more of the following: imports, capital gains, real estate turnover, agricultural exports, and land value.

This option is the most attractive of the three. Assuming normal economic activity, such a tax could guarantee to research at least minimum financial resources and a degree of stability. It need not encourage scientists to retreat into an "ivory tower," since the resources provided could be projected at the level required to carry out the minimum essential research program. Funds for other programs could then be secured through normal budgetary channels.

The government appears to have three major policy choices before it regarding agricultural research. Once these choices have been made, it can then move forward with the development of specific action proposals.

Policy Choice No. 1

The issue of subjects for research must be dealt with first. Considerations of organization, personnel, and finance all depend on that. Two broad options are:

-- A program which concentrates on sugar and rice, with only on-farm testing (Phase 1) provided for most other crops. Sugar and rice dominate the national economy because of their export earnings, their relation to diet, and their importance to employment. Such a limited program would have two objectives: to maintain product quality and to increase production levels.

   Urgency is the argument in favor of such a concentration. The country cannot afford a production decrease in either crop -- and the threat of disease and pest attack is always present. Intensive research might provide insurance against such disasters. In addition, research has the potential to develop technology which might improve yields and reduce the unit costs of production.

-- A program in which some research is done on sugar and rice, but which also includes "adaptive and applied" research (Phases 2 and 3) on several other crops. The difference between this approach and the one described immediately above is a matter of degree. How much work should be done in Guyana on crops other than sugar and rice -- and how much research (information) should be derived from outside? Regional organizations like CARDI, CCST, IICA, and UWI can be important complements to national research activities.

Some or all of the following commodity groups might then be included in such a multi-commodity program:

- Pulses: cowpeas, soybeans, and peanuts
- Cereals and cereal equivalents: maize, sorghum, and cassava
- Oil crops: coconut and oil palm
- Cotton
- Livestock feeding systems
- Fish
- Forests

No matter which choice is made, qualified people are required. The collection, interpretation, and adaptation of international information are forms of research in themselves. Each choice has obvious implications for the structure of the research organization.

Policy Choice No. 2

"Concentration" is the clearest issue in regard to such organization. How big is the research unit going to be? How much research is going to be done at a central station, and how much is going to be done on farmers' fields? There are two major options here:

— A large research unit, which would include extension and (perhaps) some input-supply services. These latter would come under the administrative supervision of regional authorities. Most research would be done at a central station, and extensionists would be responsible for the performance of field trials, distribution of results, and monitoring of implementation.

  The advantage of such a scheme is the formal link between research and extension, but there are three main disadvantages.

  - The managerial burdens on research would be high, since many nonresearch activities would also have important places in the organization. Part of this problem might be solved if the personnel reforms described above could be implemented.

  - There are not now nearly enough extensionists in the country.

  - The link between research and extension might be weaker than is planned, since the precise relationship between central and regional authorities is still being worked out.

— A small central research unit, which would depend on other organizations for the implementation of field trials and the dissemination of results. Examples might be area authorities (MMA), schools (the school farms program), and GNS. Research work in Phases 2 and 3 would then be done by the central unit, while Phase 1 work would be done by others. There are two advantages to this option.

  - little increase in staff would be required

  - the persons responsible for contact with farmers would be well-established already in the places where they work

One major disadvantage, however, is the considerable cost involved in providing means for central staff to monitor field research being done by persons posted throughout the country. But this problem could be overcome if improved transport and communication facilities were made available to agricultural research personnel.

Just as in the discussion of subject options, the choice made here will affect further decisions regarding the structure of the research organization.

Policy Choice No. 3

There are four broad alternatives as to where agricultural research should be located. They are discussed here in terms of their particular advantages and disadvantages.

Option 1 - the Institute of Applied Science and Technology (IAST)

IAST has considerable potential for making a contribution to agricultural research. It has an excellent centrally located building, an important fact if any role in the coordination of research is envisioned. Also, its laboratories are among the best equipped in Guyana. But IAST also has three major weaknesses.

-- It has few staff (three) involved in agricultural research.

-- Its program in agriculture is, therefore, limited.

-- Because it is new, it has not yet made serious demands on local financial resources. Its work has been largely funded by external agencies, with the result that it has not yet built up a domestic clientele.

One role which IAST might play in agricultural research is that of a program initiator. It could do preliminary work on commodities and problems not being handled by other agencies: for example, with the objective of handing over the most promising of this work and moving on. Its success would then be judged by the new ideas which it explored, rather than by the new technologies which it developed.

Option 2 - the University of Guyana

The University of Guyana Faculty of Agriculture (UGFA) has some of the same strengths and weaknesses as does IAST. Although it now has no physical reseach facilities of its own, it does have access to various well-equipped laboratories in the Faculty of Natural Sciences. Plans have also been developed for a large new building and adjacent farm to accomodate agricultural research and teaching.

But UGFA has several problems, which must be solved if it is to play a major role in agricultural research.

-- Its staff is small (nine). Since five out of six staff members with postgraduate degrees are not Guyanese, the medium-term stability is open to question.

— Staff members spend their time almost exclusively on teaching, with the result that they have little time to do research. No one on the faculty is involved at the moment in any field project.

— There is almost no contact between UGFA and the Central Agricultural Station at Mon Repos.

The faculty must be strengthened. Guyanese agriculture will continue to need scientific manpower, for which UG will be the most likely supplier. Educational are likely to take precedence over research tasks, at least in the medium term, but whether or not there is a need for the large new classroom-cum-farm facility now being planned is an open question.

There are examples where the association of an agricultural research institute with a university, both physically and administratively, has been successful.

Option 3 - A New Public Corporation

The "public service/sector" in Guyana is comprised of ministries and corporations. In the latter category, there are a large number of organizations which produce, process, or market a wide range of goods and services. Some have their roots in private companies (such as Guysuco), while others have always been public (such as GRB). As a result, management practices between them differ widely.

Two advantages of the corporate form of organization are often cited. They must be evaluated in any consideration of the future organizational form of agricultural research.

— Personnel. Public corporations in Guyana have historically had freedom to set their own salary scales and terms of service. They have been able, therefore, to hire the best people and to hold them. But this delegation of authority is now being slowly recalled through the government policy of "rationalizing" ministerial and corporation staff conditions. As the "rationalization" process continues, such conditions will become more similar.

— Finance. Corporations have always had more flexibility than have ministries in the way they manage funds, but this relative freedom is also being eroded. The current emphasis in government on "logical framework" budgeting, which is now being applied mainly to ministries, can be expected to spread to the corporation sector. Corporations in delicate financial cirumstances will probably be affected first. And as they are, conditions in the two parts of the "public service sector" will receive an added push toward convergence.

If agricultural research is to be placed in a new corporation, it should have plans for being self-supporting. All Guyanese public corporations are required to raise their own funds through the sales of goods and services. In the event that their revenues do not equal their expenditures, however, they are supposed to borrow on the open market (even though "emergency" transfers within the government and especially within the Guyana State Trading Corporation are not unknown). Where could an "agricultural research corporation" raise its money?

-- Seed sales. The conditions under which research might get involved in production enterprises have been detailed earlier in this section of the report. If these conditions can be met, the next issue involves the types of seeds. Rice is a possibility, though GRB now depends on revenues from seed sales, and obvious jurisdictional issues between it and a new corporation would have to be resolved. Crops such as cowpeas and peanuts also have possibilities, depending on the outcome of some prior market research.

-- Sales of research findings. The idea here would be that farmers should pay for services rendered, in much the same way that consumers now buy services from other public corporations. As a result, existing extension personnel would have to be included in any new organization in order to provide a field staff. The type of service which would be "sold" is "advice."

Such an arrangement would be difficult to set up and run. There are not many precedents or examples in other parts of the world. From a research point of view, among reasons for establishing such a corporation in the first place, one prerequisite would loom largest: scientists would have to have the freedom (and incentives) to concentrate on science, while the management of the corporation would have to be left to managers.

Option 4 - The Ministry of Agriculture

The most important fact to be considered in an analysis of the Ministry of Agriculture is that it is part of the public service. It would operate, therefore, within the context of normal public service rules regarding such matters as personnel and finance.

-- Rules on the recruitment, pay, and careers of Ministry of Agriculture staff are set now by the Public Service Ministry (PSM). Senior managers have little discretion as to how they handle employees. One of the purposes of the 1982 budgetary procedures -- which require that all employees be classified in broader categories than has previously been the case -- is to give senior managers a degree of flexibility (at least in recruitment). But more freedom is still required in matters of job specifications, job descriptions, and promotions.

- Senior managers must be able to be chosen from the ranks of either middle-level managers (preferably) or top-level scientists (in exceptional cases).

- Employees without degrees must be able to move into (at least) middle-level managerial and some scientific positions.

- Promotions must be based on criteria set by the research program, rather than by an outside agency.

The question is: Can an agricultural research program within the Ministry of Agriculture meet these conditions? And the answer almost certainly is: Only if the Ministry of Agriculture takes the initiative to develop an innovative personnel plan for agricultural research, which it then "sells" to PSM and the State Planning Commission. Such an initiative would appear to have a good chance of success.

— Finance. The Ministry of Agriculture now budgets its recurrent costs on an annual basis, as do most public organizations. But such a procedure is not completely suitable for an agricultural research program, as described above.

  How might the Ministry of Agriculture provide agricultural research with at least some degree of financial stability? Two possibilities are discussed above, production enterprises and a special tax. Any proposal to restructure the agricultural research program in Guyana must deal with this issue, and the resolution must be acceptable to the budgetary authorities.

The choices to be made are difficult ones, but the rebuilding of the Guyanese research system depends on them.

Conclusions and Recommendations

The first section of this report examines the need for developing the agricultural research service to meet the needs of the major established industries, to help to develop the production of other crops and livestock, and to bring currently unused areas of land into production. The types of research which are considered realistic, given the resources Guyana can deploy, are outlined within a systematic framework. It is postulated, on the basis of the experience of many research systems in many countries, that a number of specific conditions must be met before national research systems can function with maximum efficiency. Briefly, the first requirement is a well-defined agricultural development policy from which an agricultural research policy and appropriate research programs can be developed. Key elements for the efficient implementation of research programs are (1) assured funding and (2) an adequate number of trained research workers who are organized into groups of critical minimum size and who have adequate resources of buildings, equipment, and transport.

The current situation in Guyana is analyzed (in the second section) in light of the needs for research activities and the extent to which these needs are being met. There are many shortcomings, but there are also a number of positive features.

Perhaps the biggest single weakness is the lack of a specific and consistent research policy. Without a dynamic policy, there is little chance of gaining the support of the many persons who are involved in decisions which affect the functioning of the research system.

The present situation is characterized by the dispersion of people into a large number of units in which they have managerial and production responsibilities. These people can do only a limited amount of research, mainly of an on-farm adaptive kind. In addition, research staff in the Ministry of Agriculture and GRB have been given many duties which, although essential components of the production process, cannot be considered as research. This has lead to a dilution of the research work, which has resulted in a reduction in the amount of early adaptive or applied research (Steppler's Phases 2 and 3), and a lack of balance between the amount of on-farm adaptive work and the applied research effort. The effects of this decline in supportive research is already being noticed in the on-farm program.

Work has been hampered by shortages of equipment (particularly of transport) and of facilities at the field level in some development areas. Uncertainty about the provision of operating funds (total amount and time of release) has been a serious problem.

There are, however, some positive features on which to build:

-- There is good recognition within the Ministry of Agriculture and by the government as a whole of the need to improve the effectiveness of the research service to provide the sound technological base for agricultural development projects (some of which have suffered serious setbacks because of lack of such a base).

-- Senior manpower resources in agriculture and the related sciences are reasonable both in terms of total numbers and spread of qualifications. If these persons were brought together, it would be possible to plan appropriate research programs. These persons are presently widely dispersed (administratively), and few are doing active research. To bring them back into a research unit would create manpower problems in other areas. These problems might, however, be less difficult to overcome than those which currently exist in the research sector.

-- There are substantial numbers of persons being trained to the diploma level in agriculture. With additional training these persons could do a large amount of the Phase 1 (on-farm testing) work, provided that they could be supervised effectively and that research staff were available to design relevant programs.

-- Lack of funds does not appear to be as serious a constraint as does the lack of a clearly defined program and the necessary concentration of research staff to carry it out. In that context, it is important to add that the total funds actually being used in research activities do not approach the 1.0% of the gross agricultural product often regarded as a reasonable measure of adequacy*.

-- Physical resources of buildings, land, and ancilliary services are adequate -- with minimal re-equipping -- to house a research unit of modest but potentially effective size.

-- Progress has been made in some of the difficult research areas despite all the problems. Improved pastures of high stock-carrying capacities have been developed on the extremely difficult soils of the intermediate savannahs, and possibilities for the production of individual crops (and reasons for the exclusion of others) have been identified;

-- The sugar industry (which has its own separate research unit) has demonstrated in a convincing manner the value of research support of a long-term nature; it has been able to overcome to a large extent the severe disease problems which have beset the crop over the past few years.

Some possible program areas have been examined and some proposals are made in the annexes to this report. These are not intended as project proposals and are given in outline only. Additional research support is urgently needed in both the sugar and rice industries.

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*World Bank. 1981. Agricultural Research Sector Policy Paper. Washington, D.C.: World Bank.

The third section of the report defines a number of areas in which it is believed that decisions need to be made at the national level, in order to promote the development of an effective agricultural research system. Some of these are related to the weaknesses revealed by the analysis of the current situation.

For each decision a number of options are presented. Firm recommendations on the team's preferred choices are not given. It is felt that it is difficult for any review team to assess adequately the relative weight to be given to each of the identified strengths and weaknesses of the several options. The stress throughout is, however, on functions rather than on forms, since the essential conditions set out in the first section should be met for whatever form is adopted. The precise form chosen should permit:

-- Policies and programs to be developed;

-- qualified personnel to be attracted, recruited, and trained;

-- secure and regular funding to be obtained for development of the institutional base, maintenance or improvement of disciplinary research competence, and implementation of agreed programs of research;

-- and effective information flows within, into, and out of the system.

The team believes, nevertheless, that some firm recommendations can be made. And the following are set out:

-- A short, clear definition of agricultural research policy, dealing with what types of research and with what major objectives, should be drawn up as soon as possible and publicized.

-- Research on sugar cane should remain the responsibility of Guysuco; the corporation should be given full support in its efforts to strengthen its research team.

-- Every effort should be made to concentrate research activities into some form of central unit so that an effective critical mass of scientists can be located in one organization. It is strongly recommended that this unit should contain divisions or groups of persons to work on:

  - continuous updating of the natural resources data base (includes soil surveys and agrometeorology);
  - crops;
  - soils;
  - livestock;
  - fisheries (freshwater especially);
  - agroforestry in cooperation with the Ministry of Forestry, in interdisciplinary teams.

-- Serious consideration should be given to locating responsibility for rice research in this central unit rather than in GRB.

-- The unit should have an administrative support group of sufficient caliber (at least one senior administrator) to deal with all nonresearch aspects of the operation of the unit and its experimental farms and sites. The researchers have to be able to concentrate on planning, implementing, and reporting the research work, which must at all times be relevant to needs.

-- The central research unit would have several different but complementary functions, among them:

- to provide technological advice on which agricultural development policy could be based (note: research workers do not make development policy decisions);

- to review and interpret the world information base on subjects of interest to Guyana and to use the information to devise programs appropriate to specific agro-ecological conditions, that is, to support applied and adaptive research at the central and many on-farm level locations;

- to provide multidisciplinary research teams to service (work at for variable periods) a few experimental sites, (for example, in the intermediate savannahs, riverain terraces, coastal plain, and upland areas);

- to carry out adaptive and applied research on components of farming systems;

- to interact with the extension service to ensure the relevance of the research programs to production needs and the rapid dissemination of research findings.

These tasks can only be done by experienced persons. If the numerous personnel engaged in the on-farm trials program are not part of the research organization, the unit may appear to have too many senior staff in relation to its total size. It is most strongly recommended that full attention be paid to this point when a decision is made on the organization of the unit and its affiliation. It is essential that the qualifications and experience of the staff should be appropriate for the research functions they are to perform.

-- The central unit would be called upon to service work at many sites throughout the country. The need for good transport and communication facilities cannot be overemphasized. It is recommended, therefore, that the unit should have a transport pool and travel provisions substantially greater, in relation to its total staff complement, than those normally provided within the public service (the provision should be similar to that made in the state corporations).

-- Since research staff will be required to live and work away from base for periods (often lengthy), it is essential to make reasonable provision for comfortable living and good working accommodation at each major research site. Ebini is an example where such facilities are needed. It is recommended that the provision of such facilities (to be occupied on a rotational basis as required) be regarded as an essential requirement of the research organization.

-- The provision of adequate and assured resources for continuous operation is one of the main requirements for the central unit. Several possible institutional arrangements for the affiliation of the central unit are discussed in detail in the third section of the report. The team would support whichever option would have the best chance of providing these essential components. It recommends that full attention should be paid to the:

- advantages of research being a part of the Ministry of Agriculture, not the least of which would be the maintenance of the linkages with extension services;

- need to include extension and education in the research unit -- if the unit is not located in the ministry;

- need to establish firm linkages with seed production and plant protection services at the professional level to avoid the duplication of experienced professional staff; research staff can reasonably be expected to do some diagnostic and advisory work on particular technical problems.

Annex 1a

NATURAL RESOURCE BASE OF GUYANA

Introduction

The natural resources and the environment of Guyana are far from being favorable to agricultural development.

Guyana is divided into five natural regions, based on geomorphology and physiography, as a result of past and more recent (quaternary) paleoclimatic variations and erosion cycles (1).

The coastal plain, from 1 to 50 km in width along the seacoast, covered with recent fluvio-marine sediments (from the Amazon); the large part is below mean sea level.

The "white sand" plateau and older peneplain, including the "intermediate savannahs", covers extensively the northeast region and extends partially as remnants into the northwest with white sand deltaic deposits over brown loamy sand to sandy clay sediments; the brown sand and clay sediments occur over the plateau and extend south to the foothills of the Kanuku Mountains.

The highland plateaus and mountain in the central west with the Parakaima Mountains tableland relief, highland relicts in the central part, the Kanuku Mountains in the southwest, and the Serra Acarai in the south dividing the Essequibo-Amazon basins.

The crystalline shield upland, representing the "Guyana peneplain" between the two preceding regions, is separated by the Rupununi-Ajotai-Kumaka alluvial plains. The hilly, densely dissected and sharp valleys -- resulting from different old erosion cycles and more recent erosion cycles along the lower part of the basins and valleys -- are the two basic geomorphological units of this region dominated by tropical rain forests.

The interior alluvial plains and lowlying lands. Large areas of flat lands, at different base levels controlled by the line of falls, form wide alluvial plains. The southern savannah Rupununi-Takutu plain, the northern savannah Rupununi alluvial plain, and the central Apoteri-Kumaka plain are among the most important ones. Locally isolated alluvial plains occur over the Parakaima plateaus (Kamarang-Kukui), the upper

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(1) Food and Agricultural Organization. 1965. Report on the Soil Survey Project - British Guiana.

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Mazaruni, the Potaro above Kaiteur falls. Between the Pakaraima's escarpments and above the second level of falls (Matope-Rockstone-Tibuko and Great Falls), most of the large rivers (Cuyuni-Essequibo-Mazaruni) have developed fluvial plains forming extensive flooding areas.

Soils and Soil Constraints

The major source of information available is the 1965 FAO survey describing 99 different types of soils updated to the seventh approximation. Many efforts (more than 130 surveys) have been made since 1965 on detailed or semi-detailed soils and land use surveys for specific development projects in the main agricultural area of the country, the coastal plain and the intermediate savannah, and the valleys in the Parakaima area. The main agricultural region of Guyana is the coastal plain, where more than 90% of the population and agricultural activities are concentrated.

The coastal plain soils of fluvio-marine origin (front land clays) are of heavy clay and silt texture with a poor drainage, a relatively high fertility but with acid sulfate-, aluminum-, or salt toxicity and limited free phosphorus. Bog soils and peat and muck "pegasse soils" occur mainly in the inner part and extend mainly in the northwestern area of the coastal plain. Sandy soils ("sandreefs") of alluvial-dune origin, suitable for vegetable food crops and coconuts, are extensively represented along the coast between the Berbice and Corentyne rivers.

Along the main river, alluvial clay-silt deposits with better natural drainage are easy to crop; they were the first to be cultivated in the Guyana plain.

The pegassic clays are intrazonal black hydromorphic soils with more than 60% to 80% of organic matter of different nature, defined by low fluctuation of the phreatic table and movements of superficial water.

Before the use for agriculture of the heavy clay soils and the establishment of a drainage-irrigation system (polderization) by the Dutch settlers, the littoral soils were highly toxic either because of excess salt, high acidity (humic and sulphuric acids) or high quantities of iron and aluminum sesquioxides. With more than 60% clay, the poorly drained acid soils of the coastal plain have an acceptable and even high base saturation but are deficient in phosphorus. However, with lime and fertilizers, water control, and management practices, these soils can be highly productive; they are in fact the best soil resources of Guyana (sugar and rice production). The clay soils and pegassic soils are unequally distributed. In the eastern part of the coastal plain, presently empoldered clay soils cover a large alluvial plain between the Demerara and Corentyne rivers. In the western part in the Essequibo area and further in the Pomeroon area and the northwest, clay sediments become more rare and are replaced by pegassic peat and muck soils of low fertility.

The interior plateau belongs to the "white sand sub-continental old deltaic deposits" composed of white and brown sandy soils, the former overlaying the latter. The white sands and the brown sands (yellowish-red sandy clay or sandy loams) are highly acid and deficient in N, P, K, and Mg, and have a high level of exchangeable Al and a low water-holding capacity with fast oxidation and mineralization of organic matter. Since they are deficient in major trace elements (Zn, Bo, Mn),

these soils tend to "crust" after being cleared, and the chemical subsoil barrier (low cation-exchange capacity and base saturation) restricts root penetration. The so-called intermediate savannahs (probably derived savannahs), which are mainly in the northeastern part and consist of sandy soils with different levels of clay, have been intensively studied (Kimbia-Ebini) and might have some potential for pasture and some crop production. In economic terms, the crop productivity of the intermediate savannahs is suspected to be marginal in view of the high inputs and careful management practices necessary to produce reasonable yields.

The soils within the triangle of Bartica and the lower Cuyuni-Mazaruni, and upstream of the Essequibo, Demerara, and Berbice rivers, are generally poor and essentially composed of white sand. Dry evergreen seasonal forest on these soils are in a fragile equilibrium, since there is a tight nutrient cycle between the vegetation cover and the soils. When these areas are cleared or burned, fertility declines rapidly and intensive exploitation or shifting cultivation of these forests would rapidly start an irreversible process of savannization, erosion, and degradation. (The "green desert" of exploited Wallaba forest near Linden is an example of the early stage of this process.)

The soils of the crystalline shield upland region, mainly covered by tropical rainforest, extend from the northwest (Wauna Station) through the southeast upper Essequibo-Corentyne river basin beyond the Rupununi-Apoteri-Kumaka interior alluvium plains and lowlying lands. The soils are mostly red-yellow podzolic infertile and red-yellow latosoils with low fertility and severe limitation for agricultural uses. However the latter, mainly in the northwest, have good physical characteristics and could be used for tropical tree crops with fertilization and adequate soil crop management (Wauna).

The interior alluvial plains and lowlying lands region of the Rupununi-Apoteri-Kumaka rivers, upstream from the falls line, are mainly hydromorphic recent sandy, clayey, and silty alluvions, with a low fertility, periodic flooding during the rainy season, and serious drainage problems. The soils of the highlands, mountains, and plateau region of the Parakaima mountain in the central west, the Manuku mountain in the southwest, and the Serra Acarai, are reddish-brown lateritic and brown latosoils with different levels of base status. All these soils are poor and of low fertility or are difficult to cultivate. This difficulty is due either to the fact that the soils are shallow and gravelly or to their location on steep slopes (erosion). The most fertile and well-drained soils of the interior of Guyana are located in the northwest foothills of the Kanuku mountains (Nappi Village) and the area around the springs of the Kwitaro rivers. These relatively young reddish-brown lateritic soils, suitable for agriculture, are confined to limited and small areas. In the deep south and southeast of Guyana, the rainforests are richer and higher, and the rivers have clear water with rich fauna (fishes); this indicates better soil conditions (pH7) and likely better fertility.

To sum up: Apart from the soils of the coastal plain, the agricultural potential of the soils of Guyana is low with few exceptions, and the soils have low capabilities to produce crops economically on a commercial scale. Only the fluvio-marine soils of the coastal plain, presently under intensive drainage and irrigation control, are suitable for highly productive agriculture and are deserving of increased research and development efforts. The brown sand soils of the intermediate savannahs,

red-yellow podzolic, and humic clay alluvial soils accessible by roads or navigable rivers merit some further attention, provided that costly inputs (fertilizers, lime) and adequate soil management and cropping techniques prove to be economically feasible, or provided that the social benefits are considerable. (Annex 1c)

The bulk of the soils of Guyana should either remain under their present natural vegetation cover, or be used for extensive cattle grazing or carefully managed shifting cultivation systems.

Determination of local variability is of key importance to using the complex mosaic of heavy clay soils of the coastal plain more intensively with better management of soil and water technology. Soils with limited potential (in particular the fragile forest ecosystems) should be treated with great care. They should be protected or maintained "untouched" in order to impose a hydrological regulating regime for avoiding catastrophic floods in the coastal plain.

Climates and Weather Constraints

Between 1 and 9 degrees latitude north, the climate of Guyana is tropical humid. Rainfall is bimodally distributed through the country, except in the southwest Rupununi and the western Parakaima areas. Annual rainfall is 2,400 mm in the coastal plains with four seasons: two rainy and two dry. This rainfall pattern is not uniform along the coastal plain; it decreases from west to east, with a reduction of the rains in December to January and with great variation in the short dry season in February to March.

Large irregularities are to be noted between years; there may be one or several consecutive dry years, with practically no rainy season in December to January (1882-83; 1899-1900; 1915-1916; 1925-26; 1938-39; etc.) or, inversely, intensive rains during the same period, which are catastrophic for both the drainage system and crop production. These irregularities and unpredictable variations exert a strong detrimental effect on agricultural production, in particular on the production of the major food crops (rice, cowpeas, peanuts). Heavy rains from February to April which is, on average, a dry period, prevents timely land preparation. Intensive rains during June to July and August flood the low lands and can be responsible for severe sheet erosion in the sandy soils of the interior. Greater than average rainfall occurs during harvest time (September, October, or March), or below-average rainfall occurs in the growing season in November to December at least two years out of five.

In the rainfed agriculture, under the unpredictable variability in quantity, intensity, and time periods of rainfall distribution from one year to the other, it is difficult to define cropping calendars and to anticipate yields.

The bimodal pattern in the interior is similar to the one described above for the coastal plain, with an annual average of 2,250 mm, with 40% to 60% falling during the long rainy season and less than 20% during the short rainy season. There is similar unpredictable variability in starting dates, duration, and intensity of both dry and rainy seasons.

In the intermediate savannahs the mean annual rainfall varies from 2,250 mm to 1,650 mm (Mara Station), with two rainfed cropping seasons per year for annual crops. The first begins in mid-April with harvesting in September to October; the second is much shorter, from mid-November with harvest in March and April, also irregular with the harvesting period disturbed by unseasonal rains. The unreliability of rainfall, low water-holding capacity of the sandy soils, low relative humidity (afternoon), and high sustained winds result in relative drought conditions in September to October and February to March. In the Rupununi savannahs in the southwest of Guyana, the rainfall of 1,400 mm has a unimodal pattern with a long dry season (September to April) and a four-month rainy season (May to August) with more than 330 mm per month. September to October is a transition period (25% of rainfall), while January to April is completely dry.

The Parakaima area at 600 m altitude has a moderate bimodal pattern with approximately 2,500 mm annual rainfall and two relatively dry seasons. In comparison with the other regions, the area is generally cloudy with large amplitudes of temperature. Few meteorological data are available for the Parakaima area.

As in all humid tropical areas, rainfall distribution and variations are more important than the relatively constant temperatures, which have an annual average of 26.8 degrees in Georgetown, 26 degrees in the rainforests, 28.1 degrees in Rupununi, and 24 degrees in Parakaima. The diurnal variation does not exceed 8 to 10 degrees except in Rupununi, with 14 degrees, and Parakaima, at 600 m above sea level.

Winds are regular and generally from the east-northeast, with some variations in velocities according to the season. Accurate records of evaporation, evapotranspiration, sunshine, and soil temperatures are lacking, in spite of their importance for agriculture. No microclimatic data nor agro-bio-climatic studies have been recorded in different environments or in crop fields.

In spite of the high rainfall, the major constraints of the climate of Guyana are the irregularity of total rainfall between pairs of consecutive years and the unpredictability of its occurrence.

These factors make it difficult to define crop calendars accurately, so risks to production are unusually high. On average probability, the rains in November are insufficient for planting to be done under good conditions in three years out of five. Rainfall shortages occur once every four years during June to July, and once every two years in August. Excess rain during the dry periods of September to October or February to March are likely to damage harvest operations in two years out of five.

The unpredictable variability (both within and between years) of the rainfall at crucial time periods of cropping operations and crop growing cycles compromises yields which are, therefore, likely to be extremely variable from one year to the other, particularly under rainfed conditions.

Annex 1b

HYDROMETEOROLOGICAL SERVICE

The hydrometeorological division, in the Ministry of Works, is divided into two sections: one for hydrology and one for meteorology. The latter includes three sections: climatology, agrometeorology, and aerometeorology.

Data recording and processing is not computerized in the climatology section, which has a total of 40 professional and subprofessional established posts.

The agrometeorology section, which is run by six professional and subprofessional staff, is the smallest section of the division; the post for the chief of the section was vacant at the time of the team visit. Agrometeorological research programs and activities are limited because of a shortage of staff and, in particular, the loss of the chief of the section. In the past the chief had conducted some research related to agriculture by analysis of rainfall data on a five-day period basis in Ebini.

Little work of a cooperative nature has been done between the agrometeorology section and the different agricultural research services -- except with projects at Ebini, MARDS, and Wauna. The meteorological network in Guyana has eight synoptic stations (Georgetown, Timehri, New Amsterdam, Ebini, Mabakuna, Kamarang, and Lethem), and a large network of rainfall stations is mainly concentrated in the northern part of the country. This network is under the control of the climatology section, responsible for data recording, processing, and archiving.

The major problems:

- -- How to organize an appropriate training program for technicians and professional staff. Presently the climatology section has several staff under training at different levels, three for postgraduate, two for B.Sc., two for degree preparation to B.Sc., and two for program forecasting;
- -- Most graduates who leave the country for postgraduate training do not come back, and most of those promoted to senior positions leave after a few years;
- - The concept of seniority in Guyana is still for administration responsibilities, so that most staff coming back after postgraduate work are involved more in administration than in technical work. If they wish to perform some research they are told that they have to do it outside normal working hours.

Several factors suggest consideration of the idea of an automatic weather station network in Guyana, to be run by the agrometeorology section. Among them: lack of communications with the interior, the difficulty of controlling the work of the field staff, and the need to develop, with

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limited personnel, more accurate records of weather data as a base for improving interpretation of agricultural work.

The present agrometeorological network does not provide data suitable for the accurate interpretation required by agricultural research, since most of the stations record only rainfall and temperature.

The major hope for improvement of the agrometeorological section is the possibility of a UNDP/WMO project to improve the service through computer facilities for storing and analyzing data as well as for strengthening the agrometeorological work and data processing for crop monitoring and forecasting. This project is presently under review by the Ministry of Finance, but some doubts have been expressed concerning its final approval.

There are two urgent requirements:

-- The strengthening of the agrometeorology section with two additional professional posts for agroclimatology research and crop forecasting;
-- the approval and rapid implementation of the UNDP/WMO project.

In addition:

-- Consideration should be given to the establishment of mobile automatic weather stations at Mon Repos, Ebini, and other sites, with the possibility to move them into other experimental areas as needed for periods of up to three years.
-- A joint research program in soil/crop/weather relations should be set up between agrometeorological and agricultural research.
-- There is a need for accurate weather predicting sources, particularly for the coastal plain and the intermediate savannahs.
-- Measures need to be taken to increase the amount of data available and to develop more elaborate studies in agro-bio-meteorology to characterize weather patterns and soil/water/plant relationships through simulation modeling and to forecast crop operations and yields with more accuracy. The definition of microclimatic cropping environments from accurate agrometeorological data correlations with soil/crop management techniques to define more precisely the timeliness of cropping system operations, is known to be important in relation to the incidence of blast disease of rice in the coastal plain.

Annex 1c

INTERMEDIATE SAVANNAS

Introduction

The intermediate savannas are characterized by rolling to gently rolling topography, and range in vegetation cover from open savanna to a rather sparse scrub savanna with what appears to be typical forest subclimax vegetation. The soils are mostly coarse-textured, ranging from sands to sandy loams, and are characterized by low cation-exchange capacity, high percent aluminium saturation, low base saturation, and low available phosphorus and most other nutrients. They are low in organic matter and structurally highly unstable. The climate is hyperthermic with an annual rainfall reported to be 2,250 mm, distributed in a bimodal pattern with the main wet season from April to September and the driest period in October. There is another dry season in February and March.

Present activities in the area center on annual crop production at Kimbia, with emphasis on cotton, cowpeas, peanuts, and soybeans, and on cattle production at Ebini, including both beef and dairy activities based on improved pastures. Relatively little research is being conducted at present in the intermediate savannas, even though heavy investments are being made in production units. There is an obvious need for systematic research as a prerequisite to further expansion of commercial production in order to avoid many of the costly mistakes of the past.

Annual Crops

The production costs for annual crops are likely to be relatively high because of the low native fertility of the soil, low organic matter content, strong acidity (therefore the need to lime for most annual crops), low cation-exchange capacity (thus, poor retention of mobile nutrients such as potassium and nitrogen), and high cost of inputs at the production site.

Cost of inputs, as well as price of crops depend on world prices, on government policy relative to subsidies, and government initiative in the development of new access routes for a transport system for the river. Costs are also likely to be high initially because of the low volume of production (which is hard to overcome as long as costs are high).

Other problems with annual crop production are related to climate. Insufficient rainfall at planting time and excess or out-of-season rainfall during the harvest season are detrimental to crop quality. Pod diseases and rot organisms are common in the grain crops if rain falls during the normal drying period. Cotton is subject to stringing, staining, rotting of the fibers, and severe losses if subjected to heavy

rains during the harvest period. Drought stress is possible, even during relatively short periods, due to the low water-holding capacity of the sandy soils, the acid low fertility, and sometimes compact high bulk density subsoils that limit root penetration.

Heavy rainfall during the growing season also complicates fertilizer management by making it difficult to maintain adequate nutrient concentrations for the growing plants, especially of nitrogen and potassium. It also leads to loss of nutrients from the rooting zone due to leaching. Heavy seasonal rainfall and intense storms, combined with rolling topography, result in high erosion when the soil surface is left unprotected during land preparation and prior to establishment of complete crop canopy.

In summary, it appears that for crops to be an attractive alternative and economically feasible in the intermediate savannas, several conditions are necessary: (1) high yields of relatively high value crops must be achieved to compensate for high production costs; (2) cropping systems must be developed which will minimize the requirements for fertilizers and other purchased inputs; (3) tillage and cropping systems are required which reduce erosion hazards to acceptable levels.

Despite many problems, there seems no reason to be too pesimistic about the potential for crops in the intermediate savanna area. The climate is favorable to crop growth during much of the year, although the erratic nature of rainfall is not. It may be that the wrong crops have been chosen. This points to the need for systematic and well-structured research programs to develop a sound basis for commercial production.

Perennial Crops

In view of the problems associated with annual cropping, it appears advantageous to look at the potential for perennial crops, including pastures, and at the possibility of integrating livestock and crop farming to develop ley-type rotations of relatively long duration.

Potential Advantages of Well-Adapted Perennial Crops

The soil can be protected year-round. There is no need for annual or seasonal seedbed preparation, with the attendant erosion hazard and cost. Plants are growing year-round whenever moisture is adequate, thus taking up what nutrients are available in the root zone and reducing leaching losses. Nutrient rate requirements are not so high as with annuals, which must accumulate all their needs in a relatively short time, and thus have high requirements during their grand period of growth. Perennials accumulate nutrients year-round, and store enough in the living biomass to meet much of their needs at different stages through redistribution or translocation.

Research Priorities

Annual Crops

There is a need for the systematic screening of species and cultivars for climatic and edaphic adaptation, for resistance to diseases and insects, and for yield potential and stability. A number of annual crops appear

to be well-adapted climatically, at least as far as vegetative growth is concerned, and to grow well when the soils are limed and fertilized. However, yields are disappointingly low and production costs are high. Agronomic research is needed to pinpoint the causes of low yields and to explore means of overcoming the restraints to higher yields. These may be nutritional, but are considered more likely to be related to climatic factors, such as day length and day and night temperatures. There may be cultivars which are much better adapted to the environment than those presently used. The testing of IITA cowpea lines is an important and logical step which has already been taken. It should be expanded, along with similar efforts with cotton, peanuts, and soybeans. This screening should be done in a systematic way, making maximum use of materials from international centers and national agencies working in similar ecosystems.

Among criteria for the selection of plants are tolerance of soil acidity, high percent aluminium saturation and low base saturation, and low available phosphorus levels; and the ability to root deeply and compete aggressively. Tolerance to acidity is of special importance because of the difficulty and high cost of liming acid subsoils. Even after the plow layer is limed, nontolerant plants will be unable to exploit the subsoil for moisture and nutrients that may otherwise be lost to leaching.

Croppin[illegible] [illegible]stems

Many factors point to the need fo[illegible]ch on rotational ley cropping systems in which crop and livesto[illegible]ng are integrated and annual crops are rotated with pastures i[illegible]tively long rotations of perhaps four to six years, with a ratio of pasture to crop of 4 to 1 or more. The optimum length of rotation and ratio of crop to pasture will depend on cost of pasture establishment; effect of pasture duration on fertility buildup; resistance to erosion; control of weeds, insects, and diseases; effect of cropping time on erosion, disease, and pest buildup; and the relative value of livestock and crop production. Pastures should include legumes to improve forage quality, especially in the dry season, and to supply nitrogen for the system. The pasture phase would improve soil fertility, increase fresh organic matter content, improve soil physical conditions, and help control soil erosion. During both crop and pasture phases, most of the mineral fertilizer for the rotation should be applied to the crop. The pastures are capable of efficiently utilizing the residual fertility and recycling it, concentrating it in the biomass, and leaving it in a relatively available organic form for the subsequent crop cycle.

Major emphasis should be placed on the transition phases from pasture to crops and back again to pastures. Important questions that arise include: What kind of tillage is most efficient? Can crops be planted into pasture with no tillage, substituting chemical control for mechanical control of pasture species? Can pasture species be undersown or interplanted with the last crop in the cycle to minimize loss in nutrients and time required for the transition back to pastures?

Tillage and Planting Systems

The high cost of machinery and fuel, along with the erosion hazards associated with traditional land preparation and clean cultivation of crops, are compelling reasons for studying alternative tillage systems. Minimum or zero-tillage systems have been used successfully with most of

the crops of interest in the intermediate savannas. The major advantages are reduced erosion hazard and lower cost of production. In periods of moisture stress, no-till planting systems usually result in higher yields than conventional tillage and planting. The equipment required is relatively simple, and suitable herbicides are available for most crops. The time between crops in year-round cropping systems can be reduced to near zero; planting immediately behind the harvest is common, an important factor when timing is critical -- as it appears to be in certain seasons and for some crops in the intermediate savannas. When it is necessary to incorporate lime or phosphorus the zero-tillage system is broken, but this need not be more frequent than once every three or four years or -- in the case of ley cropping -- once in the rotation. (Reference: work on minimum and zero-tillage at the University of Kentucky, University of Ohio, Virginia Polytechnic Institute, all in the United States, and others).

It may be possible to grow some crops with a living mulch (cover crop) or with only chemical supression of a pasture which would recover after the crop is removed. A living mulch protects the land and utilizes the residual fertility from the crop. This technology has not been thoroughly developed and is more complex than other zero or minimum tillage systems. (Reference: IITA annual reports, bulletin by Rathan Lal, et al, regarding minimum tillage in the tropics, proceedings of conference on conservation of soils in the tropics, IITA.)

Mulch tillage. This is another practice that can reduce erosion hazards and tillage costs, and it may merit testing in the intermediate savannas. The major implements are chisel tines and stubble-mulch sweeps, which are mounted on a field cultivator frame and used to loosen the soil and control weeds while maintaining nearly all crop residues on the surface to protect the soil from rain impact, sealing, crusting, and subsequent erosion. Planting through the mulch is accomplished with disk openers or rolling coulters capable of cutting through the trash to prevent fouling of the planter sword.

Perennial Species

Special emphasis should be given to pasture species, both grasses and legumes. A systematic screening of species and cultivars for climatic and edaphic adaptation or resistance to diseases and insects, and for yield potential and quality is a necessary first step. Criteria for the selection should include the ability of pasture species to compete with weeds, their compatibility with associated species and grass legume associations, and their performance under grazing management. The selected perennial species should be studied systematically as resources permit. The crops which are known to be well-adapted to relatively acid, infertile conditions include coconuts, oil palms, citrus, cashews, and mango, but these crops should probably receive secondary priority at this stage.

Maximum advantage should be taken of the work of other national institutions dealing in similar ecosystems and of the International Center for Tropical Agriculture (CIAT), headquartered in Colombia. CIAT has an extensive network of regional trials of large numbers of germplasm entries over a wide range of ecosystems.

The excellent condition of the large area planted to Brachiaria humidicola at Ebini is encouraging. However, it is unlikely for cost reasons that it will be feasible to use nitrogen fertilizer on pure grass pastures on a large scale; so high priority should be given to the development of grass legume associations in which well-adapted legumes can provide the needed nitrogen for the system. It is difficult to find legumes sufficiently aggressive to compete with Brachiaria humidicola; the most promising species to date are in the Desmodium genus, specifically Desmodium ovalifolium and possibly Desmodium heterophylum. There are other grasses which are likely to do well in the intermediate savanna ecosystem, especially in rotations with annual crops where fertility levels would be considerably better than those feasible for straight pasture systems. There are a number of Brachiaria species which should be tested. It is possible that Andropogon guianensis would do well in this environment, perhaps some of the Panicum maximum would also do well in rotation with crops, since Calopogonium seems to do well. It is likely that kudzu Pueraria spp. would also be well-adapted; if these two aggresive trailing legumes can be properly managed, they might be combined in highly productive associations. Collections of legumes and grasses which are likely to be suited to a given ecosystem are available from CIAT, and the Ebini station could be included in their system of collaborative regional trials. The cooperator has the advantage of receiving information from trials in similar ecosystems, which provides valuable leads for the identification of most promising material.

Livestock

The main limiting factor in cattle production appears to be nutrition. Disease is not a serious problem. The potential of the Brahman and crossbred cattle is good, and they are well adapted to the environment. Thus, relatively low priority should be given to cattle breeding until such time as nutritional problems are clearly solved and the potential of the breeds becomes a limiting factor. Animal health should be carefully monitored, since it may develop that with increasing intensity of management more animal health problems will occur. But most of them are likely to be easily controlled by using well-established technology.

Initial emphasis should be on pastures. Selection of appropriate species or cultivars, establishment, maintenance, pasture renovation, and grazing management are all crucial elements of a successful pasture program.

Organization of the Research Program

Some problems of the organization of the research program need to be addressed. There is a pressing need for greater integration of livestock and cropping research, as well as the integration of livestock and cropping systems. At some point it would be desirable to have a pasture research team which would be multidisciplinary in its makeup.

The Rupununi Savannas

The major limitations for these savannas are similar to those for the intermediate savannas as far as soil chemical conditions. These are

complicated by climate and drainage problems. The climate is much harsher than in the Ebini area, with lower total annual rainfall and a longer and more severe dry season. In the Pirara area it was reported that perhaps 50% of the total surface is flooded in the rainy season, severely limiting access to the region. This surplus of water during the rainy season is matched on ranches by the lack of water for animals during the dry season. The quality of native species is low because of the intense moisture stress conditions.

There are, however, a number of productive pasture legumes and grasses that are likely to be well adapted to the Rupununi savanna ecosystem. A collection provided from CIAT was observed at Saint Ignatius near Lethem: Care was obviously not the best, but almost all of the Stylosanthas capitata ecotypes were found in excellent condition. If and when national priority merits the development of a research program for pastures in the southern area, it is probable that the productivity of the savannas could be dramatically increased through the introduction of improved species and their strategic use in animal production systems. At present lack of access routes results in high on-farm cost of inputs and relatively low value for the animals produced. When access routes exist and the market demand for beef is sufficient, development of the region can be justified. Given the present shortage of manpower and budget resources, this region should probably receive low priority.

The potential for beef production in the intermediate savannas is high. The climate is favorable for high forage production on a year-round basis, with minimum problem of dry season common to most tropical savanna areas. It is probable that there are large areas, presently under forest, that also have a good forage and livestock potential. But it would be hard to justify any major effort to open and clear such areas at the present time. The Rupununi savannas, on the other hand, do present severe problems of forage availability and quality during the dry season; they are among the poorest soils in tropical savanna ecosystems in South America. This is complicated even further by difficulties of access during the rainy season due to extensive flooding.

Annex 2

VEGETATION AND FOREST RESOURCES

The vegetation of Guyana covers a wide range of different types of upland tropical rainforests, swamps and marshes, forests, and edaphic and derived savannahs. It is described by Fanshawe (1952) under a physiognomical classification based on major edaphic, physiographic, and broad ecological conditions using only the dominant species.

No systematic studies are being conducted on the flora and vegetation of Guyana (no national herbarium) nor floristico-phytosociological investigations of the various native climatic forests and derived savannah ecosystems. Consequently, the dynamo-genetic interpretation of the vegetation biocenosis and pedo-botanical correlations are superficial, if not practically unknown. However, many studies related to the vegetation of northern tropical America and the Guianas (Surinam, French Guiana, and Guyana) have been published in the past decades and are relevant to the vegetation and flora of Guyana (see bibliography).

The original vegetation of the coastal plain was mainly composed of mangrove and littoral bushes on saline soils and tidal mud alluvions, marsh forests along the river banks, and different types of palm and herbaceous swamp vegetation, the floristic composition of which varies with the fluctuation of the watertable levels and the different types of soils (sandreef, peat, muck). Most of the original vegetation in the central and eastern part of the coastal plain has been removed and replaced by croplands (sugar cane, rice) through intensive sea-defense constructions and dense drainage-irrigation networks (polders) started at the end of the eighteenth century and still being expanded. The remaining unreclaimed lowlands of the coastal plain cover a large area of marsh and swamp forests, including herbaceous swamps and temporarily flooding savannahs.

The white sands of the eroded peneplain in the northeast part of the country, including the so-called intermediate savannahs, covers an area of 64,000 km^2 of an undulated landscape (15 to 150 m above sea level); the native vegetation consists of 70% Ocotea rodiaei-Eschweilera sagotiana rainforests and Manilkara bidentata evergreen seasonal forests on well-drained fine-textured soils and Eperua falcata-Dimorphandra conjugata dry evergreen forests on the deep white sandy soils. The remaining 30% consists of Curatella americana-Trachypogon plumosus savannah and various kinds of marsh and swamps. The origin of the "savannahs" is controversial, however. The existence side-by-side on the same white sandy soils (unit 700) of both Eperua-Dimorphandra dry evergreen forest and Curatella-Trachypogon savannah suggests that the latter derived from a degradation process from the former. In fact most of the Eperua-Dimorphandra forests (25 m high) have been intensively exploited for Wallaba (Eperua), leaving this fragile forest ecosystem with large openings in the upper canopy. The production of charcoal and the abundant dry and undecomposed litter of Dimorphandra conjugata

favored manmade and spontaneous fires, in particular during the exceptionally dry seasons (February to March) that occur from time to time (see section on climate). The fires destroy the regeneration process and disrupt the equilibrium, engaging these dry forests in a slow but irreversible degradation process from dry shrubby woodlands to further true savannization dominated by Curatella americana and other savannah trees, shrubs, and herbaceous vegetation. A similar sequence develops on the brown sand, loamy sand, and sandy loam soils on the plateaus (unit 800, 810, 820) and the finer-textured and well-drained red-yellow latosoils under the tropical rain forests of Ocotea rodiaei - Eschweilera sagotiana (Mabura Hill), but proceeds more slowly. The Ocotea-Eschweilera is a mixed hardwood rainforest, rich in major commercial timbers (i.e., Ocotea rodiaei, Ocotea canaliculata, Mora excelsa, Mora gonggrijpii, Peltogyne spp., Goupia glabra, etc.) of 35 to 40 m high including five canopies. The characteristics of these forests, compared with African tropical rainforests, are the large number of small diameters of the mature trees (35 to 40 cm). In the lower slopes and depressional areas along the hydrographic network, swamp forests are dominated by Mora excelsa with different types of marsh forests with Tabebuia insignis, Carapa guianensis, Symphonia globulifera, Virola surinamensis, Euterpe edubis and Desmoncus spp. palms, the floristic composition being closely related to the duration of the inundation period and alluvio-hydromorphic types of soils.

The different types of tropical rainforests mentioned above are those observed by team members during a one-day visit at Mabura Hill area, 210 km south of Georgetown. However, they represent only a small sample of the tropical rainforests of Guyana. When flying over the country, one can recognize a large diversity of plant communities within the different tropical rainforest ecosystems in the northwest, central, southeast parts, and the western Parakaima mountainous area of the country. As already mentioned, the tropical rainforests are scientifically unknown, and even the high areas upstream of the high falls in the Parakaima and upper Essequibo-Corentyne Rivers are to be considered as "terra incognita" in view of their isolation. The team was told that in the vast tropico-equatorial rainforests in the southeast, the clear transparent water of the rivers has a rich ichthyofauna, which means that the soils and waters are likely to be less acid (near pH7) than in the central and northern parts of the country, and consequently it might be expected that the floristic composition, structure, and ecosystem dynamics of these forests would be different from those of other areas about which some scanty information exists.

The Parakaima region, and other mountainous areas of Guyana (Mt. Kanuku) above the 600 m altitude, are covered with so-called montane seasonal and dry evergreen forests and tropical savannahs and grasslands in the high plateaus and valleys (Kamarang and Kukui) of which no systematic studies have been made.

The Rupununi plain, north and south of the Kanuku Mountains, is the largest savannah area of Guyana, involving a mosaic of many different types of Trachypogon-Andropogon-Mesosetum dry woody herbaceous savannahs and temporarily flooded swamps with characteristic floristic composition well-correlated with soil texture and phreatic watertable fluctuations. The northern Rupununi savannahs (Pirara Ranch), with watertable levels between 6 and 8 m depth during the dry season, are much less productive (1 head per 16 ha) than the southern Rupununi savannahs (Dadanawa Ranch)

where the water table is at 5 to 6 m depth during the dry season, with a carrying capacity of 1 head per 7 ha (see section on Rupununi savannahs). This indicates different savannah plant communities and the need to adopt different extensive ranching systems.

It is justifiable that remote and isolated areas without transportation and communications systems (roads, rivers) are not being studied (Parakaima, southeast tropical rainforests). However, it is surprising that priority regions, such as the intermediate savannahs, the Rupununi savannahs, and the "tropical" rainforest areas downstream from the falls and directly accessible by roads and waterways (lower Essequibo-Demerara-Berbice,) with present and future potential for agriculture development, are not being studied systematically. Only limited studies on soils description and analysis are available (Soil Science Department, Mon Repos).

Even for the Mabura Hill-Upper Demerara Project, financed by the World Bank, IDB, EEC, and the Government of Guyana, no studies are being conducted on growth standing volumes, growth rate by species or any forestry studies related to the floristic composition, present evolution under different exploitation systems, forest management techniques, etc.

The project covers an area of 220,000 ha, and is designed to exploit the 16 species that are exported and about 30 additional species used locally. The project aims at increasing timber exports, introducing lesser known species into the international market, and developing a small township around a sawmill (annual capacity of 40,000 m^3 lumber output) and construction of power facilities of 6,000 Kw based on waste wood fuel and an experimental wood gasification plant of 4,800 Mw.

Based on an environmental impact study, the project established some criteria, such as (a) selective felling to remove only 25 to 30 m^3/ha out of a total standing biomass of 250 to 300 m^3; (b) peak and steep slopes and riverbank areas to be excluded from logging; (c) maximum road gradients limited to 6% for main roads and 14% for spur roads; (d) part of the project would provide for further study of the possibility of protecting some Amerindian people living in the south of the project. However, persons in the project did not seem to have a clear idea of what is really exploitable, how long the cropping rotation should be, what is the growth rate of the major species to be exploited, what are the forest management techniques to be applied to maintain the forest production, to rationalize its exploitation or to assure its natural regeneration. Moreover, it seems that the road gradients are more than the 6% and 14% recommended and that exploitation through mechanized logging operations will be conducted even on steep slopes, with the consequent dangers of inducing severe erosion.

Without background information or basic scientific data, the present "creaming" of the best valuable species will inevitably result in a downgrading of economic value of these forests in the long-term future. The second round of selective cutting is scheduled to take place after 30 years, but there appears to be no evidence to support the view that such a cutting cycle would ensure the continuous and sustained yield of the merchantable trees through natural regeneration.

While a sum of US$200,000 is available for a research program to develop appropriate forest management systems, or at least to measure the growth rate of the major exploited species, no applied research program has

been started or even designed after 3 years from the start of the project and 10 years after the feasibility study prepared by the World Bank. While Guyana is in a comfortable position compared to other tropical countries, because the ratio of its forest land to population is high and most (more than 80%) of its forests resources are inaccessible, both commercial forestry and soil conservation would benefit from a better information base. The development of this base needs to be started without delay.

The tropical forest ecosystems in Guyana are in delicate equilibrium because of the inherently low soil fertility and unpredictable severe droughts. Large-scale removal of the forest vegetation -- whether by burning (dry evergreen Wallaba forest on white sands), a combination of burning and timber destruction (shifting cultivation), or forest exploitation without a sound scientific basis -- will have devastating and in many places irreversible effects on the natural nutrient cycle of the tropical forest ecosystems.

The tropical rainforest in Guyana represents the major natural resource, not in terms of foreign exchange earnings through timber export, but in terms of environmental protection, since the destruction of the forest cover in the uplands would have an adverse effect on the downstream hydrology of rivers. This could lead to extensive damage to the major and costly water control structures and land in the coastal plain during years of exceptionally heavy rainfall.

Consequently, it is imperative that rainforest ecosystems be used rationally and strictly within the limits of their sustainable total productivity (not only of the commercial timbers!).

The position on the white sands seems sufficiently clear that little research is needed. The dry evergreen Wallaba forests should be carefully protected to avoid their rapid degradation. Even on the brown sands (particularly on 10% slopes or more), the forest cover should be retained on a large proportion of the area. The remaining small areas could be used in cropping-livestock systems, but soil conservation measures will be needed together with a continuous input of plant nutrients.

The research funds available should be adequate to begin:

- a limited but well-designed applied forest research program in Mabura Hill to study the composition, structure, management dynamics and evolution, and water and erosion control under different soils, slopes, and logging techniques and exploitation systems;
- an applied agroforestry research program aimed at improving the shifting cultivation system on the alluvio-colluvial soils along the navigable rivers (e.g. Ebini/CARDI project);
- measurements of runoff and soil loss on different degrees of slope and on different types of soil, with the objective of defining the limits of exploitation and forest clearance, especially on hilltops.

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Annex 3

GOVERNMENT STRUCTURE

This annex does not attempt to describe the entire government structure. It emphasizes ministries, corporations, and units that are directly or indirectly connected with agricultural research, either through training and recruitment of staff or providing financial resources.

The government of the Cooperative Republic of Guyana is headed by an Executive President under whom are a Prime Minister, four Vice Presidents, ten Senior Ministers, thirteen Junior Ministers, and three Ministers of State. The Prime Minister is responsible for the Public Service, Cabinet Subcommittee on Economic Development, and Information. The Ministries of Public Service and Information are directly under the Prime Minister. The vice presidents are responsible for Economic Planning and Finance, Public Welfare, Transport and Works, and Parliamentary Affairs and Party/State Relations, respectively. The Vice President for Economic Planning and Finance is also responsible for the State Planning Commission and the Junior Ministry of Finance (Figure 1).

Although the Ministry of Agriculture is the principal government institution responsible for the development of the agricultural sector, and hence for agricultural research, four other senior ministries (Regional Development, Higher Education, National Development, and Education) are involved in agricultural or agriculture-related activities in production, research, extension, or training. In addition, the Ministries of Finance and Public Service, and the State Planning Commission are responsible for financial and human resource management issues which have direct effects and influence on the agricultural research system (Figure 2).

The Ministry of Agriculture, administered by a senior minister, was until recently an umbrella ministry comprising four junior ministries: Crops and Livestock, Fisheries, Forestry, and Drainage and Irrigation; each was headed by a junior minister. In addition, nine corporations (Figure 5) and the Tapakuma and Black Bush Polder Irrigation Projects came under the responsibility of the senior minister. In the current structure (Figure 3), Forestry and its corporation, the Timber Export Board, were removed and placed under the Minister of National Development, and a Forestry Commission was set up in the Ministry of Forestry. The junior ministries of Crops and Livestock, and Irrigation and Drainage have reverted to departments. The Ministry's Planning Department provides a planning service to the Ministry of Agriculture, serving as a link with the State Planning Commission; its relation with the Department of Agriculture is good. Reorganization is not complete, so the organizational chart is to be regarded as provisional.

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The Department of Agriculture consists of four divisions: crop science, veterinary and livestock science, soil science, and extension and education.

The Central Agricultural Station (CAS) at Mon Repos is the major and central location for research activities in the Ministry of Agriculture (Figure 4). There are two small agricultural stations, the Kairuni Research Station at S dyke, Linden Highway, located on forested brown sands, and the Long Creek Station located on forested white sands. The Central Horticultural Station, located at Timehri in the riverain area, is currently used for the maintenance of horticultural stocks and plant propagation. Ebini Research Station is located in the intermediate savannahs. The main research activity on this station was on evaluation of pastures and crops for the intermediate savannah conditions. The station facility was turned over to the Livestock Development Company for commercial production of livestock, but some pasture work is still being done. There are also small agricultural stations at Overwagt, the Botanic Gardens, and Wauna.

The division of crop science has three sections: agronomy, plant protection, and seed technology. Each is headed by a manager. There are two sections in the division of veterinary and livestock science: veterinary science and animal husbandry. Each section is headed by a production manager but does not have an appreciable research program. The veterinary science section has a diagnostic laboratory located at Mon Repos, and there is a collaborative program under WHO/PAHO administered by the Ministry of Health. The title of production managers for the second line of managers under the divisional heads is unusual; it does not seem to indicate a research role.

Until the recent introduction of the regional form of government, the extension and education division had administrative and technical responsibilities over its staff in 10 technical regions, each of which was headed by an agricultural officer or, in some cases, by a senior agricultural officer. The division still retains the responsibility for the formulation of the national program to cover all regions. The regional authorities have the responsibility for seeing that this national program is carried out; in doing so, they have operational and administrative authority over all staff (except research) working in their respective regions. This situation presents both problems and opportunities.

The Ministry of Fisheries has two technical divisions: marine and inland fisheries. Both divisions are headed by senior fisheries officers. The research function is accorded low priority.

MARDS Research Station and the Guyana Sugar Experiment Station are outside the Ministry of Agriculture. They belong to GRB and Guysuco, respectively.

There are four major technical divisions in the Ministry of Forestry: forest management, silviculture, wood utilization, and forest products administered by the Forest Commission. Research is under the commission but is given a low priority. There are no research programs at present.

Agrometeorology is the responsibility of Ministry of Works and Transport. The meteorology unit's current activity is mainly recording

and processing weather data from selected areas. There is no specific activity on agrometeorology.

Under the regionalization policy, the country is now divided into 10 political regions administered under the Ministry of Regional Development. The regional administrative structure consists of an elected regional council with a regional chairman, under whom is the regional executive officer. Regional technical officers are administratively and operationally under the Ministry of Regional Development, but they draw technical advice and inputs from their respective technical ministries and departments. There are regional, district, and subdistrict coordinating committees which bring together technical and administrative officers to review and plan regional development programs for submission for approval at the national level. Research units are not represented on any of these committees.

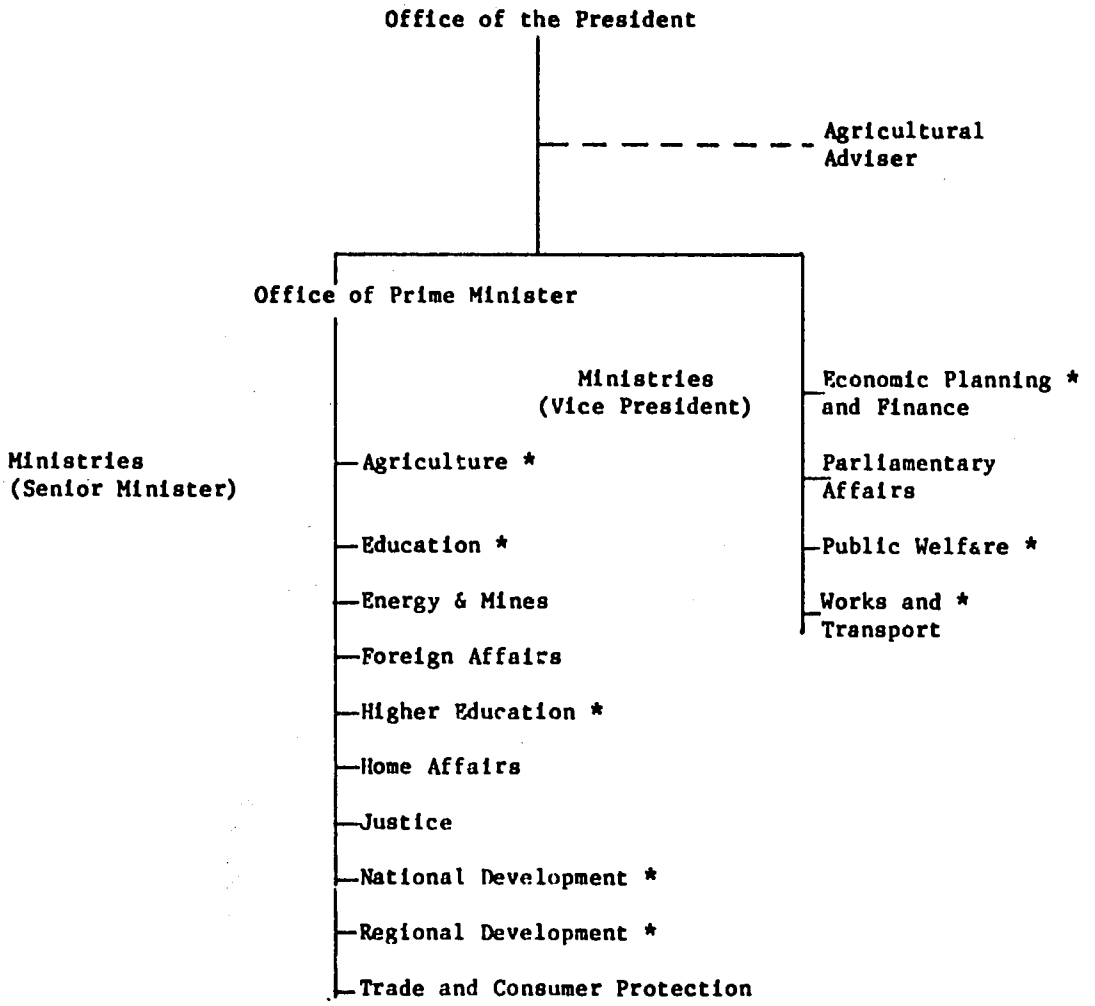
The Ministry of National Development is responsible for the Guyana National Service, which operates an agricultural production enterprise at Kimbia. It is headed by a director who reports to the minister. There is a well-equipped workshop operated by GNS at Kimbia for repair and maintenance of agricultural equipment.

The National Science Research Council and the faculties of agriculture and natural sciences in the University of Guyana are under the jurisdiction of the Ministry of Higher Education. The National Science Research Council is headed by a secretary-general. It administers the Institute of Applied Science and Technology and is responsible for advising government on matters relating to scientific research, for coordinating research activities in the country, and for scientific information management.

The Ministry of Education is responsible for developing agricultural sciences curricula in over 45 secondary and community high schools in which agricultural science is taught. In each of these schools there is a Department of Agricultural Sciences.

There are 11 state corporations in the agricultural sector. The majority are administered by boards, some of which are appointed wholly by the minister. He retains the chairmanship of all of the boards, either in person or through nominees. Most of the corporations are primarily responsible for production and processing and have small research components. The exception is GSA, which is an educational institution.

The precise lines of authority are not clear in the operation of state corporations in which the Minister of Agriculture is concerned. The organization chart (Figure 5) sets this out, showing that there appears to be dual authority in many of the corporations. It appears that the Minister of Agriculture is mainly concerned with the technical aspects of their operations.



Of the Ministries (Vice Presidential or senior ministerial) in Figure 1 several have junior ministries or components relevant to this report.

* Directly mentioned in the report

Figure 1. Structure of the government.

Ministries (Vice-President)	Relevant unit(s)
Economic Planning	Ministry of Finance, State Planning Commission
Public Welfare	Ministry of Health
Works and Transport	Hydrometeorology Division
Ministries (Senior Minister)	
Agriculture * see Figure 3	
Education	Teaching of agric. sciences in schools.
Higher Education	National Science Research Council (Institute of Applied Science & Technology); University of Guyana
National Development	Ministry of Forestry; Guyana National Service,
Regional Development	Regional structure in relation to technical officers in the Regions.

Figure 2. Functions of ministries as they relate to agriculture.

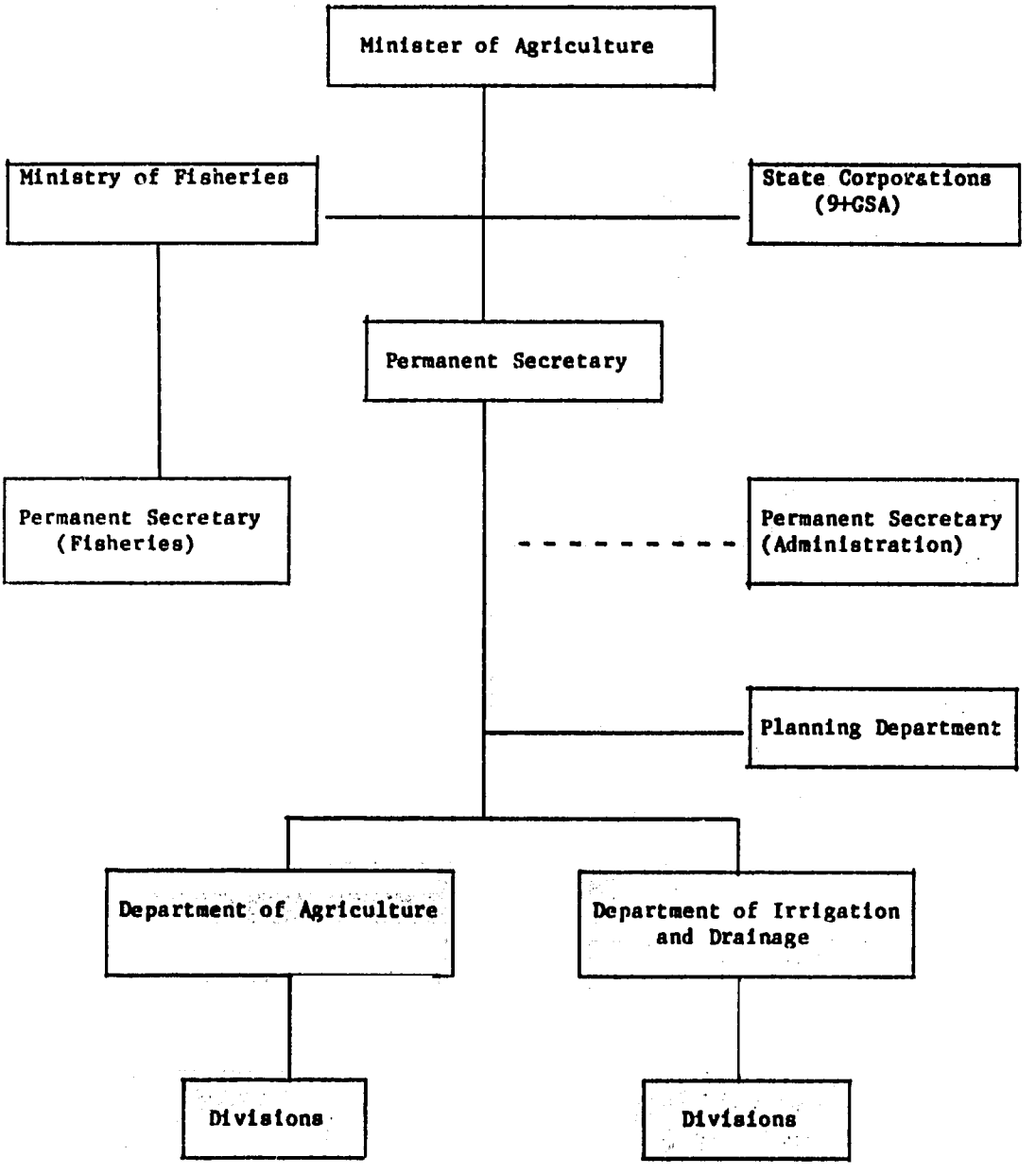


Figure 3. Structure of the Ministry of Agriculture.

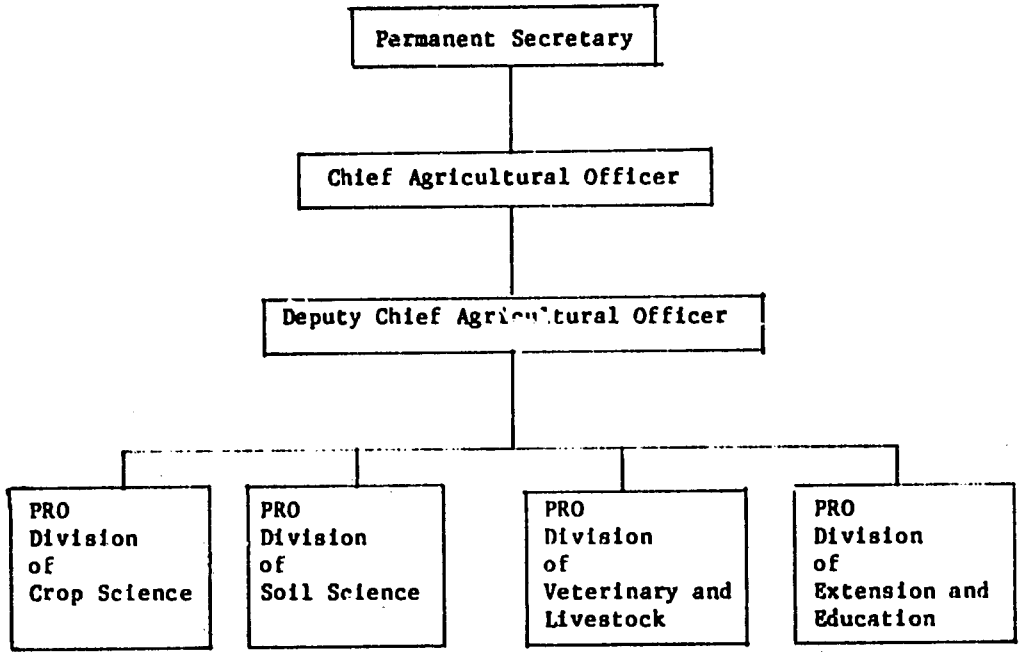


Fig. 4. Organizational structure of the department of agriculture.

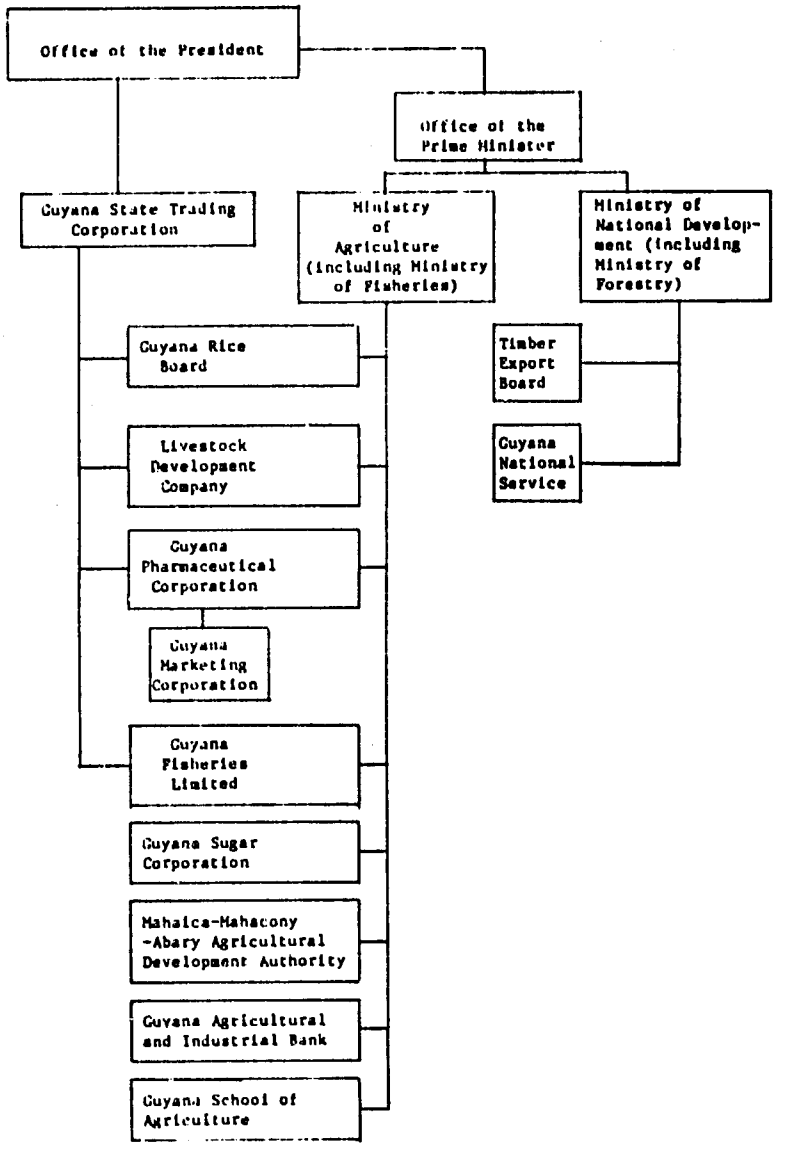


Figure 5. Governmental structure as it relates to agricultural activities.

Annex 4

INVENTORY OF RESEARCH FACILITIES AVAILABLE IN GUYANA

The extent and condition of the physical facilities (laboratories, ancillary buildings, and experimental farms) and of the equipment available were assessed at the following institutions:

- Ministry of Agriculture; Central Agricultural Station, Mon Repos,
  - Crop Science Division,
  - Soil Science Division,
  - Veterinary and Livestock Division,
- Guyana School of Agriculture;
- University of Guyana (UG), Faculty of Agriculture;
- Guyana Sugar Corporation Ltd, "Guysuco";
- Guyana Rice Board (GRB), MARDS Station;
- Institute for Applied Science and Technology, (IAST);
- Guyana Pharmaceutical Corporation Ltd.

Ministry of Agriculture:. Central Agricultural Station, Mon Repos

This station was established in 1965. Its major facilities consist of a main office/laboratory building, five smaller buildings (for microbiology, plant quarantine, machinery training, etc.), and some 20 houses for various levels of staff. The Guyana School of Agriculture, the Regional Educational Program for Animal Health Assistants, and the new Veterinary Diagnostic Laboratory are nearby.

Crop Sciences Division

This division consists of the plant protection unit (made up of six sections), the microbiology unit, the seeds unit, and the machinery training center.

-- Plant protection unit; plant pathology

- Laboratory (approx. 5 x 7 m, plus senior staff offices)
- Equipment
  - 2 microscopes, sterilizing oven
- Roofed screenhouse (approx. 3 x 12 m)

The laboratory seemed to be poorly equipped.

-- Plant protection unit: entomology

- Laboratory (approx. 5 x 9 m)
- Equipment
  - 3 microscopes, all nonfunctioning (NF)
  - 1 low temperature freezer

- 1 insecticide spray tower
- 1 microapplicator (new, not used)
- 5 small insect cages (0.5 x 0.5 x 0.5 m size)

Although the equipment was not extensive it was little used, indicating a lack of a suitable work program.

— Plant protection; weed control
- Laboratory - adequate size for 1 or 2 persons
- No major equipment

This section appeared inactive.

— Plant protection; plant quarantine
- A relatively new building approx. 10 x 15 m was labeled "Plant Quarantine Station" and seemed to contain offices and laboratories; it did not appear to be in use.

— Plant protection; agro-chemicals supply
- Assumed to be an office and storage shed, though these were not specifically identified; functions ill-defined but apparently commercial rather than scientific.

— Plant protection; Acoushi ant control
- Building (shed) 4 x 6 in. approx.
- Equipment
  - mixer
  - scale,
  - 6 trays for air-drying of pellets
  - plastic bag sealer
  - storeroom for bagged product.

A practical and useful activity but not in any way research or extension.

— Soil microbiology unit
- Laboratory - a modern well-equipped suite of 3 main rooms.
- Equipment
  - incubator-shaker,
  - 2 spectrophotometers (visible range),
  - 2 microscopes
  - 2 incubators
  - sterilizing oven (large)
  - 1 airflow isolation hood (NF)
  - 2 balances
  - flask shaker
  - constant temperature bath
  - 2 autoclaves (pressure cooker type)
  - 1 steam boiler (for autoclaves) (NF)
  - 1 air compressor (NF)
  - 1 mill to grind bagasse (as absorbent for the inoculant)
- Plant growth room
  - 30 linear feet of bench space in air-conditioned room, about.
    4 m of which were fitted with fluorescent lights. Field plots, about 15 x 30 m.

This is a well-equipped unit. The aim of the laboratory is to be able to distribute effective rhizobial inoculants for selected grain legume varieties.

— Seeds unit (includes genetic resources unit, seed production)
  - Genetic resources unit
    - Laboratory (about 8 x 10 m plus staff offices)
    - 2 large Seedboro seed germinators
    - 1 air cleaner for seeds
    - 2 seed moisture meters (1 NF)
    - 2 drying ovens
    - 1 germination tester, Vitascope (NF)
    - 3 balances
  - Storage space (seed)
    - 4 rooms, each about 10 x 10 m, maintained at 18 degrees C with wall-type air conditioners and at about 70% relative humidity by means of large mechanical dehumidifiers.

    The seed testing laboratory and storage rooms were well maintained.

  - Seed processing
    - 1 clipper seed cleaner, stated to be capable of processing about 450 kg of seed per day.
    - 1 air classifier

- 3 storage rooms for processed seed, maintained at 18 degrees C and 75% RH. (Room seen contained about 50 100-pound bags of cowpea seed (variety California 5).

  The processing plant was well maintained and seemed capable of good work, though it was not in operation on the day visited. Seed samples seen were clean and of good quality (size and appearance).

— Mechanization training center
  - Equipment
    - 2 Massey-Ferguson diesel tractors for operator training, demonstration of repairs and maintenance
    - 3 plows
    - 1 disc harrow
    - 2 field sprayers, tractor mounted, with 500 gal. tanks
    - 1 each drill press, sheet metal cutter and bender
    - teaching area in equipment area (about 3 x 4 m)
    - storeroom for parts, tools, and small equipment.

  The unit operates 4-week training courses more or less continuously through the year, with average attendance per course of 8 to 12 students. The nearby Guyana School of Agriculture also uses the facility for joint teaching and demonstration activities.

  A machinery repair shop is available to keep all machinery functioning, but the problem of obtaining spare parts was emphasized.

Soil Sciences Division

This division has three sections - soil chemistry (and associated analytical laboratory), soil physics, and soil and land use survey.

— Soil chemistry section
  - Laboratories: 2 totaling 75 sq. m. (plus offices).

    Equipment
    - 3 soil drying cabinets (approx. 2 m^3 each)
    - 1 large capacity centrifuge
    - 1 oven

- pH meter (NF)
- hot plate
- 4 digestion heaters for soil nitrogen (unused; few flasks were available to use with these heaters).

— Analytical laboratory
- Laboratory (about 5 x 8 m)
- Equipment
  - 3 atomic absorption spectrophotometers (1 of these is NF)
  - 3 spectrophotometers (visible range), 2 with auto sampling devices
  - 1 titrator
  - 2 pH meters
  - 2 ovens
  - 1 muffle furnace
  - 5 balances (1-2 appeared NF)
  - 2 multiple stirring devices
  - 1 mechanical shaker
  - 6 sample carts, North Carolina type
  - satisfactory supplies of chemicals in evidence.

Laboratory equipment was all of U.S. manufacture and had been provided by USAID. It was stated that Dr. Hunter of the North Carolina State University (NCSU) had carried out training courses for analytical staff in 1973 and 1981. The various types of equipment designed by NCSU to facilitate handling of multiple samples as batches (about 50 per batch) were evident and in use.

Considering the problems of chemicals and uneven receipt of samples, it is clear that the station's analytical laboratory was operating smoothly and had a good workload.

— Soil physics section
- Laboratory (about 5 x 10 m)
- Equipment
  - 2 sets of screens (for soil particle sizing)
  - 2 balances
  - 2 ovens
  - 1 hot plate
  - 4 soil suspension mixers
  - 2 pressure membrane plates (for soil water release)
  - 1 constant temperature bath
  - 1 large capacity centrifuge

This laboratory has been well equipped from Swedish aid (SAREC) funds.

— Soil and Land Use Survey Section
- Laboratory - office
  - 1 drawing room outfitted with some drafting equipment.

Little evidence was seen of current soil survey and mapping activities.

Main Library

The library is not assigned to any section at the Mon Repos station, and is designed to serve all sections. The collection includes about 500 volumes, some standard texts and references, many FAO publications. Many current subscriptions to agricultural journals have been cancelled since

1980 because of a lack of foreign exchange. This is regarded as a most unsatisfactory situation.

Veterinary and Livestock Section

This section shares staff and facilities with the Regional Education Program for Animal Health Assistants (REPAHA). The section's main work is the operation of the Veterinary diagnostic laboratory.

— Veterinary diagnostic laboratory
  - Laboratories
    - Equipment
      - 6 microscopes
      - 1 microtome
      - 1 centrifuge
      - 2 incubators
      - 2 ovens
      - 1 constant temperature bath
      - 2 refrigerators
      - 2 pressure cookers (for autoclaving and sterilizing)

The present laboratory is in an old office building in Georgetown. The "main" laboratory is approximately 5 x 6 m; the "animal room" is only 2 x 3 m, plus part of a corridor. Despite these difficulties, good work is being done, and the laboratories, though crowded, are well used. Equipment was generally new and good, since equipment funds provided by UNDP (through the Pan American Health Organization, PAHO) for the new building (see below) have been utilized already.

It should be noted that three consultants have been provided to the Veterinary Diagnostic Laboratory by UNDP/PAHO over the last 1 to 2 years; these consultants have contributed to the research and teaching activities of the laboratory.

A new building for the laboratory is located about 500 m from the REPAHA site at Mon Repos. This building, costing about US$2 million and having 700 m^2 area, is being funded by the Canadian International Development Agency, with the equipment and supplies provided by UNDP/PAHO.

The new facilities provide about five times as much work space as was available in the old.

— Regional Educational Program for Animal Health Assistants (REPAHA)
  - Laboratories (3, each about 10 x 120 m.)
    - Equipment
      - 20 microscopes, mostly student type
      - 4 ovens
      - 4 clinical centrifuges
      - 1 milk centrifuge
      - 2 sterilizers
      - 2 incubators
      - 2 constant temperature baths
      - 3 fume hoods (NF - not connected to ducts)
      - excellent collection of chemicals and histological stains

- Other:
  - 2 classrooms with audio-visual equipment
  - animal operating theater (not in use)
  - sheds with stalls for cows (1 present)
  - dormitories (2) for about 25 students
  - library
  - 1 tractor with harrows and mower for field work
  - 3 buses (2 NF) for student transport

The excellent facilities provided by UNDP/PAHO are in buildings provided by the Guyanese government. The program graduates about 30 assistants each year, of whom about 5 are from Guyana.

Guyana School of Agriculture

Founded in the early 1960s, this school is an autonomous corporation with the Minister of Agriculture as chairman of the board. It has been the principal source of trained agricultural personnel in Guyana at the diploma level.

As a small public corporation, its chief advantage over a public service department is that it is partially self-supported financially through its own food production program. This gives it some measure of flexibility in operation, since income funds are not tied to specific line items of expenditure.

Its main activity is the training of students in agriculture (crop science, animal husbandry, food science) through work in the field and in the classroom Trainees take either a 1-year or 2-year course, leading to a certificate or diploma, respectively.

Equipment

-- Field work (for crop sciences)
  - 2 Massey Ferguson tractors
  - 5 plows (1 new, unused)
  - 2 harrows
  - 2 seed planters (new)
  - 1 mower (new)

Farm Land

-- Presently 19 ha in rice, about 12 ha in citrus and carambola orchards, 8 ha in pastures, 5 ha in student plots (corn), test plots (tomatoes, beans). More land available.

Food Sciences

-- Food sciences processing plant
  - Kitchen/processing line (8 x 12 m area) - 4 retorts, 2 gas stoves, pulper, peeler not connected to electricity.
  - Food laboratory (6 x 8 m) - 1 freezer, 1 refrigerator, 4 work counters
  - Chilling room (approx. 3 x 5 m) - used as storage area for 5 pressure cookers, 6 large cooking vessels, 1 steam blancher.
  - Food preparation room (approx. 3 x 5 m) - not finished, but used for washing and dicing of herbs.

- Boiler room - steam boiler not connected to equipment (e.g. retorts) due to lack of parts.
- General - 3 solar driers (for trays of fruit), herb garden.

This unit could be used for some research work in this field.

Livestock

— Livestock
  - cattle shed, small milking barn (have 20 animals)
  - swine shed (have 100 swine)
  - 3 poultry houses (have 17,000 chickens), egg-sorting shed
  - 1 cooler (20 m^3 capacity) for meat storage.

  Teaching laboratories of ample size

— Equipment
  - 2 ovens
  - 2 centrifuges
  - 1 constant temperature bath
  - 1 muffle furnace
  - 2 pH meters
  - 1 colorimeter
  - 6 balances, various types

  Much of the equipment was new and unused, having been received in late 1981.

Other

- Dormitory building (2 additional ones in long-delayed construction)
- Cafeteria
- Auditorium
- Plant sciences building (large laboratory space not completed)
- Administration building
- Retail sales building (under construction)

The Guyana School of Agriculture has good facilities that seem generally well utilized for teaching purposes. Outside funding for various facilities was evident, and the school has attracted financial support from both international and local sources.

University of Guyana Faculty of Agriculture

This faculty was set up at the University in 1976, by Cabinet decision, but was not funded for two years. Although teaching began in 1979, the faculty has no buildings and has used space in other departments, particularly in the Faculty of National Sciences (built and equipped by CIDA). The faculty buildings to accommodate 200 students are to be funded by EEC, and plans are being discussed. Some US$1.3m is available, and a 1500 m^2 building is being designed.

Since there is no real pressure on the space in the Faculty of Natural Science, and the number of candidates for degree courses in agriculture is small, there is no immediate need for extensive buildings for the Faculty of Agriculture.

Guyana Sugar Corporation Ltd. (Guysuco)

Guysuco has the oldest agricultural research program in Guyana. Although it has been confined to the production of sugar cane, it has also accumulated substantial knowledge of the soils of the coastal belt and of the rainfall patterns in this part of the country. The management of these soils is an art in itself, and this experience could be most useful when attempts are made to use these soils for other crops.

The research work of Guysuco in sugar cane is summarized in Annex 5a.

Guyana Sugar Experiment Station

— Field (50 ha experimental land)
  - 2 Massey Ferguson tractors (1 newly purchased)
  - 2 harrows, minor field equipment
— Laboratories (2 in number, each about 3 x 8 m in size)
  - 2 stereo microscopes
  - 1 dissecting microscope
  - 1 precision balance

— Cane juice testing
  - 1 autoclave
  - 1 cane cutter/grinder
  - 1 mechanical press
  - 1 polariscope (old, but in use)
  - 1 drying oven (new)

— Other
  - 1 greenhouse/screenhouse (5 x 20 m, filled with cane seedlings)
  - 1 rearing cage, 3 m^3
  - 1 insect collection (small, but in good condition)
  - 1 seed storage shed.

  Note: The Guysuco Central Analytical Laboratory does not do juice assays for this station.

The Central Analytical Laboratory

This is a supporting laboratory for analyses of leaf tissue, sugar, molasses, and soil, in support of Guysuco production and research activities.

—Facilities
  - 1 digital spectrophotometer with sampler
  - 1 flame photometer
  - 2 analytical balances
  - 1 polarimeter
  - 1 viscometer with temperature control
  - 1 pH meter
  - 3 drying ovens
  - 1 muffle furnace

This is an old laboratory of some 120 m^2, but adequately equipped for the specialized work required of it. The total number of samples analyzed in 1981 was low compared with what could be achieved in a laboratory of similar size, arising from the lack of modern automated or batch-type equipment.

The small research laboratory (3 x 4 m) equipped with 2 vacuum pumps, a balance, and a nonfunctional soil centrifuge. Problems of soil salinity in coastal soils are being studied.

Guyana Rice Board

MARDS Station

Responsibilities assigned to the station include: applied research on the improvement of rice in Guyana; extension services; provision of certified seeds to rice growers; and agricultural services (equipment rental) to these rice producers. Little is being done in the research component of this program.

— Laboratories (4, each approx. 5 x 8 m)
  - Analytical - 1 colorimeter (NF), pH meter (NF), 2 ovens, large blender, shaker, constant temperature bath, 2 balances.
  - Entomology - 2 incubators, insect-rearing cage.
  - Pathology - microscope, incubator.
  - Agronomy - scales.
— Screenhouse (approximately 10 x 20 m) - not in use.
— Seed processing plant
  - storage bins (8), elevators
  - cleaners (stated to be capable of cleaning 200 bags - 12.7 tons of rice per day)
— Machinery repair and maintenance shop
— Field machinery
  - 10 tractors, 4 of which are NF, others are old
  - 2 self-propelled combines, 1 is NF
— Farm land - 270 ha, of which 50% to 60% is in rice production.

Blackbush Polder

This subunit is an adaptive research unit, currently staffed by five expatriates (financed by the USAID project for the strengthening of GRB) with little staff support from GRB.

The facilities are a set of offices, field laboratory, and workshop; the site is an operational base rather than a research substation.

Institute of Applied Science and Technology (IAST)

This Institute opened in March 1980 in an excellent building provided by CIDA. Its stated purpose was to support the food industry and to aid in the development of mineral and energy resources. The only work in progress in the agricultural sciences was on the extraction of oil from local nuts.

Laboratories

— Each laboratory was approx. 10 x 20 m in size, plus offices.
  - Mineral sciences laboratory - pilot plant scale kilns, rock crusher, mills
  - Energy laboratory - 2 muffle furnaces, 3 ovens, mills in laboratory; 4 solar driers used to dry fruit

- Agricultural sciences - 3 microscopes, drying oven, incubator, gas stove, hot plate, refrigerator, oil extraction equipment
- Analytical laboratory - gas-liquid chromatograph with recorder, 2 atomic absorption spectrophotometers (1 NF), infrared spectrophotometer, ion activity/pH meter, digital dispenser/diluter
- Natural products - blender, 2 ovens, pH meter, centrifuge, photometer, thin layer chromatography equipment, including UV plate viewer.

The Institute is well-housed and well-equipped by international standards. At present the agricultural sciences section seems far removed from the real problems in agriculture; there seems to be no contact with the Ministry of Agriculture.

Guyana Pharmaceutical Corporation/Quality Foods Inc.

Quality Foods Inc. (Agriculture Division)

This unit is engaged in the manufacture of the following products: carambola jellies, preserves, juice; pineapple juice, punch concentrate; table sauce (made from plantain flour, fruit juice, other ingredients); vegetable catsup (from pumpkins); various herbs (thyme, basil, seasoned salt).

The plant was assessed from the point of view of its being available for some research work on the processing of local foods. The facilities are modest but could be used to pilot plant scale.

- Cookers for fruit, work tables for washing, peeling, cutting (all work is done manually, in dispersed work areas)
- Canning and bottling machines.

Summary

The facilities available for agricultural research in Guyana were evaluated by on-site visits to the Central Agricultural Station of the Ministry of Agriculture, the Guyana School of Agriculture, and the University of Guyana Faculty of Agriculture, the latter two being the main technical training institutions in agriculture for Guyana. Visits were also made to three Guyanese national corporations active in agricultural production or processing (Guysuco Ltd., the Guyana Rice Board, and the Guyana Pharmaceutical Corporation) and to the Institute for Applied Science and Technology. At these organizations, the laboratories, glasshouses, and experimental fields were inspected (as found), and existing equipment was noted. While such brief visits cannot lead to an exact inventory of equipment, the estimate of facilities was used as a basis for a subjective judgment regarding the adequacy of present physical resources for carrying out agricultural research in Guyana.

Each of the three divisions (crop science, soil science, veterinary and livestock) in the Central Agricultural Station located at Mon Repos were considered separately. Crop sciences, the largest division, includes the plant protection unit, the microbiology unit, and the seeds unit (concerned with production, not research). The physical resources in the

microbiology and seeds units were considered excellent. On the other hand, the plant protection unit appears to need substantial upgrading of its facilities (for example, microscopes). The soil sciences division was reasonably well equipped and well run. The veterinary diagnostic laboratory was housed in crowded conditions in an old building. This situation will be improved when the new building is available in 2 to 3 months time -- neither equipment nor manpower was seen as a constraint for the operation of this laboratory.

The Guyana School of Agriculture has good facilities for teaching. Research is not presently a part of its activities, but the principles of research could be included in its curriculum since the GSA graduates may form the majority of the on-farm research workers.

The University of Guyana, Faculty of Agriculture, while at present using facilities in the Faculty of Natural Sciences, has access to good laboratories and classrooms for teaching purposes. Arrangements for faculty members to do practical research projects at the nearby Institute for Applied Science and Technology (IAST) would strengthen both organizations. The excellent facilities at IAST were found to be underused.

The Guyana Rice Board's MARDS Station has good laboratory and experimental field facilities that are underused. A substantial amount of adaptive research is being done within individual projects. The backup research is weak.

Expansion of Guyana's efforts in food processing could increase market outlets for fruit and vegetable production. The manufacturing and marketing capabilities of the Guyana Pharmaceutical Corporation (GPC), when combined with the food processing facilities at the Guyana School of Agriculture, could assist this effort. Some research could be done without the need for extensive additional buildings or equipment.

The basic question -- "Are there adequate physical facilities for agricultural research in Guyana?" -- must be answered with a qualified "yes." The Central Agricultural Station, as well as the two educational institutions (Guyana School of Agriculture and Faculty of Agriculture) that directly supplement it by supplying manpower, have, with a few exceptions, adequate physical facilities and scientific equipment to support a small but good program of applied research appropriate to the needs and resources of Guyana (see table). The more critical problem is that of manpower, in terms both of numbers of trained and experienced scientists and senior technicians, and of use of the manpower resources. The dispersion of the small number of trained personnel over numerous projects (many not research) has led to a serious dilution of effort. Only at Guysuco, in the Black Bush Polder (all expatriates) and in MMA, does there appear to be a critical mass of scientists and technicians able to interact with one another and to work effectively in research.

Many pieces of scientific equipment were seen that were not functioning, sometimes because of the lack of spare parts, sometimes for lack of simple maintenance. Training of technical personnel should extend into electronics and instrument maintenance, and equipment should be chosen which can be kept in working order (for example, several simple colorometers may be more useful than one complex spectrophotometer).

Table 1. Estimate of space: Central Agricultural Station (Mon Repos).

Present Use	Approx. Area Sq. M.	Staff Holding Capacity of Laboratories Senior	Technicians
First floor			
Soil physics lab.	50	2	4
Land survey room	30	1	2
Analytical lab.	40	*	*
Soil chemistry labs.(2)	60	2	4
Samples storeroom	20	*	*
Offices (5)	20 each	*	*
Second Floor			
Assistants' room	50	2	4
FAO project office	25	1	2
Pathology lab	35	1	2
Entomology lab	40	1	2
Weed science lab	35	1	2
Entonology lab no. 2	20	1	1
Offices (3)	20 each	*	*
Library	40	*	*
	Total	12	23

* Propose to keep to present general use; not to be converted to research labs.

Note that these totals are maximal and do not allow any space for supplementary services (e.g. sterilizing, glassware cleaning).

Annex 5

MANPOWER RESOURCES

Quantity of Manpower (Aggregate Figures)

The first point to be made about manpower for agricultural research in Guyana is that there is enough of it -- if various of the reforms described below are implemented. Seventy-one graduates now work in the Ministry of Agriculture (heads 27 and 28); there were 53 in the other seven agencies surveyed. Thirty-one of the 71 in MOA have postgraduate qualifications, as do 25 out of the 53.

Graduate Expertise

An analysis of the scientific fields covered is also encouraging. Of the 71 graduates in the Ministry of Agriculture (MOA), the "specializations" of 55 were available. The other 16 are equally divided between the crops and extension/education divisions, and have therefore been counted there (in parentheses).

Crops - 21 (29)

agronomy - 4	microbiology - 2
plant pathology - 3	seed technology - 3
entomology -3	soil science - 5
plant breeding - 2	

Animal Science - 22

general - 6	veterinary medicine - 4
nutrition - 3	dairy - 2
parasitology - 1	swine - 1
pathology - 2	fish - 2
breeding - 1	

Other - 10 (18)

extension - 1 (9)	economics - 6
biology - 1	food technology - 1
chemistry - 1	

Postgraduate Expertise

As to postgraduate qualifications, the "specializations" of 28 out of the 31 individuals in MOA were available.

crops - 10	animals (including fish) - 13
extension - 1	economics - 4

Twenty-four have M.Sc., 6 have DVM and 1 has a Ph.D. These numbers are small, and most scientific fields are represented by only one or two

persons. However, when postgraduates from other agencies are taken into account, these are the national totals:

crops - 25	animals (including fish) - 18
extension - 1	economics - 7
chemistry - 1	NA - 4

Among this number are 39 with M.Sc., 8 with DVM, and 9 with Ph.D. The fields most represented by postgraduates are soils (9) and entomology (6). Those least represented are agronomy (2), microbiology (2), plant pathology (3), plant breeding (3), and animal breeding (1).

What Are These People Doing?

The proportion of graduates in managerial positions is not high. In MOA, it is 26% (n=66). This is considered a reasonable figure, given the dictates of seniority and the need for at least some top managers with scientific backgrounds. The others are mostly at Mon Repos or in the extension/education division and posted to the regions.

The comparable proportion in the corporations is 56% (n=25). There are probably three reasons for such an "upward push" there.

- Most corporations are smaller than MOA. They need a minimum number of managers, and scientists are therefore promoted into such jobs.
- Corporations must be production-oriented (in order to generate revenue). They place considerable emphasis on management.
- Corporations have historically had more flexibility than have ministries to reward their personnel, such as through promotions.

Further analysis of the MOA figures shows that 74% of managers have postgraduate qualifications (n=19). Taken as a proportion of total postgraduates in MOA, this figure means that 14 out of the 31 (or 45%) are in managerial positions.

Such numbers cause concern, on two grounds:

- The loss of scientists into management;
- the implicit assumption that scientists (who have had little, or no, in-career training) make good managers.

The Hole-in-the-Middle

A side-effect of the pressure to promote postgraduates into managerial positions is the lack of qualified senior- and middle-level (practicing) scientists. MOA's 31 postgraduates may be categorized as follows:

managers - 14
senior- and middle-level scientists - 5
junior scientists - 12.

Among the 40 remaining graduates in MOA are:

managers - 6
senior- and middle-level scientists - 1
junior scientists - 28
NA - 5

Since the most experienced postgraduates have been promoted into managerial positions, they have not had time to do research (and therefore to train junior scientists on the job). Without such training, junior scientists have not been equipped to do the scientific work which middle- and senior-level positions would imply. And without such positions filled, relatively little scientific work has been done.

A further constraining factor has been the relatively low number of senior- and middle-level scientific positions allocated in annual budgets (a chicken-and-egg question). Whatever the case, the new budgetary procedures (including new categories for personnel) should allow more movement into such positions.

The Next 10 to 15 Years

Only if this "hole" is filled can scientific research work move forward. The ranks of management appear to be filling up. In the 16 years since independence, the government has had both to replace expatriate staff and to build new institutions. To do so, it has often raided scientific ranks in the name of management.

Now it has its managers, and most of them have at least 15 years to serve before retirement. Age data are available on 15 of the 21 top managers in MOA: five of them are over 45, and 10 are 35 to 45.

Such figures have two implications:

1. Senior positions will probably be occupied for a long time, by more or less the same people who occupy them now;
2. as a result, the "hole-in-the-middle" which now exists can usefully be filled.

If the hole is to be filled, however, government will have to provide better incentive packages to keep young scientists in the system. Such changes in personnel management are a top priority and will require considerable imagination. The key elements of such packages are likely to be more flexibility in research programs, more promising careers, and improved remuneration.

Priorities Now

More Effective Use of GSA Diploma-Holders.

Most such persons are designated now as "technical assistants" and "field assistants," and their career prospects are limited. As a result, they tend to think of a GSA diploma as a ticket to a temporary job, which they will leave as soon as they can get "study leave" (for their B.Sc.).

At least one-third of GSA diploma-holders now carried on the rolls of MOA are studying. Such a pattern has four questionable effects.

-- It undercuts GSA, which was established to train semi-professional technical and field staff.
-- It deprives the country of badly needed semiprofessional personnel.

-- It costs the country more, since higher education is much more expensive than is training for the semiprofessional.
-- It perpetuates the impression (now a correct one) that a university degree is the only ticket to a good career.

Change can come only if GSA diploma-holders are given good career prospects. The "A21 bar" is a major obstacle. If MOA can devise an innovative plan to provide careers to its semiprofessional staff, there would appear to be an excellent chance that the plan would be approved. There is no prima facie reason why good nondegree people cannot perform some of the middle-level scientific and managerial tasks now reserved for graduates.

Without such a reform, the prospect for strong field-level programs in agriculture is not good. The University of Guyana Faculty of Agriculture is projected to produce about 25 B.Sc. graduates per year. On the assumption that MOA attracts (and holds) five of them, its complement of graduates will double in the next 15 years (from 71 to approximately 150). Such numbers will be necessary for an expanded research program and for effective monitoring of field-level activities.

The staffing of research and production programs in the regions will thus depend on the retention of GSA diploma-holders within MOA.

Development of a Management Cadre within MOA

At the moment, senior officials spend a considerable portion of their time on tasks which should properly be done by others. Examples include the procurement of supplies, organization of transport, and administration of routine financial matters. As a result, they are not able to concentrate on the scientific work for which their education has qualified them.

Such a situation could be remedied by turning the provision of support services into a professional task. Selected MOA staff might be assigned management jobs. In such a system, senior scientific officials would retain overall authority -- but they would be able to delegate many of their managerial responsibilities to others. The benefits of such a reform are clear:

-- Senior scientists would be able to do more scientific work.
-- New graduates would receive more scientific on-the-job training, which they need if the hole-in-the-middle is to be filled.
-- Research management would be put on a more professional footing.

Where might such research managers come from? Two possibilities exist:

-- From the ranks of new graduate recruits to MOA. A major cost of this approach, however, is the diversion of potential scientific talent into nonscientific jobs.
-- From the ranks of GSA diploma-holders. This approach is almost certainly preferable, although it would require two related reforms.

  - A modification in the A21 bar rules, so that nongraduate managers have good career prospects and a status comparable to that of at least some of their peers in scientific work.
  - A good program of in-career management training.

A Methodological Note

Data for this annex come from two sources: (1) the 1981 official staff list of the MOA and (2) information provided by senior officials of MOA (including the Ministry of Fisheries), Guysuco, GRB, LIDCO, the Ministry of Forestries, GSA, UG/FA, and IAST. For reasons of time, data could not be gathered from a small number of other organizations which also employ agricultural scientists (such as MMA, GAIBANK, etc.).

No claim is made that the data are 100% accurate. The officials who provided data often had to assign staff to go through large numbers of personal files to compile them. They noted that there might be omissions or other inaccuracies. However, the orders of magnitude are considered reliable.

Annex 6a

RESEARCH ON SUGAR CANE

Introduction

It is almost a truism that sugar cane has been grown successfully in Guyana in spite of the conditions rather than because of them. The soils of the coastal plain are mostly heavy clays at or below mean sea level. Extensive water control and management structures are needed to ensure reasonable drainage and protection from the ingress of saline water. It is only by a complex system of water control that the soils can be kept in cultivation. The maintenance of these structures is extremely costly, and the system as a whole demands a high level of management.

The bimodal rainfall distribution gives rise to two relatively short dry seasons during which harvesting is possible. Most of the cane-growing area is only about 5°N, and the seasonal variation is small in the generally high mean temperatures, especially in the minimum night temperatures,. The mean daily period of sunshine of about 5.8 hours is low compared with that in other cane-growing areas.

The combination of heavy soils that dry slowly, high mean temperatures, relatively low insolation, and relatively short dry periods, makes it difficult to grow cane of reasonable sugar content in Guyana. While the yields of cane are high, the yield of sugar per hectare is relatively low. Since most of the costs of production are related directly to the weight of cane, rather than to the actual sugar produced, costs of production per ton of sugar are consequently high.

It is hardly surprising in this situation to find that the industry has a long tradition of research, particularly in the breeding and selection of varieties to suit the difficult conditions, and in the careful use of fertilizers to maximize the yield of sugar (not necessarily the yields of cane). Methods have been evolved for handling the difficult soils, but they are expensive, calling for the use of heavy machinery.

Cane is transported to the factories by barge, and the unique systems of waterways have the double function of transport and water control. They provide an economical means of transport, but they present serious problems in relation to possible future mechanization of harvesting -- which may become necessary in the face of steadily rising labor costs.

Research Organization

Research work is under the general control of the corporation's manager (agronomy), who also has responsibility for the technical aspects of production on the estates.

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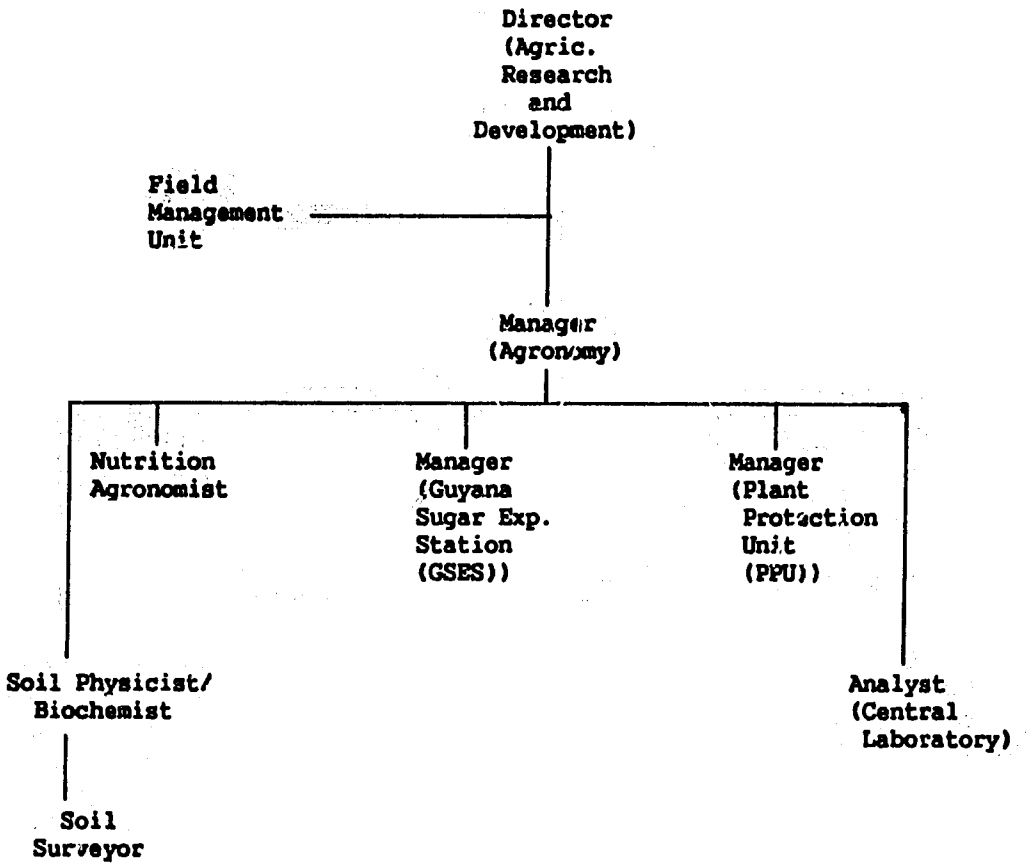
Some reorganization of the structure of the agronomy department is in progress but the essential features of the organization, as it relates to the research component, are shown in the figure.



At present the manager (PPU) acts as manager of GSES, with a supporting staff of: varieties agronomist, weeds agronomist, entomologist, and farm manager (varieties selection). The soil physicist post is filled, but the posts of nutrition agronomist and analyst are vacant.

In addition to the research staff shown, there is a qualified agronomist on each of the 10 estates. Although the varieties agronomist and farm manager (varieties selection) have prime responsibility for the varietal improvement program, the estates agronomists have an active role in the experimental work done on their respective estates.

A feature of the organization is the close integration of the research program into the needs of the estates and the cooperative effort in

getting the work done. This is achieved without burdening the officer in charge of the research effort with other duties connected with production.

The soil physicist has an investigational program, mainly on the hydrology and water relations of the clay soils; he also supervises the central analytical laboratory which analyzes samples of soil, water, plant materials, sugar, and other products for both research or routine purposes. The excellent internal management training programs, which are a feature of Guysuco, are considered in another section of this report.

Work Program

The established research program on the breeding and selection of varieties (refs. 1 and 3) has been able to provide a sufficient number of alternative varieties to replace those struck down by disease during the past seven years, enabling the industry to overcome a potentially disastrous situation. The varietal improvement program is carried out as part of a cooperative network involving several countries of the Caribbean and the Central Cane Breeding Station in Barbados (financed by the participating countries themselves). Altogether 8 to 10 of the established varieties have been replaced since 1974 because of their sensitivity to smut (Ustilago scitaminea) or rust (Puccinia melanocephala). There is now an additional threat to the variety B41227 (which occupies almost 60 percent of the area under cane) from the yellow spot disease (Mycoyellosiella koepkei).

The control program for all of these diseases is based on using resistant varieties and managing the mixture of varieties on each estate in such a way as to reduce the infection potentials to levels at which varieties can be grown that have only partial resistance but other desirable attributes.

The varietal improvement program has thus become more difficult during the past few years. Some reappraisal of both the staff composition and the facilities available would seem to be needed.

Until recently, the major insect pests have been froghopper (Aenolamia flavipennis) and Spodoptera cutworms/caterpillars, with large and small moth borers of Castnia and Diatraea spp. of more localized occurrence. The main approach to the control of insect pests is through various forms of biological control, mechanical means such as flooding, and chemical control agents applied at critical and specific times.

Fungal pathogens of the Metarrhizium group have been shown to have considerable promise against froghoppers, the large moth borer and, of possibly greater significance, against the leaf-eating caterpillars of Spodoptera spp. This work is severely hampered by the lack of the necessary equipment for isolation, characterization, and production of experimental quantities of the pathogens.

Linkages With Other Institutions

The long-standing cooperative network of cane-testing stations linked to the Central Sugar Cane Breeding Station in Barbados has proved invaluable

in developing cane varieties. These varieties have allowed the major diseases to be overcome, or their effects greatly reduced, while the yields of sugar have been maintained at a reasonable level.

In the biological control field, work is carried out with the help and guidance of the staff of the Commonwealth Institute for Biological Control (CIBC) through the Trinidad station.

Through these two organizations, experienced and specialized guidance (and materials) have been provided for use in the national program. This is a particularly important source of assistance in fields of urgent need in which there are not adequate numbers of trained staff in the national programs.

The senior pathologist from Barbados has helped to plan the varietal development strategy in Guyana, and the staff of the CIBC station in Trinidad has provided parasites and predators of insect pests and fungal parasites from outside the Caribbean.

Budgets

It is almost impossible to assess the amount of money spent specifically on research activities, since this work is interwoven with work on the estates and to some extent uses common facilities.

The approximate cost of running the activities at and from GSES in 1981 was less than GY$500,000. Even twice that figure for the total cost of research represents only about 0.3 per cent of the gross value (ref. 2) of the sales of the corporation. It would not be unrealistic for the expenditure on sugar cane research to be increased substantially, even to ensure that current output levels can be maintained.

Additional Requirements

The most urgent requirements are to fill the vacancies at the technical level within the total organization, with special emphasis on a senior plant pathologist, an experienced analyst, and supporting subprofessional technical staff in all research activities.

While some additional buildings (laboratories) are needed, the more urgent need is for equipment to allow the varietal improvement program to be intensified (a programmable calculator would be a great help), and for the program of research on fungal pathogens of insect pests to be developed.

The team was told that approaches had been made to an external agency for support in these fields, and this approach can be fully supported.

Enquiries made within Guyana, however, located a few (but not all) of the items of equipment needed in other institutions, where they were not being used. Increased cooperation between national agencies would help to alleviate some of the equipment problems which have been identified.

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RESEARCH ON RICE

Introduction

Rice is grown on the heavy soils of the coastal plain, and production is possible in two seasons. Where water control is adequate for both drainage and irrigation, two crops are possible on the same land in each year. Most of the area is rainfed rather than irrigated, and many areas are subject to flooding during heavy rainfall periods. Although an estimated 100,000 ha of land is used for growing paddy, the total area planted, taking both crops together, rarely exceeds 120,000 ha.

The massive investment schemes now in progress to improve the water control situation are expected to lead to a substantial increase in the total area of land which can grow paddy; they may also increase the cropping intensity.

The main feature of the industry at the production level is that, while a large part of the crop is grown by farmers who have 10 ha of land or less, it is fully mechanized apart from sowing operations and the application of fertilizers on some farms. This means that the industry is capital-intensive and depends on imported inputs to maintain productivity. In such a situation the industry should develop and maintain a sound technological base to sustain the high level of output needed to ensure a reasonable return on the capital investments at the infrastructural and on-farm level.

Research Organization

The Guyana Rice Board (GRB) has a wide range of responsibilities in relation to the farmers. It is the sole buying and marketing agency for rice; it provides machinery services to farmers who have less than 6 ha of land; it grows and distributes seed of the approved varieties; it is responsible for the supply of fertilizers and pesticides; it is also responsible for the research and extension services.

The establishment for GRB provides for the manager (research and agricultural services) to be supported by two senior managers, one in research and extension and the other in agricultural services. Both posts were vacant in January 1982, and the whole of the management load was being carried by the manager (research and agricultural services). Within the research and extension unit there is provision for eight research posts, three posts in applied research and extension (one in each of the main rice-growing regions), together with support staff in the laboratories and on the farms.

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Of the 11 technical posts, only 4 are filled. There are two junior plant breeders, one junior agronomist at the MARDS research station, and one research and extension officer in the Essequibo region.

Work Program

Although good work has been done in the past to develop improved rice varieties, two of which are widely grown, and to establish a reasonable general basis for fertilizer use, the research effort is now small. In the opinion of the team, it is inadequate to support a major industry.

GRB has initiated action to improve the situation, and a team of specialists (all expatriates) financed by USAID is working in the Black Bush Polder Project on various aspects of adaptive research. They are not supported by matching Guyanese colleagues, so some potential value of such a group in the training field is being lost. They have identified a number of fields in which a determined and continuous program of applied research is needed. The most important of these are the intensification of the breeding program with the objective of introducing greater resistance to blast disease than is shown by present varieties, the more precise characterization of the environment by increasing the number of agrometeorological stations and the range of observations taken, and more detailed work on crop responses to added fertilizers especially on double-cropped land to ensure maximum economy of use.

It would also appear that there is an urgent need to study the farming systems of the coastal plain, since most of the rice growers also own appreciable numbers of cattle and grow some ground provisions for themselves and to sell. The major development schemes appear to stress the double-cropping of rice on all suitable land to obtain reasonable returns on the investment, but many farmers may see cattle as a means of spreading the risks over a high-input, high-cost rice crop of considerable risk and relatively low profitability and a low-input, low-cost but low risk cattle enterprise. There seems little doubt that the farmers have integrated rice and cattle into one system. In this connection the "zoning of cattle" into specific areas, which has been proposed, would seem to need much more careful study.

In addition to the adaptive research being done in the Black Bush Polder area, there is a team of seven to eight graduate scientists working with MMA on farm-level trials. This team includes livestock and water management specialists. The general manager indicated that availability of a suitable technology was not a major constraint to rice production at present and that profitability considerations were more important determinants of the decisions made by farmers. To meet some of the problems, efforts were being made to increase the average farm size by the allocation of currently unused land, thus increasing a farmer's total income (if not his income per unit area).

Concern was expressed, nevertheless, that the central research on rice was at a low ebb and unable to provide the backup services which would be needed in the event of a biological emergency, especially if this could only be overcome by the introduction of new varieties or biological control measures. The team strongly supports this view, and it may be

pertinent to ask what would have happened to the sugar industry over the past few years had there not been a strong research base and previously developed varieties to overcome the serious disease problems which arose. The MARDS research station has a range of laboratories and offices which could accomodate an adequate team of scientists. The facilities available are given in Annex 3.

Linkages With Other Institutions

There is a long-standing link with CIAT, and material is received from CIAT on a regular basis. The blast nursery is of particular importance to Guyana, since this disease may become of more importance as the area of rice is increased. It has already been found that the incidence of the disease is affected by location, even within the apparently uniform conditions of the coastal plain, so that constant vigilance and improvement is called for. One member of the staff had received training at IRRI, but much of the IRRI work does not fit the context of mechanized rice production in Guyana.

The mandate of GRB also covers cereals other than rice, and some work is in progress in cooperation with CIMMYT on maize and triticale on the better-drained soils at Kibilibiri on the west bank of the Berbice River. While it is not inappropriate for GRB to be involved in farm systems research in situations where rice is the main crop, research on the other components of such systems would seem to be out of place. It could best be done as part of a wider commodity-based program to avoid overlap.

While there is contact with the international institutes, there appeared to be little with workers in Surinam (although some of the USAID team at Black Bush had visited there). It is clear that Surinam has an active rice research program, which has produced more than 20 improved varieties during the past few years. It was reported that there is some feeling of competition and rivalry from the Surinam side, and since both countries export rice there is some feeling of commercial competition.

Linkages with other national agencies appeared to be weak, although the soil science division of the Ministry of Agriculture is doing a lot of routine analysis for GRB. In the field of credit, some interesting observations were made by officials of GAIBANK to the effect that the GRB did not have enough extension staff to provide the detailed technological base for the appraisal of applications for loans from rice farmers. This had caused the bank to employ almost 40 GSA graduates to do the work, which indicates a demand for technical information from an unusual but important source.

Budgets

The total allocation for agricultural research, seed production, and extension activities in 1981 to 1982 was about GY$1.0 million; of this less than GY$200,000 (at a generous estimate) was allocated to research activities. This may be contrasted with the US$1.8 million for the technical assistance component of the Black Bush project, financed by a consortium of donors (principally USAID), and the value of the crop estimated to be on the order of GY$300 million.

Even 0.5% of this figure would provide GY$1.5 million, and this would represent a modest and realistic minimum percentage to be spent on rice research. Perhaps GY$0.5 million is being spent on adaptive research in various projects, leaving a considerable gap between the actual and what is considered a minimim desirable expenditure on research.

Additional Requirements

There is an urgent need to bring the applied research team on rice back to an effective working size, in particular to strengthen the plant breeding and pathology components.

Of much greater importance is to separate the research activities and the management of research activities from direct involvement in production and input supply activities. There seems to be difficulty in some places in distinguishing between production-oriented research and involving research workers in production activities; the team fully supports the former but not the latter.

It is open to serious question as to whether GRB -- with its many other, chiefly commercial, functions -- provides the appropriate institutional base for rice research activities. GRB is not a production organization and in this sense has no direct vested interest in the yield of a field or of an individual large farm. In this it differs from Guysuco, where the manager in charge of research is also responsible for production. In the latter situation, there is an intense vested interest in ensuring that relevant research is done, that it is done well, and that the results are applied effectively to the field situation. This situation does not exist within GRB -- although interested in promoting rice production on a national scale, GRB cannot be expected to have the same intensity of interest in research as it would have as direct producers.

There would seem to be a good case to be made for the applied research on rice, and on farming systems based on rice, to be done in a multidisciplinary unit covering crops and livestock, rather than in isolation from workers in other commodities and in livestock. It could be financed directly by some type of cess on the rice industry; this would help to ensure accountability for the use of the funds and the relevance of the research program to national needs. This is pursued further in the fourth section of the main report.

Annex 6c

RESEARCH ON OTHER CROPS

Introduction

The estimated annual requirement for attaining self-sufficiency in edible oil is about 6,000 tons. At present about 2,400 tons of coconut oil are produced, divided almost equally between the production from private mills and from the Guyana Pharmaceutical Corporation.

Three main potential sources of increased supplies of edible oil have been identified:

-- increased output from the coconut industry -- following rehabilitation of plantations, some replanting, and improvements in the drying and production of copra;

-- extraction of the oil from rice bran. One solvent extraction plant (with a capacity of 1,000 tons of oil per annum) is scheduled for commissioning in April 1982, and another unit of similar capacity has been ordered;

-- production of palm oil and palm kernel oil from an expansion of the oil palm plantation at Wauna to cover a total of 4,000 ha. A large new factory would be needed to process the oil from this plantation.

In addition there is a possibility of extracting some oil from certain of the wild nuts which can be collected in some areas and from soybeans when production problems have been overcome. It can be seen that if the output of coconut oil could be increased by about 50% (a realistic estimate based on a survey carried out by the FAO adviser), and when the extraction plants for rice oil are functioning, the total output should be about 5,600 tons.

The production of oil from rice bran does not require an agricultural research effort. The requirements of the coconut and oil palm crops are discussed separately but within the same context.

Oil Palm

The study made by the Commonwealth Development Corporation (CDC) in 1978 at the request of the Government of Guyana recommended a large scale (4,000 ha) commercial oil palm plantation project in the Wauna area based on small plantation established in 1973.

The choice of Wauna in place of San Juan for pedological reasons appears to be sound, but the CDC estimate of potential appears optimistic for the following reasons:

-- Wauna, San Juan, and other small plots in Ebini, Mon Repos, and Timehri -- established between 1960 and 1973 -- have not been used as anticipated for accurate observations on growth and yields, nor for preliminary experiments with fertilizers, green cover crops, and other cultural practices. Thus no data are available today on which to make a sound assessment of likely yields under the prevailing conditions. There are no accurate data on the growth and yield potential of oil palm under the ecological conditions found in Guyana.
-- While more suitable than San Juan, Wauna conditions are considered to be marginal for oil palm production on a large scale because of low soil fertility level, low moisture retention, and the danger of a serious moisture deficit in consecutive months during some years. In the northwest area the small dry season from January to February or March might extend also to April, which means three or four consecutive months with sometimes less than 10 mm rainfall. This occurred in the past (1940-41, 1965-66, etc), with water deficits of 289 mm (1940), and 198 mm (1966). The sunshine hours for Wauna, between 4.9 and 5.5 hours per day, are also marginal for optimal production from oil palm.
-- Manuring. Nothing is known about the fertilizer requirements of the crop at Wauna. This information could already have been obtained from systematic experimental trials of NPK and Mg requirements. These are essential elements that should have been made available before making a decision to expand the cultivation.
-- There is also a need for experimental trials with different green cover crops and organic matter applications, and for measurements of soil moisture availability during the dry season.

The 20 to 22 t/ha of fresh fruit bunches (FFB) might prove to be an optimistic production average, and it seems unlikely that per hectare yields of 4,000 kg palm oil and 900 kg kernel palm oil would be produced on a regular basis.

As no decision has been taken so far for financing the full project, an applied research program on oil palm should be started without further delay, initially to:

-- study and record data on oil palm growth and yields,
-- conduct fertilizer trials on the three basic soil series identified at Wauna at three stages of development: (a) 1 to 3 years, (b) 3 to 6 years, (c) above 6 years;
-- measure the effect of different cultural practices and different green cover crops on yields.

Coconuts

In 1980 the Ministry of Agriculture initiated a review of the possibilities of increasing the output of the coconut industry, and a UNDP/FAO review to prepare a coconut rehabilitation project is in progress. The FAO adviser, Manthiratne, indicated that, if known corrective measures were to be applied over a three-year period, it would be realistic to expect an increase of about 50% from existing plantations. The experience of members of the ISNAR team in similar, and to some extent less favorable circumstances, supports this conclusion.

The program would consist of the adjustment of the stands, which in many places are too dense but contain a high proportion of young to medium-age

trees (few plantations appear to have seriously over-aged stands), application of modest amounts of fertilizer, improvements in ground management, and the use of better methods of drying copra to improve its quality and reduce waste. There is considerable use (and theft) of green coconuts for drinking purposes, and this reduces the quantity of mature nuts left for copra production. The planting of dwarf (early maturing) types of coconut would quickly meet the demand for fresh nuts and lead to some further increase in copra production.

There are a number of problems and questions on which some research is needed. The most pressing of these is the control of leaf-eating caterpillars which cause serious damage in most years. Control by chemical methods is hardly practicable, because of the difficulties of getting the small-holders in an area to cooperate, and, in any event, the spraying of tall trees is difficult. There appear to be possibilities of using biological control methods.

Work also needs to be started on the selection of superior mother palms for use in a hybridization program and on the development of improved nursery techniques (these are known but need some adaptive work to use locally available materials). The use of fertilizers could be regulated by using the results of foliar analysis to guide the quantities and composition of the fertilizers to be used. This method is acknowledged to be less satisfactory than the use of yield trials but is well established, can be applied using existing resources, and gives early results.

The adviser felt that it would be unrealistic to attempt to set up a comprehensive research program. He felt that much improvement in production could be achieved by using extension workers who had been given intensive training in the modern methods of coconut production to help, advise, and train farmers. An initial subsidy on fertilizers might be needed since no responses would be obtained in the first year of application. The control of insect pests is more difficult, and a small research program in cooperation with the Commonwealth Institute for Biological Control would be appropriate. The ISNAR team gives full support to these proposals.

Coffee

The team reviewed the FAO Coffee Survey in Guyana (H. R. Cambony, 1981) and fully concurred with the conclusions reached on the major limitations to, and difficult ecological conditions for, the growing of coffee in Guyana. The coffee industry is facing biological, technical, processing, marketing, and administrative constraints; investments would be required in human, financial, and infrastructure which seem out of proportion to the expected outputs or foreign exchange savings that would result from even good production from the 1,460 ha of small-holding coffee plantations. The coffee research program proposed is technically sound but is considered unrealistic under present conditions in Guyana.

Agricultural research resources, especially of skilled research workers, are severely restricted. It seems more realistic to concentrate these on commodities of higher priority (rice, food crops, oil crops, pasture, livestock). Tthe team would find it difficult, therefore, to endorse the optimistic and costly proposals and conclusions of the FAO Coffee Report.

Most of the coffee in Guyana appears to be C. liberica and is, theref well suited to the wet peaty soils of the coastal plain. It also see. likely that it would grow well on the more freely drained soils of the riverain terraces. Bearing in mind the expressed intention of the government to develop other areas of the country, the possibility of using C. robusta on some of the soils currently under forest might be considered.

Parts of the Mabura Hill area, which the team visited, has brown-sandy loamy soils and lateritic red-yellow latosoils (tropical rain forest of Ocotea rodiaei). These might provide a more appropriate environment for growing coffee, allowing for the establishment of C. robusta plantations on a commercial scale.

The team is of the opinion that with minimal resources, mainly concentrated on few nurseries for multiplication of Coffea liberica and new genetic material of Coffea robusta, a small but efficient group of extension specialists supported by adequate facilities and services would be worth considering for the rehabilitation and rejuvenation of the total 1,460 ha of coffee, and for expansion into other areas as required. Such a modest program, supported by a fair coffee price policy, subsidized inputs, and well-organized cooperatives of coffee producers, could lead to appreciable increases in production.

Groundnuts (Arachis hypogea)

This crop is mainly grown by small farmers for the local market, where there is a good demand and prices are high. Appreciable quantities of unshelled nuts are imported from other parts of the Caribbean, principally from the island of St. Vincent.

Good yields have been obtained in trials conducted in the Wauna area by Guysuco and on the riverain soils along the Berbice river using mainly high oil types. Production is being encouraged in the Essequibo and Upper Pomeroon areas in the Food Crop Production and Marketing Program. Yields of up to 1500 kg/ha of dry unshelled nuts were obtained formerly, but yields have declined to about 350 kg/ha, possibly through degeneration of the seed stocks (accumulation of viruses) and a decline in soil fertility under continuous cropping. It was reported that there was reluctance on the part of the farmers to use freshly imported seed of potentially more productive varieties.

While local research efforts have been limited to variety trials and the chemical control of leaf spot (Cercospora spp.), CARDI has had a successful research and development program at several locations in the Caribbean, including Guyana.

There would seem to be a reasonable potential for this crop in the riverain areas and possibly in the savannahs when the fertility has been built up, but much of the present output comes from the heavier but well drained soils in the Wauna area.

Since there appear to be no unusual problems associated with the growing of the crop. There is a good regional research program under CARDI, and the information and seed supplies needed to develop the crop in at least some of the likely areas in Guyana should be readily available without

the need to mount other than a small adaptive research program on this crop. The most serious problems likely to arise are from leaf diseases and insect damage (Spodoptera frugiperda caterpillars), but methods of control are known (even though they may be difficult to use under Guyana conditions, which are rather more humid than those found in the main groundnut-growing areas of the world). These conditions may limit the extent to which the crop can be developed. If costs of production remain high, because of the cost of plant protection measures, it will not be possible to consider the use of groundnuts for oil production, and demand will be limited by the size of the fresh-nut market.

Cassava (Manihot utilissima)

Cassava is widely grown in Guyana in mixed cultivation with maize, pigeonpeas, and pulses of various kinds.

In the past few years, efforts have been made to grow cassava on a larger scale for the commercial production of flour (to use as a partial substitute for wheat flour, all of which is imported), stockfeed, and other products. The mills established for this purpose have been unable to obtain adequate supplies of cassava from farmers at the prices offered. Even at these prices, cassava flour could not be produced at a cost equal to that of imported wheat flour.

To try to overcome these problems, Guysuco started to develop large-scale production of cassava at Kaituma in the northwest, and experimental work on the mechanization of the crops has been done under IICA auspices.

Improved varieties have been imported from CIAT and yields of 25 to 37 t/ha of fresh roots have been obtained. There has been no concerted research and production effort or trials of the best available varieties and technology on a range of soil types. The heavy soils of the Kaituma area and the peats of the Essequibo and Pomeroon areas would not seem to offer good possibilities for mechanized production of crops of reasonably high dry-matter content.

Research programs on cassava should emphasize introduction and evaluation in various ecological conditions of suitable varieties, including drought-resistant optimum response cultivars for intermediate savannahs. Intercropping of cassava with sorghum or legumes and direct planting into killed grass swards may be practical means of production once fertility has been built up.

The pest problems currently recognized as of economic importance include the cassava hornworm (Erinnyis spp.), the budworm (Chilozala bifalalis), the shootfly (Silba perezi), and the cassava mite (Mononychellus caribbeanae).

Introductions should be subject to strict quarantine measures to avoid bringing in new destructive diseases and pests which are not known to exist in Guyana. Important among these are cassava bacterial blight (Xanthomonas manihoti), cassava mealybug (Phenacoccus manihoti), and the green cassava mite (Mononychellus tanajoa).

Black-Eyed Pea (Vigna unguiculata)

Black-eyed pea is an important grain legume in Guyana. It is widely grown by small farmers for their own consumption, and considerable quantities are imported from the United States. Guysuco and the Guyana Rice Board have tried to develop large-scale mechanized production of black-eyed peas using the variety California 5, imported from the United States. This variety has been grown on an experimental basis in Guyana since 1978, with average yields of 450 to 600 kg/ha and a maximum of 1,050 kg/ha. Large-scale production trials at Kimbia have yielded 770 to 990 kg/ha of shelled dry peas, using NPK at the rate of 330 kg/ha, and Treflan for weed control. At these yield levels the cost of production is considerably higher than the local (controlled) price of the crop. Problems of pod rot, leaf miners, and leaf hoppers are common; while the pests can be controlled effectively by monocrotophos, control of pod rot may best be achieved by the breeding of improved varieties. California 5 is a long-duration variety, and the crop length makes it difficult to schedule both planting and harvest of the crop to take advantage of the bimodal rainfall patterns.

While the variety in use is not well-adapted to the soil and weather conditions of Guyana, the yields indicate that well-adapted varieties could well have a sufficiently high yield potential to make them economically attractive.

Some investigations being carried out at Mon Repos include variety trials with IITA, agronomy weed and insect control, and the use of selected rhizobia to increase nodulation. There is scope and sufficient promise for work on this crop to be extended. One staff member has received training at IITA in the cowpea program, but he is currently working on seed production rather than on a full research program.

Maize (Zea mays) and Sorghum (Sorghum bicolor)

Maize has been grown for generations as part of the mixed cropping commonly found in kitchen gardens and small holdings throughout the Caribbean. Grown in this way, yield is not important and hand-harvesting of a few plants is scarcely affected by the weather.

Research work by the crops division of the Ministry of Agriculture and by CARDI (for the Caricom Corn and Soya Bean Co.) has been aimed at the selection of varieties of higher yield potential than the established cultivar (Charity) and having the same or higher degree of tolerance to adverse conditions, including insect attack. The cultivar Tuxpeño, introduced some years ago, outyields Charity, but it must be harvested early to avoid serious attacks by weevils in the field. A newer cultivar introduced by the crops division, CAS 181, yields as well as Tuxpeño under well-drained conditions and has the requisite other attributes. It does not yield well, however, where drainage is restricted.

The nutrient requirements of the crop are well known. The main research question is how to meet the needs economically, especially on the poor soils of the intermediate savannahs. A considerable amount of research work has been done on this problem.

On the soils of the coastal plain the major problems of obtaining adequately fine tilth to ensure good germination and of maintaining good drainage during periods of heavy rain have yet to be solved.

Insect pest problems have been found to be severe on maize crops grown almost anywhere in Guyana and at any season. Stem borers (Diatraea spp.) and the armyworm (Spodoptera frugiperda) are the main pests and, because of the cost and difficulty of controlling these by the use of chemicals, biological methods are being sought.

The balance appears to be weighted heavily against the large-scale economical production of maize; at least for the intermediate savannahs, sorghum may offer a better alternative. The major factor which cannot be controlled is the weather; sorghum which is generally less sensitive to adverse weather conditions than is maize (except at harvest time) would appear to be well worth considering, particularly as a replacement for imported livestock feed. The results from the early sets of trials are sufficiently promising for this work to be continued and possibly intensified.

Yields approaching 2.0 t/ha had been obtained in the Kibilibiri project in 1971 to 1972, and some commercial production (60 ha) was attempted. The varieties available at that time proved sensitive to helminthosporium, and the work was abandoned. Since that time a much wider range of genetic material has become available from several sources, and the search has been resumed by the crop division and by CARDI for varieties which will yield satisfactorily under Guyanese conditions (which would seem to be consistently too humid to be really suitable for the growth of the crop). Small plot yields of up to 2.0 t/ha-equivalent were recorded from some of the hybrids used. Although the hybrids may have advantages of uniformity and production under the conditions for which they were produced, they were all so sensitive to helminthosporium that a wider range of plant materials may need to be considered. There does not appear to have been direct contact with ICRISAT and other sorghum-breeding centers in developing this research program, although there could have been indirect contacts through CARDI. A systematic approach to the selection of materials to be tested on the basis of their known attributes could perhaps save a considerable amount of time and effort and could lead to an earlier decision as to the feasibility of growing the sorghum successfully in Guyana.

This serves to emphasize the great importance of good communications in order to maintain an up-to-date awareness of what is available on a world basis. The team gained the impression that the research workers in Guyana were isolated and out of touch (or not fully familiar) with recent developments in a number of fields.

Cotton (Gossypium hirsutum)

The small research program on this crop was not considered in detail. The team had access to the report of a cotton specialist who had examined the situation. This report emphasized the extreme difficulty of growing any crop which has precise nutrient and soil moisture requirements and which needs a dry period for ripening and harvest under the unpredictable and erratic rainfall patterns found in Guyana. To this extent, the

problems of growing cotton are different in degree rather than in principle from those of growing other crops. The pest problems, though not presently of serious proportions, must be expected to increase. At best, cotton production on a large scale would seem to be an expensive and risky operation, even though some of the technological problems may be overcome in time.

Annex 7

RESEARCH ON LIVESTOCK

The livestock industry is considered in two parts: first, those components which rely heavily, if not entirely, on imported stock and feedstuffs (concentrates) and second, those which rely on mainly pasture (native or improved) as a source of feed and where the imported input is confined to fertilizers and other soil ameliorants and essential mineral supplements.

Enterprises in the feed-based (as opposed to pasture-based) sector have developed rapidly during the past 10 years, and the country now produces enough eggs, poultry, and pork to meet its requirements. This may seem a satisfactory position, however, the intensive poultry industry imports all of its requirements for hatching eggs and virtually all of its feedstuffs. It may be argued that the industry is a net user of foreign exchange, since it is likely that frozen chicken could be imported to meet needs at a lower foreign exchange cost than the feed and other inputs needed to produce it. This argument may be less valid when applied to pork products, but it is clear that the benefits to the country do not flow primarily from the savings made in foreign exchange costs.

The reason for this situation is that imported materials used in the manufacture of pig and poultry feeds have been replaced by locally produced materials much more slowly than was considered possible when the two industries were being developed. This points to an urgent need to examine why this replacement has not happened and what, if anything, can be done to improve the situation.

The question first considered was why there has been little progress in replacing imported ingredients by locally produced materials. Efforts so far have been concentrated on replacing like with like, and since the rations contain large amounts of maize and soybean products, research and production attention has been concentrated on those crops. However, there are only small areas of land (on the riverain terraces) which could be considered as well-suited in fertility level and physical conditions for the growth of maize and soybeans.

In addition, both of these crops have specific and critical requirements of adequate water and sunshine during their major periods of growth, then relatively dry and sunny conditions during maturation. The erratic and unpredictable rainfall patterns make it virtually impossible to choose periods of the year when these conditions are met, ensuring reasonably secure production of acceptable yields.

The reasoning behind the direct replacement approach appears to be that to use other locally available alternatives as part of the ration would reduce the energy content and increase the fiber percentage to such an extent that conversion ratios would be adversely affected.

It would seem to be realistic to approach the problem in another way, starting from the position of what can be grown reliably and at modest cost (absolute and of imported inputs), and how these materials can be used to maximum advantage. This does not rule out continuation of efforts to grow soybeans (and possibly maize) in some places, but it does widen the range.

Three developments are taking place which could result in an increase in the range of potential ingredients. First, in fisheries, the commissioning of a small fishmeal plant and concurrent efforts to bring ashore much more of the by-catch from the shrimping industry, should result in a small but significant amount of high quality protein and minerals becoming available. Second, two plants are to be commissioned in 1982 which will result in substantial amounts of de-fatted rice bran becoming available -- despite digestibility problems in some classes of stock, this potential feed source should not be overlooked. Third, there is a project in preparation for the rehabilitation of the coconut industry which, if implemented, could lead to an increase of up to 50% in the amount of coconut meal available for stock feed.

These developments are in addition to the efforts being made to increase the production of other materials. Cassava and sorghum would seem to merit research attention in this context. A broad view (i.e., to find out how to use effectively what can be grown economically and with acceptable risks) seems to be needed in research in this component. It could include production aspects, milling and compounding, and feeding trials, the latter coming within the livestock research program as an essential component.

One general question about the strains of livestock used may be pertinent: are these fully appropriate to a situation in which it would be advantageous to be able to use locally produced feeds even if these are of lower quality than those available elsewhere? Most strains of poultry and pigs have been developed to use efficiently high quality rations. Are they the best to use in situations where importation of feed places a major strain on foreign exchange resources? As one farmer commented, "The Creole fowl produces eggs without being fed." (An exaggeration, perhaps, but thought-provoking.)

There are two main thrusts in the forage-based sector of cattle, sheep, and goats: production of meat and of milk. Both require adequate forages of appropriate quality. Considerable work is being done by LIDCO on the development of pastures in the savannah areas; the potentials, problems, and some program suggestions are discussed in more detail in Annex 1c. This development work is based on the results of the substantial amount of research done on crops, soils and livestock (especially the nutritional aspects) over several years in the ministries of Agriculture and Livestock. One main line of investigation put forward is for an integrated approach to crop and livestock production; apart from technical considerations, this is an area which appears to have received too little socio-economic attention. Most of the ruminant livestock in Guyana (up to 75%) are located in the coastal plain; they form part of a complex farming system involving rice, cattle, and ground provisions.

As indicated in Annex 6b on rice, a better understanding of the total farming system and of its total output per farm could assist in achieving the targets set for rice production under the large investment schemes now being carried out.

Good yields of good quality grasses and forage legumes can be grown on heavy clay soils. These crops are much less likely to be damaged by erratic rainfall than are those which have a finite harvest time (at the dry seed stage). Some of the "Merker" strains of Napier grass from Venezuela grew well in Trinidad on very heavy clay soils, but it was impossible either to graze them or to harvest them mechanically without causing excessive damage to the soil. Yields were high, however, so that for the finishing of beef cattle or the production of milk, hand-cutting may be economically feasible (Haworth, unpublished results). Some work would appear to be justified to assess potentials for this type of fodder production as a way to try to maximize total production from the fertile soils of the coastal plain. It could be done as part of a comparative study of different systems of production of ruminants in which the old low-cost and trouble-free "Creole system" of milk and meat production should be included.

The implications of any such intensification of research on livestock production are important for the organization of research. The type of work envisaged has two parts: study of the production systems as farm systems; and the study of specific components of each of the systems. To achieve the necessary working interaction between several different specialities involved, it would be most appropriate to have a research organization that would permit and promote the establishment of multidisciplinary teams of researchers. Although little comment has been made on disease problems, since these were considered by the livestock specialists in Guyana to be essentially under control and of lower research priority than the production of feeds and the testing of feeding systems, any team working in this field should have the advice and support of the veterinarians so that the disease situation can be closely monitored.

Priorities for research in livestock production are seen to be in production of stock feeds (concentrates and forage) and in the study of systems of livestock production, whether in the coastal plain or in the savannahs. At the national policy level, there should perhaps be reconsideration of the emphasis afforded to ruminant production, as opposed to the production of nonruminants largely on imported feeds, in the light of the respective net foreign exchange demands, the potentials for local production of the types of feeds required, and the likely costs involved.

FISHERY RESOURCES

Guyana's rich fishing waters have attracted a large number of marine powers (1,624 boats and 245 trawlers in 1974). The extension of sea limits to 200 miles has provided new waters for her fishing and shrimping industry, assuring a substantial government income in fishing zone fees.

Guyana is the largest exporter (among Caribbean countries) of fish and shrimp; the United States and Japan are among its more lucrative markets.

Fishing is one of the major natural resources in Guyana, with a 1979 fish and shrimp production of 43.6 million lbs. and 8 million lbs., respectively. Statistics show an increase of 63% from 1970 to 1979 for fish production, but a 44% decrease for shrimp production during the same period. Without a study on the evolution of the shrimp stock and production capacity, it is difficult to ascertain the reason for the decrease, which started in 1974-75 after a record production of 15.5 million lbs. in 1973 (when a fleet of 214 shrimp trawlers was operating). It might be that shrimp harvesting from 1970 to 1974 exceeded the stock capacity.

The Ministry of Fisheries, a part of the Ministry of Agriculture, has two major departments under the supervision of senior fishery officers (one for marine fishing and one for inland fishing and aquaculture), who are responsible for applied research activities.

Research activities are limited in both departments in spite of the great potential of the fish resources and of the fish industry in Guyana to contribute to food supplies, exports, and animal feed production.

The marine fishery research section has approached several international agencies, including FAO and bilateral donor agencies (NORAD-DANIDA), for advice to build up a program of applied research and development for both industrial and artisanal fishing; it is pursuing an IDRC second-phase project on marine by-catch resources. Some projects have been completed: with the Union of Soviet Socialist Republics on pelagic fish resources; with Cuba and the United States on shrimp; and with the Democratic Republic of Germany on commercial fishing.

The inland and aquaculture section has an IDRC project on production development and fish culture. The aquaculture project of IDRC with Guysuco is a comprehensive study of the potential production of fish under various soil and water conditions in the elaborate irrigation/drainage canal system established for sugar cane cultivation (about 5,000 miles of canals) and in the flood fallows that cover approximately 2,500 ha annually.

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The six- to ten-month flood fallowing of fields from which sugar cane has been harvested is part of the sugar cane production system. It enhances soil productivity by maintaining a good tilth for planting the next crop and controls weeds and some of the parasites and other pests of cane. It also appears to provide an increment of soil nitrogen through various forms of biological fixation.

The study, which was started in 1979, aims to determine the potential for fish production in different soils in flood fallow fields with different species of fish in mono- and poly-culture systems under different conditions related to time of flooding, rainfall, stocking rate, and supplementary feeding techniques.

Several indigenous species, especially the much prized hassar (Hoplosterum littorale), the already acclimatized Tilapia, and other exotic species (e.g. the grass carp from China) and other herbivorous species (e.g. Pacus) are being investigated; breeding programs are being conducted in the fisheries unit situated in the Botanical Gardens and in the zoology laboratory of the University of Guyana. Large fish hatcheries on Blairmont and Enmore estates are using induced spawning (salmon pituitary extract) and natural breeding for juvenile fish production. These are being fed with tested feeds, and the nursery ponds are being fertilized with sugar factory "pressed cane" to produce fingerlings for stocking the flood-fallowed fields.

Yields of Tilapia in ponds, using NPK fertilizers and good feeding practices, were more than 350 kg/ha.

In flood fallows, the results have been less promising -- it is a more extensive system that lasts only six months, and the feeding practices have not yet been well defined. More investigation is needed on supplementary feeds, both in terms of composition and amount.

The flood-fallow system may need more controlled and refined practices for feeding to produce the same yield as in the specially prepared ponds. However, the major bottleneck to an expansion of pond culture is predation by animals and theft by man!

The European Development Fund (EDF), within the framework of the Lome II convention, has provided an inland fishery consultant (E. N. Dunn) for four months to identify and assess the overall potential and to make proposals for inland fishery and aquaculture development. No identified projects have yet been proposed.

Discussions recently took place in Georgetown between FAO, EDF, and CARICOM on the possibility of setting up a regional station for fish culture in the Caribbean. The Government of Guyana put forward a proposal for locating the station in Guyana.

A number of research topics related to fisheries were identified by the ISNAR team:

-- Intensification of the aquaculture project with IDRC and its possible expansion to rice fields, together with studies of feeding techniques in flood-fallow systems.
-- Preparation of a detailed inventory of ichthyofauna and the evaluation of the inland fishery capacity.

— Survey of the dynamics of fish and shrimp population to assemble biological data on shrimp resource potentials in different seasons.

Since there is ample external support on offer, and few trained Guyanese staff available to make full use of the offers, training requirements need to be given a high priority in the Ministry of Fisheries.

Annex 9

LIST OF PERSONS MET

Ministry of Agriculture

Joseph A. Tyndall	Minister of Agriculture
S. Prashad	Minister of Crops and Livestock, Ministry of Agriculture
J.S. Browman	Permanent Secretary
Leo Ramotar	Permanent Secretary (Administration)
E.A. Hubbard	Chief Agricultural Officer
P.A. McKenzie	Deputy Chief Agricultural Officer
Harry B. Persaud	Principal Agricultural Officer, Crop Science
Walter R. Matadial	Principal Agricultural Officer, Extension and Education
M. Nazeer	Deputy Chief Agricultural Officer, Planning
P.D. Sookraj	Principal Agricultural Officer, Planning
Dr. L. Applewhaite	Production Manager, Veterinary and Livestock Division
Somdeo Singh	Senior Agricultural Officer (acting), Extension and Education
Godfrey Nurse	Senior Livestock Officer
V.O.M. McPherson	Veterinary Officer
Courtney Bullen	Senior Agricultural Officer, Soil Science
Lewis L. Amsterdam	Executive Secretary, Food Crops Production and Marketing Program
Basil Phillips	
B.K. Khemraj	Principal Assistant Secretary, Finance
V. Girdhari	Principal Personnel Officer (acting)
Julius Ross	Senior Agricultural Officer, Crop Science
Clarence Wilson	Agricultural Officer
John Clowes	Agricultural Officer, Region 2
Julian Seaton	Agricultural Officer
Patrick Williams	Agricultural Officer (acting)
Noel Fields	Agricultural Field Assistant
Trebouchan Meghoo	Livestock Assistant
V. Lallbachan	Technical Assistant
Dr. Michael A. Granger	Technical Adviser, Soil Science
Dr. Robert M. Reeser	Agricultural Planning Adviser

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Guyana Sugar Corporation Ltd. (GUYSUCO)

Vybert Young-Kong	Director, Agricultural Research
F. McLean	Manager, Agronomy Department
Oscar Henry	Personnel Manager
Mohan Gosain	Education and Training Officer
Gordon J. Muller	Manager (Other Crops)
Bigyan Chandra	Manager (Agricultural Operations)
R. Bhim	Officer-in-Charge, Guyana Sugar Expt. Station
Harold B. Davies Jr.	Chemistry Division
Michael Critchlow	Varieties Agronomist
A. Rajendra	Eutomologist
R. Dookan	Farm Manager - Varieties Selection
Sat. Sukdeo	Weeds Agronomist

Regional Programme for Animal Health Assistants (REPAHA)

Jerald La Rose	Principal

Guyana Rice Board

Ramratan	Secretary
Philbert M.A. Benjamin	Manager, Personnel Services and Industrial Relations
Leroy Small	Manager, Research and Extension Division
Frank Richmond	Manager, Region 2
L. Tulsieram	Plant Breeder, MARDS
C. Roberts	Plant Breeder, MARDS
H. Cumberbatch	Agronomist, MARDS
B. Jagnandan	Stats. Officer

Consultants at Black Bush Polder:

C.H. Wang	Research
James F. Jacks	Water Management
R. Terry Montgomery	Extension
G.F. Duffy	Agricultural Economist
Fengchow M.A.	Agricultural Engineer

Livestock Development Company Ltd. (LIDCO)

Noel L. Holder	Managing Director
Richard Fraser	Manager, Pirala Ranch, Rupununi
Egbert Ralph	Manager, Ebini Ranch, Ebini

Ministry of Forestry
(in Ministry of National Development)

V.S. Viera	Conservator of Forests (acting)

Demerara Woods Ltd

Ivan A. Welch	Project Officer, Mabura Hill Project

Forestry Commission

B. Udit	Assistant Conservator of Forests (Silvicultural Unit)
G. Innis	Senior Assistant Conservator of Forests (Wood Utilization Unit)

Ministry of Fisheries

H.I. Leal	Permanent Secretary
Dr. Ruben Charles	Chief Fisheries Officer
Terence Philipps	Principal Fisheries Officer

State Planning Commission
(in Ministry of Economic Affairs amd Finance)

Clarence Ellis	Secretary
Clyde Roopchand	

Ministry of Works

Sudama Raghunandan	Chief, Hydrometeorological Service

Public Service Commission

Joyce Sinclair	Permanent Secretary, Training Division
Rupert Daniels	
Francis Cumberbatch	Secretary

Ministry of Education

Winston Dennis	Senior Education Officer, Agriculture
L.P. Thompson	Education Officer
C.C. Crawford	Agriculture Program

Ministry of Higher Education

Alan Munroe	Permanent Secretary

Ministry of Health

Mr. Ruiz	Director UNDP/WHO Project, Veterinary Diagnostic Laboratory

Guyana Co-operative Agricultural & Industrial Development Bank (GAIBANK)

John C. Yates	Managing Director
Basil A.T. Phillips	
K. Hunte	

University of Guyana (UG)

Professor S.K. Prasad	Dean, Faculty of Agriculture
Dr. A. Schuetze	Faculty of Agriculture
D.H. Persram	Lecturer, Faculty of Natural Sciences (Forestry)

Guyana School of Agriculture(GSA)

W.A. Davidson	Principal
D.A. Nicholson	Deputy-Principal (acting)
M.O. Cumberbatch	Senior Lecturer-Manager
Clifton Paul	

Guyana Pharmaceutical Corporation Ltd

Leslie Chin	Group Technical Director
Naresh Singh	Senior Research Officer

Guyana State Trading Corporation GUYSTAC

Roy McArthur	Vice-President, Administration

Ministry for Regional Development

Stanley Hamilton	Permanent Secretary
K.A. Hopkinson	Regional Chairman, Region 2
Joseph Harrop	Chairman, Marketing Subcommittee, Region 2
Stanley Singh	Regional Executive Officer, Region 9-1

National Science Research Council (NSRC)

Dr. P.A. Monroe	Secretary General

Institute of Applied Science and Technology (IAST)

Dr. A.V. Downer	Director, Research

Guyana National Service (GNS)

Joe Singh	Director General
John Piggott	Deputy Director General

Inter-American Institute for Cooperation in Agriculture

Reginald E. Pierre	Director
Franz C.M. Alexander	Animal Health Specialist

Caribbean Agricultural Research and Development Institute (CARDI)

Joe Bergasse	Executive Director (based in Trinidad)
Samsunder Parasram	Director of Research (based in Trinidad)
Roland Fletcher	Director, Guyana Program
Bill Massiah	Agronomist

University of the West Indies, St. Augustine, Trinidad & Tobago

Dr. Roger Barnes	Deputy Dean, Faculty of Agriculture
Frank Gumbs	Soil Science Department
Dr. Alma Jordan	Director of Library

Inter-American Development Bank (IDB) Georgetown, Guyana

Sergio U. Molina	Agricultural Sector Specialist (Guyana Office)
Helen A. Edwards	Program Officer for Guyana

International Development Research Centre (IDRC)

Christopher W. MacCormac	Research Officer
Edward J. Weber	Senior Program Officer

Others

Kenneth Gordon	Project Manager, Tapakuma Irrigation Project
G.C. Hopkins	Project Manager, Water Conservancy Construction Project, Tapakuma
B.W. Carter	General Manager, MMA Irrigation Scheme
Bas van Helden	Agricultural Adviser, European Economic Community
James Trehy	Technical Assistance Expert, GAIBANK

Michael Askwith	Deputy Residence Representative, UNDP
Dr. Evan Bolle-Jones	FAO representative Guyana/Surinam
Anthony M. Kern	Labor Attache US Embassy, Barbados
Charles Jenkins	USAID, Georgetown
John A. Spence	Caribbean Council for Science and Technology

Annex 10

LIST OF ACRONYMS

CARDI	Caribbean Agricultural Research and Development Centre
CARICOM	Caribbean Common Market
CAS	Central Agricultural Station
CCST	Caribbean Council for Science and Technology
CIAT	Centro Internacional de Agricultura Tropical
EEC (EDF)	European Economic Community (European Development Fund)
FAO	Food and Agriculture Organization of the United Nations
GAIBANK	Guyana Cooperative Agricultural and Industrial Bank
GNS	Guyana National Service
GPC	Guyana Pharmaceutical Corporation
GRB	Guyana Rice Board
GSA	Guyana School of Agriculture
G(C)SES	Guyana (Central) Sugar Experiment Station
GUYSTAC	Guyana State Trading Corporation, Ltd.
GUYSUCO	Guyana Sugar Corporation, Ltd.
IAST	Institute of Applied Science and Technology
IDB	Inter-American Development Bank
IDRC	International Development Research Centre
IICA	Inter-American Institute for Cooperation on Agriculture
IITA	International Institute for Tropical Agriculture
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
LIDCO	Livestock Development Company, Ltd.
MARDS	Mahaica Abary Rice Development Scheme
MMA	Mahaica-Mahaicony-Abary Agricultural Development Authority
MOA	Ministry of Agriculture
NSRC	National Science Research Council
PSM	Public Service Ministry
UG/FA	University of Guyana/Faculty of Agriculture
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
UWI	University of West Indies

Annex 11

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Annex 12

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