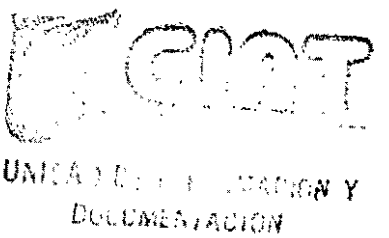
GLOBAL CASSAVA RESEARCH AND DEVELOPMENT:

The Cassava Demand Studies and Implications for the Strategies for the CIAT Cassava Program

[Attached to this document is an executive summary of the Cassava Demand Studies in Asia and Latin America]



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As a crop grown exclusively in the tropics of the Third World, adapted to marginal conditions, grown chiefly by small farmers, a provider of an important source of inexpensive calories to 500 million of the poorest consumers, grossly underresearched in developing countries and lacking a research knowledge base from developed countries, cassava would appear to be the ideal candidate to be assigned highest priority for maximum allocation of funds in the CGIAR system. Yet the CIAT Cassava Program, despite having been assigned global responsibilities for this crop, has been perennially plagued by questions as to its future role, and indeed, very existence.

Many of these doubts originated within the Center itself as the Board and management repeatedly questioned the future and constrained the growth of the Cassava Program, making it the first target for reductions in times of budget constraints. These doubts about a crop of such obvious importance to the poorest farmers and consumers were the result of skepticism about the future demand for cassava and the subsequent misgivings about the need for improved production technology. Consequently, the Cassava Program embarked upon a series of studies to ascertain the future role of this crop in the agricultural economies of developing nations. This effort was accelerated and expanded in response to the recommendation of the 1984 EPR of CIAT that studies be undertaken to assess the future demand for cassava and cassava products; that the future direction and scope of the Cassava Program should be reviewed after the completion of such studies; and that in the meantime, the program should be held at its current level. The CIAT mid-term plan for 1985-1989 (a revision of the long-range plan "CIAT in the 1980's, taking into account the recommendations of the EPR) also reserved judgment on the Cassava Program pending the outcome of the studies. In the interim, the TAC, in its "Review of CGIAR Priorities and Future Strategies" (pp 3-11 & 3-12), gave strong support to cassava as an important small-farmer crop of special importance to and with high potential payoff for research for Africa and stated that demand was "buoyant" in Asia; but they considered the situation in Latin America to be more complex, with future demands for cassava unclear. The TAC stated: "Firm recommendations for the longer term must await the outcome of the market study."

These studies have now been completed for Latin America and Asia. The results of the studies, as well as the empirical observations of what is happening to cassava in the rapidly changing economic conditions of the Third World, convince us that cassava is indeed a crop whose time has come!

This document briefly describes what we now consider to be the present and future role of cassava; the objectives and strategies of a program with the global mandate to conduct research to enhance that role; and the minimum size and deployment of a research team to carry out such a strategy. It should be seen as an update and addendum to the other documents referred to above. In the interest of brevity, much that should be said about cassava cannot be included here; thus for a more complete picture, the reader

should also read the CIAT long- and mid-term plans and the TAC priorities paper.

ROLE OF CASSAVA

Present Status

Nature of the Crop

The cassava plant, which originated in Latin America, was probably first cultivated by Amerindian tribes about 4000 years ago. The fact that it spread so rapidly and became an important component of small farmers' cropping systems and of the diets of hundreds of millions of the people in Africa and Asia so quickly after its introduction to these continents by Spanish and Portuguese traders less than 400 years ago, attests to its unique nature. It is one of the world's most efficient converters of solar energy to carbohydrates. The crop's special stomatal response to low relative humidity allows it to survive and produce a reasonable harvest under conditions of drought and sporadic rainfall that frequently cause other crops to fail. Because of its drought tolerance and the fact that its roots can be left in the ground for long periods as a food reserve, it represents excellent insurance against famine. The plant's inherent characteristics and association with mycorrhizae make it especially well adapted to acid, infertile soils. As the plant does not have a critical growth stage when a severe insect or disease attack can cause complete crop failure, it is particularly suited to biological control measures. These characteristics have made cassava an attractive option for farmers with limited resources in marginal agricultural areas of the tropics. It ideally meets the equity criteria of the CGIAR. As cassava production and processing are highly labor intensive, it responds to CGIAR concerns for employment generation.

Distribution

Cassava is grown throughout the lowland tropics. Total world production is about 130 millions tons (52 million tons cereal equivalent), with about 40% of production in each of Africa and Asia, and 20% in Latin America. Brazil is the world's largest producer and consumer of cassava. In terms of total calories produced in the tropics, cassava ranks fourth, following rice, sugarcane and maize.

End Uses

Cassava is a multipurpose crop as shown in Table 1. These global statistics mask large inter- and intraregional, and even intra-country, differences. In Latin America use as human food is about the same as the global figures; while in Africa a larger portion is utilized as food. In several African countries cassava provides 40 to 50% of the total calorie intake and is the single most important source of calories. In the economically depressed Northeast region of Brazil, it is the dominant food staple.

Table 1. World Utilization of Cassava, 1975-77

End Use	Percentage Contribution
Human Food	64.6
Fresh	30.8
Processed	33.8
Animal Feed	11.5
Starch	5.5
Export	7.0

Source: FAO

Future Prospects

Demand Studies

Defining the problem. Much of the basis for skepticism about the future demand of cassava relates to the observed decline in per capita consumption of this crop in Latin America. This was perceived as being due to rapid urbanization, rising per capita incomes, and increasing possibilities for commodity substitution. It was reasoned that (a) cassava was an inconvenient, bulky, perishable, and less desired commodity that would--like many other basic staples--gradually become less important as economic development and urbanization proceeded; and (b) that the Latin American experience might be a portent of the future for Asia and Africa. The corollary to this reasoning was that there would be little demand for improved production technology for a crop with a declining market. On the other hand, it seemed precipitous to abandon a crop of such importance for income generation by poor farmers and with the potential of providing inexpensive calories for consumers. It was necessary, therefore, to determine whether or not this trend would continue in Latin America, whether it would apply to Africa and Asia, whether alternative uses of this multipurpose crop would come more into play with the evolving economic conditions, how new technology would affect the future demand, and how all of these factors would affect the research agenda.

Methodology. As consumption patterns, government policies, and the resource endowment and production costs for cassava and alternative crops vary so greatly among and within regions and, in some cases, within countries, it was not possible to speak about future demand on a global basis. Thus the studies were disaggregated by regions and for selected key countries.

Coverage. The Latin American studies, considered to be the most critical by the EPR and the TAC, were conducted most intensively. Under the leadership of the senior economist of the Cassava Program, three postdoctoral economists were contracted for a two-year period each. They conducted individual country studies of Brazil, Colombia, the Dominican Republic, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru and Venezuela. These studies, conducted collaboratively with economists from national programs in the respective countries, used secondary data and, where necessary, collected primary data to:

1. Analyze the current and potential role of cassava for human consumption.

2. Evaluate the income generation and employment opportunties created by cassava production and processing.

3. Describe the current and potential incorporation of cassava into animal feed.

4. Identify the regions where cassava production can be expanded and the markets that it will enter.

Special attention was given to production costs for cassava and possible competing crops to determine those cases where cassava could/could not compete. Current government policies that might artificially affect such competition and possible changes of policy that would benefit the economy were also considered.

In addition to these Latin American economic studies, a doctoral student conducted his dissertation research on consumer trends in Colombia to determine the factors behind the decline in per capita consumption in urban areas and consumer preferences for cassava in relation to other starchy foods.

The Asia demand study relied exclusively on secondary data. It was conducted by the senior economist of the Cassava Program, with the valuable contribution of senior economics consultants from Thailand and Indonesia. Individual country studies were conducted for China, India, Indonesia, Philippines and Thailand. In the case of Indonesia, CIAT was fortunate to draw upon the intensive studies on cassava carried out by the Food Research Institute at Stanford University.

African demand studies will be carried out jointly by CIAT and IITA, beginning in early 1988. These will take more time and will be more costly as more primary data will need to be gathered. A three-year project involving four economists has been jointly developed by the two centers. Each is placing half of the estimated costs into its core budget request for 1988-90. While it is obviously important to understand the trends better and explore the future potential for cassava in Africa, the importance of the crop for human food and the fact that some of the factors responsible for the changes in consumption patterns in Latin America and Asia (i.e., increased per capita income and rapid urbanization) have not progressed as far in Africa suggested that this study was less urgent than those for the other continents.

Highlights of the Results

It is obviously impossible to do justice to the wealth of valuable information on the potential for cassava for various uses in a wide range of ecological, social, economic and political conditions coming out of the demand studies in any brief summary statement such as this. The reader is therefore urged to read the Executive Summary of the studies. Even that summary cannot provide adequate information on methodology, data and qualifications to satisfy the skeptic that the conclusions are based on sound economic analyses. Those so inclined should read both the full reports and the Stanford commentaries.

Overall, these results demonstrate a buoyant market potential for increased cassava production; but this is not true for all uses in all countries. The studies show that:

1. The observed decline in fresh consumption in Latin America is principally due to the urbanization process. High marketing costs have shifted relative prices of cassava and grain staples between rural and urban areas, causing consumption to be lower in urban Latin America. Fresh cassava has a positive income elasticicity and consumption can be expected to grow modestly; new preservation technology is likely to reduce marketing costs and accelerate this growth.

2. Where human consumption of processed cassava has declined, this has largely been the result of government subsidies of competing cereals. These trends are already being reversed as these subsidies are removed, and demand for cassava in processed form can be expected to grow; these products will continue to serve as an important source of inexpensive calories to the very poor.

3. Starch, much of which is used in the production of various foods, is expected to provide a growing demand for cassava, especially in Asia.

4. A major potential for growth in demand for cassava is seen as a component of animal feed, chiefly for domestic use in Latin America; and for both domestic use and export in Asia.

5. The growing market for cassava in Asia has already reached the point that production is not keeping up with demand.

6. Cassava is an important tool for equitable development. Its characteristics are such that the benefits of new technology can be targeted on the very people who have normally been left out of the development process.

Empirical Observations

The world did not stop while the demand studies were being carried out. Important changes in the economy were taking place, and a number of developments were under way. It was clear from the outset that a good deal

could be learned by following these developments that would complement the economic studies.

When the studies were initiated, a pilot project to help small farmers' associations develop drying and chipping capacity to process their cassava and sell it to animal feed manufacturers was getting under way in Colombia. This has been a remarkable success. To date, 37 such farmers' associations have been established. Analyses of the impact have shown that the farmers' incomes improved markedly, both from the sale of their produce and from the distribution of association profits; the new agroindustry has generated considerable employment in an economically depressed area; yields have increased as farmers have incentives to apply improved production technology; and, surprisingly, the benefits have gone chiefly to small farmers. Although large-scale farmers are present in the region, the maximum benefits from the project have been obtained by farmers with farms of around 3 hectares.

The success of the Colombian project led to the development of a similar agroindustry in Ecuador. In 1986 that experiment seemed to be running into trouble. Rainfall, usually a limiting factor in the area, was abundant, resulting in a bumper maize crop and a depressed market for the cassava chips. It was then discovered that dry cassava chips when finely milled are an excellent substitute for imported binding agents used in shrimp concentrates. This cassava flour sells at over US$300 per ton, a price higher than for wheat flour. The implications of this discovery for potential cassava demand for the vast and growing shrimp culture industry is still unknown, but could be tremendous.

Dried cassava is currently being produced profitably in Colombia, Ecuador, Mexico and Panama, demonstrating that the potential for use of this crop in this form to increase small farmer income and generate rural employment is no longer hypothetical, but an economically viable reality. Brazil, Cuba, Nicaragua and Peru all have active plans under way to develop similar agroindustries.

Thailand, at the peak of its export of cassava chips to the EEC in 1982, sold 6.7 million tons to that market. Later that year, through an international agreement, the "voluntary" quota for imports of Thai cassava chips to the EEC was reduced to 5 million tons, with a further reduction to 4.5 million tons in 1985. There was great concern as to what Thailand would do with its excess production and what alternative crops the Thai cassava farmers could plant now that they could no longer sell all of their product at the artificially high prices in the protected EEC market. These developments were certainly watched with interest, as they would give an indication as to how cassava pellets could compete in the cold world of international markets. Cassava production in Thailand has continued to rise, reaching just under 20 million tons in the 1984/85 crop season. This has been possible through the opening up of new export markets and increased domestic use in animal feed rations.

The Cassava Program in conjunction with the Tropical Development Research Institute (TDRI, London), had developed a simple technique for conserving fresh cassava and making it more convenient food. There were doubts as to whether farmers would adopt the new technology and whether the consumer

would accept the new product. Thus a pilot project was established with the Colombian Rural Integrated Development program to test the new technology with small farmers who were organized into an association. In the initial phases an intense extension effort was required; today, the farmers are now using the technique on a routine basis. The farmers are paid more for their cassava than the going price paid by the middlemen in the region; yet the farmers' association is able to sell to the small shopkeepers in the nearby urban centre at a discount price. The shopkeepers report that shoppers are delighted with the new product and now make special request for the bagged, conserved cassava.

Conclusions

The demand studies and empirical observations in a rapidly evolving economic scene have clearly demonstrated that there is sufficient potential demand for increased cassava production. They have also confirmed that because of its unique qualities, cassava is a "natural" for the CGIAR system. On the other hand, cassava is different from most of the commodities dealt with by the CGIAR centers. Its different end uses under different socioeconomic and ecological conditions dictate a decentralized strategy for research and development. The nature of consumption patterns, marketing requirements and multiple end uses of this remarkable crop also dictate that the traditional germplasm approach will not be sufficient for cassava research and development to yield its maximum social benefits. Production research must be integrated with work on processing, utilization, marketing and policymaking. These all affect the strategy and activities of CIAT's Cassava Program. A revised program strategy, based on these realities, follows.

A GLOBAL CASSAVA PROGRAM

Goals and Objectives

The goals of the CIAT Cassava Program are to contribute materially to increased income and food supplies of small farmers and to improve food availability in tropical developing countries. The Cassava Program is not in a position to reach this goal on its own; rather it forms part of a global network dedicated to exploiting cassava as an important traditional rural and urban staple and to developing new forms of utilization suitable for changing economic circumstances. Within this context, the Program in close collaboration with national agencies, pursues the following objectives:

1. Develop components of production technology that form the basis for stable, cassava-based cropping systems with low costs per unit output.

2. Develop technology that allows cassava to be grown on presently underexploited lands.

3. Develop processing technology that makes cassava a low-cost, high-quality, convenient food.

4. Develop both production and processing technology that is cost-competitive, increases farmer income, and is sufficiently labor intensive to generate employment for landless labor.

5. Develop marketing strategies for cassava that reduce the marketing margin.

6. Stimulate the development of markets for cassava that provide a stable price floor for the raw material, thus providing farmers the incentive to increase production, thereby reducing price fluctuations for the consumer.

7. Assist in the development of novel uses of cassava that increase the overall demand for the crop.

8 Develop waste-reducing technology that increases the percentage of total production that is finally consumed.

9. Stimulate other agencies to play an active role in the cassava research and development process.

10. Increase the capacity of national programs to carry out cassava research and development projects.

Strategies

Operational Principles

As a CIAT commodity research program, all activities of the Cassava Program are governed by the set of operational principles underlying all the Center's activities. Included among these principles are Relevance, Equity, Complementarity and Cooperation, Comparative Advantage, and Sustainability.

Relevance. The efforts of the Cassava Program are directed towards increased food production that favors the poorer segments of the population, rather than increasing the body of scientific knowledge per se. Research is focused on solving the most important problems in the regions served by the Program.

Equity. In seeking to contribute to increased food production, the Cassava Program attempts to benefit primarily the small, resource-poor farmer, as well as the low-income urban and rural consumers.

Complementarity and cooperation. The Cassava Program's activities represent only one segment on the cassava research and development spectrum. Consequently, all activities are designed to complement those of other organizations. Of particular importance are the efforts in support of cassava by national agricultural research and development agencies in countries that the Cassava Program seeks to serve. The Program maintains strong linkages with these agencies and coordinates its work program closely with those of collaborating national programs.

Comparative advantage. The Program concentrates on resolving those problems and developing those techniques and methodologies for which it has a clear comparative advantage in relation to other agencies, be they international or national, public or private. The comparative advantage arises from certain characteristics of commodity research programs in international centers, including: (a) the ability to bring a critical mass of scientists to bear on problems; (b) the facility to move information, biological control agents, and genetic materials across borders; (c) a high degree of continuity of effort; (d) location in the tropics; (d) being in a position to coordinate activities of different entities on a regional or international level; (e) the ability to capitalize on economies of scale; (f) and the ability to take a long-term view of the overall research and development process.

Sustainability. The Cassava Program, in its endeavor to make a major and lasting contribution to cassava production and consumption, emphasizes long-term cumulative gains over dramatic short-term impacts. Hence it seeks to develop production technology that promises environmental harmony; relatively broad adaptation to important production constraints; and relatively low requirements for purchased inputs.

Operational Strategies

Cassava research must operate within an evolving context where principal constraints on the development of the crop often shift from production to utilization to processing and marketing. An effective research strategy for cassava must focus on the complete commodity system and in so doing provides an effective integration between research on production, research on processing and post-harvest utilization, and research on consumer preferences, market demand, and appropriate methodologies for technology introduction. In this way the return on investment in production research is maximized, knowing that market and processing constraints have been dealt with. Moreover, the number of potential interventions in the commodity system allow for maximum flexibility in beginning to target the technology on the aforementioned objectives. This holistic strategy allows a particularily effective approach to ensuring impact on equity objectives.

To attain the aforementioned interlinking objectives requires the existence of an interdisciplinary team of sufficient size to have the multitude of specialized expertise required to address these objectives, but with a flexible structure that allows continued interaction amongst the various specialists. The following is a description of the broad areas of endeavors that need to be addressed by this interdisciplinary team in its pursuit of the goals and objectives outlined above.

Assembly of a basic body of knowledge of the crop. In order to develop new technology for any crop, it is necessary to have a systematic understanding of it. This includes knowledge on the basic biology and growth processes; the reaction to different environmental conditions; interactions with pests and diseases and an intimate knowledge of their biology and epidemiology; and the physical and chemical characteristics of the plant. Before engaging on strategic research in any of these areas, the Cassava Program first of all evaluates the comparative advantage it has to carry out the work and the possibilities of cooperating with other agencies. Only when

there is a clear advantage or it is likely that no other agency will become involved does it proceed with the setting up of a research effort to increase the knowledge base in the particular area under consideration.

Genetic conservation and improvement. It is evident that any attempt to develop efficient production technology is highly dependent upon the existence of a good variety. The development of effective varieties, in turn, is dependent upon the availability of a gene pool that possesses desirable characteristics. CIAT is in a unique position to collect, characterize and conserve the world's cassava germplasm in such a manner that it can readily be used by other agencies. In this context, the use of germplasm by other agencies can be made much more efficient if the desirable characters--for specific ecosystems or end uses--are already concentrated in elite gene pools, which are then distributed to national breeding programs. Therefore, the Cassava Program provides to breeding programs throughout the world gene pools that combine high harvest index with high total biomass production; tolerance to diseases, pests and adverse soil conditions; and high levels of starch in the roots.

Integrated pest management. The reduction of losses caused by diseases and pests in a long growth cycle crop grown by small farmers is most effectively achieved through an integrated approach to pest management. As a first step, the Cassava Program evaluates the importance of individual pests or pest complexes in terms of losses caused and the potential area over which they can cause damage. Work is then concentrated on developing the basic building blocks of an integrated pest management program for the most damaging pests and diseases. This includes a thorough knowledge of the organisms and the cassava plant's response to them, as well as the evaluation of alternative strategies such as phytosanitary control, biological control and host-plant resistance. When host-plant resistance or biological control are deemed to be important components of an integrated pest management strategy, the Program identifies resistant lines and collects and evaluates biological control agents. In the case of host-plant resistance, the sources are incorporated in the elite gene pools; biological control agents are distributed to agencies working on biological control of cassava pests. CIAT's Cassava Program is in a unique position to carry out these activities as it is located in the center of origin of cassava and the pests and diseases that have co-evolved with cassava. The economies of scale that result from having one center collect and evaluate the sources of resistance and the biological control agents are considerable.

Sustainable agricultural production systems. Production systems are inherently location specific; nevertheless, certain basic technological components and principles can be applied over a wide range of conditions. Of particular importance here are measures to reduce and control soil erosion (which range from appropriate management practices to to the use of intercropping and a variety of ground covers) and to counteract soil depletion (though appropriate crop rotation and the use of fertilization at the minimum threshold level). The approach used by the Cassava Program is to utilize some of the more basic knowledge developed through its strategic research efforts to understand the crop in applied research on crop management. Most of this research is carried out in close cooperation with the national programs. The results of the multiple efforts of the national

programs and CIAT are compiled and analyzed by the Cassava Program in order to develop the principles of improved crop management. These findings are then used by a national programs in their own adaptive research programs.

Improved root quality. The development of new varieties and the rapid move of cassava into new end uses have highlighted the fact that cassava roots of different varieties are characterized by considerable variation in their quality characteristics. No one characteristic can be selected as optimal for all end uses. The situation is further complicated by the fact that at this time, little is known about the basic nature of differences in quality. This makes screening and selection not only slow, but also a haphazard process. Given that the varietal component is of such paramount importance in determining root quality, additional systematic attempts to improve root quality must be based on the world germplasm collection at CIAT. This research will be carried out in conjunction with various agencies with expertise in this field, including the Tropical Development and Research Institute (TDRI) and a food research institute in the UK.

Improved preservation and processing technology. The movement of cassava into new markets is dependent on its being converted into a competitive, low-cost and convenient product. This requires the development of improved methods of postharvest handling. These technologies should be relatively nonlocation-specific and their transfer to new application sites should require only minimal adaptive research. Certain postharvest technologies for cassava are already well developed or are being investigated by other agencies. In general these technologies are for large-scale industrial use--an area in which the Cassava Program does not, and will not, play an active role. In the development of small-scale processing technology, however, the Program has already taken a lead role. In the future emphasis will be on refining the techniques for fresh cassava conservation and the development of technology for the production of high-quality flours. This latter product will then form the basic raw material for developing a variety of new food products. In the area of animal feed, efforts will be largely limited to refining technologies so as to ensure continuous availability of cassava in an appropriate form for use either in the feed industry or on the farm. Other agencies are expected to carry out feeding trials and adaptive testing of available technologies.

New products and alternative markets. The changing economic and social conditions in the developing world are leading to changes in people's habits and life-styles and the products they purchase. The CIAT Cassava Program will continually be monitoring the overall patterns of these socioeconomic parameters, with a view towards identifying likely new markets for cassava-based products or new ways of bringing traditional products more effectively into the changing market structure, in such a manner that they improve the nutritional status and/or economic well-being of low-income urban consumers. This work will provide a constant input into the other efforts of the Program to ensure that new varieties and processing technology are appropriate to the new marketing niches as they emerge.

Development of an appropriate policy environment for cassava. The world agricultural scene today is frequently characterized by economic distortions and conflicting policies that neither serve the best interests

of the countries nor favor the poorer, more marginal sectors of the population. Large, economically powerful agricultural groups, often organized in commodity federations, have the resources to analyze the situation of the particular commodity they deal with and use this analysis (often one-sided) to further their cause at the expense of the marginal sectors. CIAT is in a unique position to assist national programs in the analysis of the possible effects of policy decisions that affect cassava. Through continued economic analyses of the role of cassava and other crops for which it can substitute, the Cassava Program will provide information to national policymakers to assist them in assessing the potential benefits and disadvantages of the various policy options available to them.

Institutional models for development with equity. To meet the goals of equitable development through increased cassava production and improved postharvest handling and marketing, it is necessary to integrate the efforts of diverse agencies. In the past public sector agricultural development projects have tended to concentrate on the production side. Even in the case of integrated rural development programs, the production side has frequently been divorced from processing and marketing aspects.

Both the theoretical and empirical bases for the institutional structure to support the integrated development of production, processing and marketing programs are poorly developed. Recent experience, however, has shown that the form of institutional structure is critical to successful programs and that the form can steer the program to provide benefits to the target population. Although it is true that each project will differ depending on the specific agronomic, climatic, social and economic environment, there are a series of common guiding principles for implementing successful projects. These principles can only be deduced form a hands-on approach and close contact with development projects. The Cassava Program will continue to assist national programs in the setting up of pilot development projects. The careful monitoring of these projects will permit an evaluation of the most effective approaches.

CIAT will be instrumental in stimulating the development of a network of agencies involved in cassava-based development projects, through which the rapid diffusion of the most effective methodologies will be ensured. It should be noted that CIAT's role is not that of a development agency, but that of a source of information and advice on the most effective means of achieving equitable development.

National Program Capacity. The future ability of cassava to fulfill national agro-economic policy goals is dependent upon the capacity of national programs to implement policy decisions. Thus strong national programs are an essential part of the cassava-based development process. The CIAT Cassava Program plays an active role in strengthening national programs not by attempting to carry out functions that are naturally their domain, but rather through assisting them to develop the capacity to function effectively. This is to be accomplished by various means. Information of cassava for example, is widely dispersed and many national programs do not have effective means of easily obtaining information on cassava from other countries. CIAT's strategy is to compile the available information in its specialized documentation center, and then summarize and package it in such a manner that it is readily usable by the national

programs. A major limitation to this approach is the delay between collecting data and its publication and distribution to interested parties. CIAT, through its Cassava Newsletter, which is published in Spanish, English and French for distribution to cassava workers throughout the tropics, shortens the time between information being obtained and its becoming widely distributed.

This information exchange is also facilitated by providing national program staff the opportunity to participate in a series of workshops in which they can interchange ideas with cassava workers from other national and international centers. These workshops are organized in cooperation with national programs, frequently away from CIAT headquarters, so that national program staff can obtain a broader perspective of cassava development in other countries or regions.

The workshops are normally attended by national program staff who are already active and experienced in cassava; however, many new cassava programs do not have such staff. Consequently, CIAT offers training opportunities for them. Upon their return to their respective programs, CIAT staff provide follow-up support and advice, particularly in the critical early years of national program development.

Through its regional outreach programs the Cassava Program also fosters the establishment of specific networks in a variety of fields, ranging from germplasm development to the methodology for integrating cassava production, processing and marketing projects.

Activities

The fact that cassava is uniquely produced in the tropics has had and continues to have a profound effect on the organization of world research on the crop. There is no research (apart from that currently linked to IARC's) on cassava in developed countries, meaning that funds for cassava research have had to come from developing countries or international aid funds. This situation has had three profound effects: (1) the research history on cassava is extremely limited, especially when compared to grain crops; (2) the basic research on the crop, on which sound applied research is based, is virtually non-existent; and (3) world research on cassava will continue to be limited to the tropics but because of the very limited funds for cassava research, there is need for a more rational division of labor. The CIAT Cassava Program has had to bridge well prioritized strategic research with appropriate applied research and the latter with methodology development for adaptive research and technology introduction. The program has filled this breach, while working toward the development of a worldwide cassava research network which makes the most effective use of the limited research funds for cassava.

Thus, the Cassava Program's activities can, in broad terms, be divided into the general areas of (1) strategic and applied research of a more general nature, which is carried out by the central, largely headquarters-based program, as well as collaborative research, normally of a strategic nature, with research agencies in both developed and developing countries; (2) regional activities that are interwoven with national agricultural

research and development agencies and that are of an applied or adaptive nature; and (3) networking.

Strategic and Applied Research of Global Significance

A strong critical mass of cassava researchers at headquarters forms the basis of this activity. This concerted effort is directed towards nonlocation-specific research, the benefits of which are expected to be felt in the cassava-growing areas of the world in approximate proportion to their present shares of total world production.

Physiology of the crop and identification of desired characteristics. The basic physiology of the crop is investigated, and characteristics of the crop that lead to high, stable yield under adverse conditions are identified for use by the breeders in crop improvement. Particular emphasis is placed on the identification of drought tolerance and the improvement of productivity through variation in the photosynthetic capacity of the crop.

Germplasm collection, development and distribution. Germplasm is a critical component of the research strategy but in turn that strategy does not depend just on improved varieties. Because cassava is strictly a rainfed crop where supporting inputs are rarely used and because it is grown across such a wide range of edapho-climatic conditions, usually under single or multiple stresses, the breeding strategy has to accomodate this significant variability. The strategy developed is two pronged: (1) developing elite gene pools for principal eco-systems -- these eco-systems are continually refined by the CIAT's Agro-Ecological Studies Unit, and (2) selection from broad-based seed material in the target area, where the gene pool has been matched to the national program's selection site. This system optimizes the needed diversity that goes to a national program, while the selection is done under the stresses relevant to the production region. The selection process is backstopped by periodic visists to national programs by CIAT breeders. This breeding approach epitomizes the decentralized research strategy of the program: well developed research methods and broadly targeted technology which in turn incorporates sufficient malleability to be adapted to local conditions.

Germplasm from all over the world is collected, evaluated and conserved. Currently, emphasis is on the collection from specific ecosystems which are poorly represented in the present collection. New breeding methodologies are developed and tested, and the possibilities of using biotechnology are evaluated. In the case of biotechnology, further research on anther culture could lead to the development of hybrids and the production of cassava from true seeds. This would make it easier to store seed and reduce disease transmission via seeds. A compromise solution that is being explored is the use of somatic embryos, which could be considered as pseudo seeds. In the crossing program, selected lines are used to develop elite gene pools specifically directed at different ecosystems. These materials are then distributed to national programs for testing and evaluation.

The CIAT breeders keep close contact with their counterparts in national programs so as to ensure that the specific requirements of collaborating

national programs are met. This involves continued visits to the different breeding programs and the joint evaluation of lines.

Colombia, because of its wide range of climatic conditions; has served handily as a base for development of the elite gene pools in priority ecosystems. However, refining of these ecosystems for Latin America and more recently for Africa has highlighted the importance of semi-arid regions and sub-tropical ecosystems, which do not exist in Colombia. These ecosystems do exist in Brazil and moreover a large and diverse germplasm also exists in Brazil which is adapted to these environments. Several of these elite gene pools will have to be developed in Brazil, backstopped by a systematic survey and collection of existing varieties.

Diseases and pests. Research on cassava diseases and pests takes advantage of the fact that through a number of testing sites and a wide range of growing conditions in Colombia, most of the important diseases and pests can be adequately covered within the country. When this is not possible, close links are established with national agencies in other countries so as to develop the required information on these problems.

The identification of viruses and the development of effective indexing methods is emphasized, and clonal materials are routinely "cleaned" and tested to ensure that they are free of viruses before shipment. Although virus transmission is not a problem in the case of sexual seeds , they must be certified clean of fungal and bacterial pathogens.

Utilization. The quality characteristics of cassava roots for various end uses are studied in order to establish guidelines for developing techniques for the rapid measurement of root quality. These techniques then become a routine part of the breeding program.

Fresh cassava conservation technology will be further improved. New products for controlling microbial deterioration are being tested, and the possibility of biological control using fluorescent bacteria will be explored.

The basis for novel, convenient food products is the conversion of cassava to a more stable form. The prototype technology for low-cost drying systems to produce high-quality flours now exists and will be tested and modified in the light of its performance under commercial conditions. Once it is possible to produce these flours commercially, research activities will need to concentrate on their introduction as a partial substitute for wheat flour and on the development of novel, cassava flour-based products.

Socioeconomic studies of cassava production and marketing. The demand studies underlying the research strategy espoused here highlighted the importance of socioeconomic information in determining research priorities; such information should also prove highly useful for policymakers. Although the intensity of such data collection and analysis activities, outside of Africa, will decline in coming years, the Cassava Program will continue to carry out this type of work in strategically selected countries.

Regional Programs

Cassava as a plant species is adapted to a wide range of edapho-climatic conditions, although any single genotype, if well suited to its environment, has only a narrow range of adaptation. In an analogous manner cassava as a commodity is well adapted to economies at very different stages of development but similarly this adaptation, especially in product utilization, takes very different forms. This malleability with respect to quite different market conditions in turn makes cassava a useful instrument in meeting a range of policy objectives in developing countries. Because the structure of the agricultural sector and the stage of development is so different between Asia, Latin America and Africa, different strategies are called for in this area often called outreach, which in the Cassava Program case marries applied research of a region-specific nature to the adaptive research needed to achieve impact.

Africa

1. Collaboration with IITA. Within the CGIAR system CIAT has global responsibility for cassava, while IITA has regional responsibility for the crop Africa. CIAT's strategy in Africa is very clearly to complement the IITA research program. This includes more basic or strategic research, applied research in priority areas on which IITA has decided not to work, and research in Latin America that directly supports the research effort in Africa. A research base in Latin America has already been shown to be critical to the success of research on biological control of mealybug and green spider mite in Africa. The same is expected to apply in the future to development of gene pools for particular ecosystems in Africa, to some of the utilization and root quality research, and even to the areas of market development.

2. Agroeconomic studies of cassava in Africa. The importance of cassava in Africa is beyond doubt; nevertheless, the data available for the purposes of planning research and development programs based on cassava are deficient. This makes it difficult for the two Centers and national programs to develop a coherent research strategy for this continent. Consequently, CIAT and IITA propose to set up a major short-term (three-year) agroeconomic study of cassava that will characterize the present production, processing and marketing systems in Africa; and assess the potential for producing cassava in new areas as well as changes in demand that are likely to occur in the coming years. These studies will form the basis for a coordinated CGIAR system plan for cassava in Africa, which will be jointly presented by CIAT and IITA.

Asia

Implications of the Studies for the Cassava Program

In Asia a multiple-market structure for cassava has already developed in most countries. ~~Markets are in place that~~ and can absorb significant increases in production. ~~or~~ If prices can be lowered, new markets ~~are~~ will be opened ~~poised to come on line.~~ Hence the efforts of the Cassava Program are

directed towards establishing an effective cassava production research network. ~~The structure of that network was discussed at a workshop held in June 1984 and the results were published as "Cassava in Asia, its Potential and Research Development Needs."~~

Genetic variability in cassava is limited in Asia, indicating that the potential exists for increasing productivity through the introduction of new germplasm. CIAT is developing and servicing a network for testing and evaluating both CIAT and local germplasm throughout the area. Scientists from the region are being trained in handling germplasm and making special crosses to suit ~~the~~ conditions ~~in the region~~. Nevertheless, new varieties alone cannot remove all the constraints to obtaining highly productive cassava-based systems. In the intensive Asian cropping systems, maintenance of soil fertility and the control of erosion are critical. ~~Over the past decade,~~ A considerable body of basic information on ~~the principles of~~ mixed cropping, soil fertility maintenance and erosion control has been developed in Colombia. ~~In order to apply this knowledge to the Asian situation,~~ A regional Cassava Program agronomist assists Asian programs in developing improved cropping systems. The regional team ~~(i.e., the soil scientist/agronomist referred to above plus a plant breeder) not only work in their specific areas, but~~ also play an important coordinating role in the region to ensure the full integration of cassava research in the regional network.

There is still a need for
The initial phase of the CIAT economic studies was designed to determine the potential demand for cassava in the region. Yet to be carried out at the microeconomic scale is (a) a critical evaluation of how new technology will fit into the intricate cropping patterns of the region and (b) an identification of constraints on the adoption of new technology.

For cassava production to increase markedly in the region, the fresh roots will have to be processed. At present the available processing technology is relatively efficient and is not seen as an immediate constraint. CIAT will limit its activity in this area to transferring new processing technology developed at headquarters to Asian national programs through training and conferences.

Latin America

In Latin America demand for cassava is still reliant chiefly on food markets, which in turn have inhibited the development of alternative markets. It has been shown that cassava can compete in such markets, especially the animal feed market, but incentives to invest in processing capacity have been masked by the nature of price formation in cassava food markets. To overcome this constraint, CIAT has developed the concept of integrated production, processing and marketing projects ~~in order~~ to foster increased cassava production and utilization and better market integration. Moreover, these projects utilize this unexploited demand potential as a means of increasing small farmer incomes in Latin America, especially farmers in more marginal areas. ~~Much field-based research has been spent on developing methodologies and project design components which will~~

maximize the quity potential of cassava development in Latin America. This is felt to be ther priority objective for an IARC operating in a Latin American environment.

Moreover, the integrated projects, which have now been established in Mexico, Panama, Colombia, Ecuador, and, more recently, Brazil, provide a focal point for ~~germplasm testing and agronomic research. This research is thus well targeted, has back-up support provided by the project, has continuity, and provides the capacity for field-level, problem identification for feedback to CIAT. The projects are thus the laboratories for much of CIAT's decentralized~~ research on agronomy, biological control, and processing methods.

1. Integrated production, processing and marketing projects. These projects are run and managed by the national programs. CIAT's role is to assist and give technical advice. The funding for this activity is from bilateral funds or, as in the case of Colombia, paid for by the government. The basis of integrated projects rests on a study of possible markets and areas of production for cassava. This is followed by the selection of the most appropriate processing technology, and the setting up of a pilot project to evaluate the possibility for subsequent expansion into a major development project. While this procedure is simple, its execution is complex. It requires the testing of production technology, an analysis of the best forms of organizing the production to ensure equitable distribution of benefits, and systematic market development.

2. Support for integrated projects. If current trends are any indication, it can be expected that there will be an increasing number of integrated development projects in coming years. Some of the older ones will achieve their objectives and will essentially disappear form the scene, while new ones will develop. A CIAT headquarters-based "integrated projects team" will provide a continuity of effort in this area and will use the experience of the various projects to develop generalized methodologies for the successful implementation of such projects. This team will then use this experience to stimulate national agencies to develop their own such projects and will assist national programs in the planning stages, provide technical support in the establishment phases, and help in the design of systems to monitor their success in meeting objectives. The team will consist of a social scientist (specialized in economics) who is intimately involved in determining the initial feasibility of developing a project, in designing the project, and in monitoring and evaluating the project; an agronomist who will be closely involved in the area of evaluating the potential for production, as well as working with national agencies in the development of production packages that ensure a steady supply of raw material to the project; and a processing specialist who will be involved in advising on appropriate types of processing techniques and in the planning and carrying out of adaptive research to develop technology suitable for local conditions.

Networking

Networks function differently in the work of the Cassava Program from most other crop programs. Finished technologies do not flow within the cassava network. Rather the Program focuses on introducing a significant degree of diversity or malleability in the "technology" at the level of the national program or the project site. The network focuses on both broadening and deepening the methods by which technology is adapted to local conditions and in the identification of research areas not covered within the network. A national, field-level research capacity and pooling of research results are critical to the functioning of the network. A range of different networks on cassava has evolved as follows:

The international cassava research and development network. Its members are all national research and development agencies interested in cassava; individuals in national agencies working on cassava; advanced research institutions in developed and developing countries working on cassava, and international and regional agencies with an interest in the furtherance of the crop. This is a large and amorphous group, held together by the cassava newsletters, the information/documentation service on cassava, and frequent but nonsystematic contacts between and among members.

Regional and subregional germplasm exchange networks. Because of the marked differences in the adaptation of germplasm in different regions and subregions (i.e., a strong genotype-by-environment interaction), germplasm exchange networks are most meaningful and effective if they are regionally based, although they can as well cut across particular agro-climatic zones. Germplasm exchange in cassava moves principally as sexual seed, originating from elite germplasm pools. Such gene pools have been developed in Colombia, are in the process of being developed in Asia, and are projected to be developed in Brazil. In addition to the exchange of germplasm, the networks focus on methodology development and interchange of information.

Specialized networks. These networks seek to unite cassava research that lays outside the national cassava programs. In Asia much research on cassava processing and utilization is done in specialized research centers, unconnected to national cassava research programs. Plans call for the organization of an Asian cassava utilization network to rationalize and support research in the region. In Latin America a network of agencies involved in cassava integrated projects is being organized, again principally to interchange methodological approaches and organizational options.

The Cassava Program will continue to act as a catalyst in the development of these networks, and in servicing them to the extent possible. The principal resources available to support this effort are training, international and regional conferences, newsletters, and the world cassava documentation and information center based at CIAT. While the Program seeks to be instrumental in the efficient functioning of the networks, it also seeks to make sure that the Program itself is not placed in the focal point as the principal source of information and materials; rather, it seeks to stimulate active participation on the part of all network members and attempts to ensure that the networks are marked by a horizontal exchange of ideas, germplasm and technologies.

RESOURCE REQUIREMENTS

Using senior staff positions as the basic unit for the projection of required resources, ~~the following is a description of existing and projected senior staff positions that~~ CIAT considers to be essential for the Cassava Program to carry out its mandate as described ~~in this document.~~ Table 3 provides a summary listing of the positions ~~described here.~~ in a p. 26

Headquarters-based Staff

Program Leader. The coordination and leadership required to ensure a fully integrated multidisciplinary, decentralized approach to global cassava research and development is provided through the Leader position at headquarters. Technical supervision and monitoring of all activities of the headquarters and outposted team members, as well as technical collaboration with IITA and collaborating advanced research institutions, remain the central responsibility for the scientist in this position.

Pathologist. Research on the fungal and bacterial disease complexes of the crop, particularly as these relate to key cassava ecologies, will continue, with emphasis not only on germplasm improvement but also in providing a sound framework in which specific integrated disease control methodologies for those ecologies can be applied in the development of sustainable cassava cropping systems. Monitoring research on the means for the safe and efficient international transfer of germplasm will continue.

Entomologist. The research on cassava pests will continue to strengthen the existing inter-center effort on biological control of major cassava pests through the identification, rearing and distribution of beneficial insects from the center of origin. In addition attention will continue to focus on germplasm evaluation for pest resistance and tolerances as a basic input into germplasm improvement.

Physiologist. The research will continue to concentrate on further unravelling of the basic physiology of the C3-C4 intermediate in collaboration with scientists in advanced institutions. At the same time, genotype responses and the underlying mechanisms of those responses to a range of stress factors, reflecting the environmental focus of cassava--particularly water use efficiency and stress tolerance, and low soil fertility adaptation with particular emphasis on phosphorus and potassium nutrition including the role of mycorrizae--will be assessed.

Table 7. Actual (1987) and Projected (1988-1992) Staffing Pattern of the CIAT Cassava Program

Position	1987	1988	1989	1990	1991	1992
Headquarters						
Leader	1	1	1	1	1	1
Physiologist	1	1	1	1	1	1
Pathologist	1	1	1	1	1	1
Entomologist	1	1	1	1	1	1
Breeder(s)	1	2	2	2	2	2
Economist	1	1	1	1	1	1
Agronomist	1	1	1	1	1	1
Utilization Specialist(s)	1	2	2	2	2	2
Virologist[1/]	0	1	1	1	1	1
African Region						
Agroeconomic Study Team[2/]		[4]	[4]	[4]		
CIAT Cassava Specialist at IITA	0	1	1	1	1	1
Asian Region						
Breeder	1	1	1	1	1	1
Agronomist[3/]	1	1	1	1	1	1
Economist	0	1	1	1	1	1
Latin American Region[4/]						
Agronomist/Breeder (Brazil)	0	1	1	1	1	1
TOTAL	10	16[+4]	16[+4]	16[+4]	16	16

1/ Position attached to the CIAT Virology Unit

2/ For Agroeconomic Studies of Cassava in Africa; restricted core positions for a fixed term period of three years.

3/ Position presently funded on Special Project basis

4/ Additional positions are expected to become available, through bilateral and other non-core funding, for a fixed term involvement in integrated cassava development projects in particular countries.

The basic role of the physiologist at CIAT is to stimulate and conduct research on a crop that has not received sufficient global attention, with a view to providing a basic knowledge framework for germplasm improvement and developing sustainable cropping systems.

Breeder I. The existing position at headquarters will continue to focus on genetic improvement of cassava within the framework of a decentralized improvement program through the continuing evaluation of the growing cassava germplasm collection and the incorporation of sources for tolerance or resistance to a wide range of biotic, edaphic and climatic factors into high-yielding background populations with appropriate quality characteristics for the wide range of end uses for which cassava is destined. The breeder will have specific responsibility for developing germplasm resources for the humid and subhumid lowland areas of Latin America and Asia. Research will include collaborative decentralized breeding and selection activities with national program scientists and in servicing outposted CIAT breeders in Asia and Brazil.

Breeder II. This new position projected at headquarters will strengthen the decentralized improvement program through concentration on the middle-altitude tropical highlands and the subtropical ecologies of Latin America and by providing improved populations through IITA for these same ecologies in Africa and elsewhere. Both headquarters-based breeders will increasingly adapt new tissue culture methodologies in the germplasm improvement effort as these become available; e.g., through the possible use of haploids through anther culture and in somatic embryogenesis for producing artificial seeds. The scientist in this position will provide the main channel for collaborative breeding activities with IITA to ensure that the full range of genetic variability available can be applied in Africa. The scientist will also provide the input required from the Cassava Program for the management of the international cassava collection in collaboration with the Germplasm Resources Unit.

Economist. The Economist will continue to focus on studies of socioeconomic factors affecting cassava research and development through the production, processing, marketing and utilization of the various end products. The principal role of the Economist is to provide an economic framework in which integrated cassava development can take place in identified areas of greatest potential. The Economist is an integral part of the headquarters team devoted to the catalytic activities associated with CIAT's collaboration with development projects in Latin America, as well as providing the means for the intercontinental transfer of socioeconomic experience. In this regard a close association of the Economist with the IITA-CIAT agroeconomic studies planned for Africa will ensure that experiences obtained elsewhere in cassava development can be better applied within the Africa context once the study period is completed.

Agronomist. The headquarters-based Agronomist forms part of the sub-team specifically devoted to collaborative activities in integrated cassava development in the Latin American region, particularly in relation to working with national programs in decentralized research to ensure that appropriate agronomic practices leading to sustainable cassava based cropping systems are developed. The recognition of the need for more location-specific agronomic research gives a specific focus for the

agronomist via collaboration with ongoing national integrated cassava production projects and those projected by collaborating agencies.

Utilization Specialist I. The existing utilization position will continue to focus on the engineering and logistical aspects of cassava processing for the wide range of end uses, not only in developing new methodologies but also in providing input into the improvement of traditional processing systems which presently have a low efficiency of labor use in many instances. The possible application of new or improved methodologies in Africa (through IITA-CIAT collaboration) that will be required will be identified through the planned agroeconomic study of cassava in Africa. This scientist also forms part of the headquarters sub-team devoted to CIAT's role in integrated cassava development in Latin America and the Caribbean.

Utilization Specialist II. The acceptance of new varieties is highly dependent upon the quality characteristics of the fresh roots as related to the final end market. Little is known at present about the parameters that determine root quality. An additional position is projected in the utilization section at headquarters to work closely with the breeders to define these biochemical parameters and develop screening techniques that will discriminate among genotypes accurately. Guidelines will also be developed and methodologies designed to improve the quality of cassava products after processing; this cassava quality work will have direct application to the wide range of cassava products in Africa.

Virologist. As a vegetatively reproduced crop cassava is prone to virus problems transmitted through the planting material. This not only affects production on farmers' fields but also inhibits the free exchange of germplasm. It is essential to characterize the cassava viruses accurately, develop techniques for their detection and elimination and to devise control methods. In order to do this, the Biotechnology Research Unit, which provides an administrative and resources umbrella for all virology work at CIAT, is projected to increase its personnel by one senior staff position.

African Region

CIAT Cassava Specialist at IITA. The nonlocation-specific research done by the overall CIAT effort can bring great benefits to African cassava producers. CIAT does not, however, apply this technology directly to African conditions. The information, germplasm and biocontrol agents are transferred directly to IITA, who incorporates these elements into its regional efforts in Africa. To establish an effective liaison between the two centers, IITA and CIAT have agreed that a CIAT cassava specialist be posted at IITA to ensure that African needs and requests that can make use of CIAT-based resources are rapidly met. Both Centers agree that in the light of the scarce resources this scientist should form an integral part of the IITA cassava effort and carry out an active research program. At the present time, IITA is developing a new strategic plan which will define the priority area of research for the cassava specialist. At this time, the two areas that appear to have highest priority are the transfer and adaptation of either Latin American germplasm or postharvest technology to African conditions.

Agroeconomic Studies of Cassava in Africa. The importance of cassava in Africa is beyond doubt; nevertheless,the data available for planning research and development programs based on cassava are deficient. This makes it extremely difficult for CIAT and IITA and the national programs to develop a coherent research strategy for this continent. As a result CIAT and IITA are proposing to set up a major short-term (3 year) study of cassava. This study will characterize the present production, processing and marketing systems in Africa and also assess the potential for producing cassava in new areas, as well as the changes in demand that are likely to occur in the coming years. In order to do this, the setting up of a study team is envisaged to be headed by a study director (an agricultural economist) and three economists (each one assuming responsibility for a separate geographical region). This team is to be supported by a series of national study coordinators. The total projected amount needed for this activity is US$2.25 million for the three-year period. CIAT and IITA are each including one-half of this amount in their respective budget requests. (It should be noted that while the resource requirements are being requested in equal parts by both IITA and CIAT, these requests should be considered for funding as one integrated whole.)

The results of these studies will form the basis for a coordinated CGIAR system plan for cassava in Africa which will be presented jointly by CIAT and IITA.

Asian Region

Breeder. The present position in Asia forms part of the regional cassava program for Asia which is projected ultimately to have three scientists. The position provides a focus for the decentralized regional breeding program in collaboration with the national researchers within a regional germplasm development network. Backup from headquarters in terms of a providing a broader germplasm base for Asia is balanced by a concerted program to stimulate genetic recombinations and selection for specific local environmental constraints and end uses. The specific role of the regional breeder is to provide guidance to national efforts and to stimulate effective and save intercontinental exchange of improved germplasm. The lower incidence of cassava diseases and pests in Asia permits greater concentration on yield, quality, and adaptation to environmental stress.

Agronomist. In the complex Asian cropping systems in the upland areas, sustainability of production is a major concern. An agronomist is stationed in Asia to assist national programs in developing production systems that reduce erosion and maintain soil fertility. This position is special project-funded through 1989, whereupon it is projected to be incorporated into CIAT's core budget.

Economist. An integral member of the Asian team will be a social scientist (economist) whose main task will be to ensure that the new technology fits into the intricate Asian cropping systems and is acceptable to farmers. This will involve working closely with the CIAT agronomist and the national program agronomists in the testing of new technology packages at the farm level and in the monitoring of adoption of new technology. In addition the economist will analyse the overall direction of cassava development in the

region so as to ensure that the other research activities are directed to resolving the problems related to changing socioeconomic conditions in the region.

Latin American Region

Breeder/Agronomist - Brazil. It is not possible at present for the headquarters team in Colombia to dedicate adequate attention, within the Center of origin of the species, to two important cassava ecologies, namely, the subhumid tropics and the cool-season subtropics. In view of the overall importance of cassava in Brazil and the existence of these two ecologies there, CIAT has projected a new position in Brazil. The location of the Breeder/Agronomist will depend upon discussions with EMBRAPA, but most likely will be in Northeast Brazil. In addition, the scientist would supervise a research associate to be located in the South to handle the development of breeding populations for the cooler ecosystems. The Breeder/Agronomist at the base location will mainly be developing specific cassava germplasm pools adapted to the drier areas of the lowland tropics. The future role of this particular germplasm in the subhumid savannas of Africa will be studied in collaboration with IITA. The richness of the germplasm resources available in Brazil is a key element in this decentralized strategy.

Integrated Cassava Development Projects. In the foregoing definitions of the role of existing and projected senior staff positions, three scientists from the core-financed headquarters team of the Cassava Program are given specific responsibilities to provide collaborative linkages to integrated cassava development projects in Latin America and the Caribbean; i.e., in addition to their normal activities in the Program. These scientists are the Agronomist, Economist and Utilization Specialist I. CIAT plans to stimulate integrated cassava development projects in carefully defined regions with the greatest potential and across the range of end uses for cassava. These projects will be funded through special projects to CIAT and/or through bilateral projects funded directly to the collaborating country institutions.

CLOSING COMMENTARY

The resource requirements ~~summarized in Table~~ 2 represent a marked increase from the current staffing level of 10 senior scientists. This expansion ~~in the Program~~ represents a transition from a period of consolidation, where the focus was on the honing of research strategy, the development of a body of research on the crop, building of national programs, and the structuring of an effective outreach strategy, to an expansion phase, ~~where with additional resources everything is felt to be in place~~ to achieve a major impact on cassava production and utilization.

The projected level of staffing is thought to be modest in relationship to the breadth of the task. This expansion in resources for the development of the cassava crop fills three principal dimensions in which the Program works. First is the integrated approach to technology development, where the commodity system encompassing production, processing and post-harvest utilization, and market development are researched in an interactive way. Second, because of the underfunding of cassava research worldwide, the Cassava Program has had to work across the research spectrum from strategic research through applied to adaptive research. The third dimension has been the focus on institutional development. When the Cassava Program started there was only one functional cassava research program in the world. A large effort has been spent not only on building national research programs but also on developing institutional models for cassava projects within development programs, and on integrating cassava into the overall agricultural policy process.

The base is now laid for a significant push in cassava and the timing is right. There are now strong, functioning cassava research programs in all the principal Asian producing countries and healthy programs have been developed in primary target countries in Latin America. A strong critical mass has been assembled at headquarters but resource restrictions have limited outposted core staff. The new positions being requested are principally focused on strengthening regional programs and developing a more effective linkage to the IITA program. With the expansion in regional programs additional resources are required in the breeding program to backstop the widening network of national program-based selection sites. Finally more strategic research is needed in cassava utilization, especially on quality parameters of both the fresh root and processed products. This research feeds directly into breeding, cultural practices, processing, and market research.

What then are the benefits to be expected from this investment? Cassava is felt to be an important vehicle for moving the Green Revolution into the rainfed sector, especially to those areas where edapho-climatic constraints are particularly limiting. To achieve this the Cassava Program has moved away from the concept of improved varieties as the sine qua non for impact. Recognizing the heterogenity, not only of production conditions in upland areas, but also of market and demand conditions in developing countries, the Cassava Program has adopted a more holistic approach to research and development of the crop. ~~This focus on the commodity system has shown its value in Latin America and Asia; the same approach is felt to be necessary~~ to achieving impact in Africa. The approach allows more degrees of freedom

for technology introduction since impact is not dependent only on the variety and, because of the multiple design options, there is more scope for targeting the technology on key objectives. Improved benefit distribution through cassava development is a major feature of this targeting process. A detailed knowledge of the target area, highly malleable technology, and a decentralized research approach are all directed to maximizing this impact.

GLOBAL CASSAVA RESEARCH AND DEVELOPMENT

ATTACHMENT A

Executive Summary of Cassava
Demand Studies in Asia and Latin America

The Impetus for a Cassava Demand Study

Cassava is something of an enigma in the international center system. Research on cassava was initially funded because of its obvious importance (third after rice and maize) as a starchy staple in the tropics and because of its phenomenonal yield potential, even under significant stresses. However, ignorance about the crop has often unjustifiably resulted in the image of cassava as something of a pariah, being accused of impoverishing soil, causing cretinism among cassava consumers, and stymieing the economic progress of cassava producers. A crop produced by poor farmers on poor lands for poor consumers was perceived to be the antithesis to the modernization process being pursued by developing countries. As growth in funding for the CGIAR system slowed and resource allocation between commodities become a central issue, cassava was affected by this image problem, as doubts were raised--not about the current importance of the crop, but about cassava's future as countries within the tropics developed.

Doubts about the amount of research resources that should be devoted to cassava found their expression (1) in the 1983 decision by CIAT Board and management to reduce the Cassava Program significantly in a period of very tight budgetary constraints; (2) in the 1984 External Program Review of CIAT, which recommended that funding for the Cassava Program be frozen (at the 1983 reduced level) until the future demand for cassava was better characterized; and (3) in the TAC's current "Review of CGIAR Priorities and Future Strategies," which sees future funding on cassava to be held to current levels. These actions must be seen as a vote of no-confidence, not in the CIAT Cassava Program, but in the cassava crop itself.

The concerns about cassava focused on the demand for the commodity. Cassava was seen, if not as an inferior good, then as a commodity with very inelastic demand and therefore with limited growth prospects as the overall economy developed. Such inelastic demand would result in significantly reduced payoffs to research investment. However, the problem is not unique to cassava. At some point in a country's economic development, per capita consumption of basic food staples will decline. Almost by definition, demand for food staples is inelastic, particularly when they bulk large in the diet. However, this fact has not hindered research investment in grain or legume staples, if nothing else because of the benefits to be derived by consumers. One could conclude then that cassava was being unfairly singled out, especially when appropriate processing makes it possible for cassava to enter alternative markets with significant growth potential.

The other dimension of the cassava enigma is that the crop in most respects contradicts the paradigm created by the Green Revolution wheat and rice

varieties. A singular focus on development of improved varieties is not sufficient to achieve impact in cassava. A research strategy for cassava has to focus on the complete commodity system; that is, production, processing, marketing and demand. It is very apparent that a lack of investment in research on postharvest technology can significantly reduce the payoff on investment in production technology and vice versa. The analysis of demand for cassava in different markets at different stages of economic development is an integral part of the research process, helping to define strategy, priorities and outreach activities. Understanding demand is key to understanding the potential impact of research on socioeconomic goals and, in turn, in designing technology introduction strategies that will maximize the achievement of CGIAR objectives. Unlike the rice and wheat model, a cassava research strategy is complex. There is no one-to-one correspondence between release of a new variety and impact on farmer income and food consumption objectives. In cassava research, complexity is necessary to be effective; it also breeds uncertainty and doubts among those who would support it.

The commitment of resources by the CGIAR to cassava indeed should be defined by the future potential of the crop and the contribution cassava can make to the stated objectives of the CGIAR system. As will be shown, cassava is uniquely placed to make a contribution to some of the more intractable of those objectives, especially by maximizing this multifarious demand for the crop.

Problem Structure and Methodology

A world economic study of cassava, focusing on the future potential demand for the crop, is beset from the beginning by the problems of a very weak data base and considerable methodological complexity. The sources of that complexity arise from the following:

-- Cassava is a multiuse commodity, comparable only to maize in the range of its uses. The potential demand for cassava is, therefore, an aggregation of the demand in each individual market. These markets in turn are independent of one another, yet must compete among themselves for the roots. Even within cassava food markets, different cassava products have distinctly different demand characteristics.

-- The postwar period has witnessed a significant increase in the possibilities for commodity substitution, especially in markets for carbohydrate sources. Cassava often competes with different substitutes in different markets. Moreover, although cassava has remained outside the policy arena, policy interventions in the markets for competing substitutes have an obvious impact on the demand for cassava. These policy interventions vary by country. To understand the potential demand for cassava requires an understanding of the complete grain (both food and feed grains)-livestock sector in each country.

-- Under certain conditions cassava is considered a tradable commodity (and thereby directly influenced by trade and exchange rate policies); but under other conditions, cassava is a nontradable (in which case an

assumption of autarky would apply in the analysis of demand). Moreover, because cassava moves in a semiprocessed form, there is no one international market for the commodity; rather there is a starch market, a pellet and chip market, and a flour market. These markets, in turn, have been heavily influenced by trade and tariff policies established by importing countries (there is virtually no market intervention by the exporting countries themselves).

The research problem--the potential world demand for cassava--therefore had to be significantly simplified by comparting the problem into independent components. The first, and absolutely necessary, division was an analysis of cassava production and demand country by country as food consumption patterns, price and trade policies, agroclimatic characteristics, crop production patterns, and overall economic development all vary. As these factors affect cassava demand, the country had to be the unit of analysis. The second level of analytical subdivision was the market. Individual cassava markets were assumed to be independent, and the potential demand in each market was analyzed separately--market size, growth prospects, and the price at which cassava would compete with principal substitutes. A simultaneous evaluation of cassava supply and demand within a multiplicity of markets in each country was beyond the scope of the data base and the manpower available. Two questions then followed from the market analysis: (1) Are production costs for cassava below the market entry price? and (2) what is the potential for bringing the implied root price in the different markets into line; that is, expanding the production base?

The study, in the end, does not give a quantitative projection of the future demand for cassava in the world. Rather the study adopts a positive (rather than normative) approach, asking whether cassava can compete at current production costs and under current prices of substitutes and policy regimes in markets with significant growth prospects. For this study a positive answer implies a basis for demand growth for cassava. The country-by-country analysis, in turn, offers something of a comparative framework for assessing cassava's potential at different stages of development. Cassava already plays a role in all the markets considered in at least a few countries. Understanding what factors have been responsible for cassava's use in these markets gives some basis for understanding whether these same cassava markets will develop in other countries.

Cassava within a Development Framework

Demand is a necessary, but altogether limited, criterion for evaluating the future of cassava in the tropics. Instead, cassava should be evaluated in a broader context, focusing on the crop as a vehicle for development. Ironically, cassava has remained outside the purview of agricultural planners and policymakers; yet it has contributed significantly to meeting policy goals in many developing nations. In other countries this role has been curtailed because policies on grain substitutes have indirectly discriminated against cassava.

The role of cassava in the food and agricultural sector changes as the overall economy develops. In the initial stages when most of the population lives in rural areas, cassava has generally served as a basic

food staple. Cassava's high-yielding ability, adaptation to drought, tolerance to disease and pest attack, and indeterminate harvest period have made it a subsistence crop par excellence, providing a secure food supply even under quite risky conditions. In many areas processed products were developed in order to eliminate the HCN in the roots, as a means of storage, and as a staple for trade. In traditional, rural, cassava-consuming areas per capita consumption levels are usually very high.

In Asia and Latin America today, it is unusual to find farmers who produce cassava purely for subsistence purposes. As urban markets develop and farmers enter into the market economy, cassava shifts increasingly to a cash crop, first supplying food markets. Because processed cassava is relatively inexpensive, it often becomes the staple of the urban poor, such as farinha de mandioca in Northeast Brazil or gari in many parts of West Africa. However, these processed staples usually face a very inelastic demand in urban areas; and it is the growth of other markets such as starch and animal feed that provides the potential for further increases in demand for the crop. Unlike most other carbohydrate staples, cassava is able to maintain a significant elasticity in demand throughout the growth process by shifting into increasingly expansive, alternative markets.

Nevertheless, the transition to a multimarket cassava system has often been inhibited by a number of constraints including grain price policies that discriminate against cassava; capital constraints for investment in processing; insufficient technical information; and inefficient price formation in cassava markets. Knowledge of this unexploited demand, however, opens up cassava's potential as a development tool. Potentially elastic product demand, together with competitive production costs, implies significant income-generation potential for cassava producers.

As these are almost always small-scale farmers operating under some principal agroclimatic constraint, cassava is a rare case where the benefits of new technology can be targeted to that stratum which has normally remained outside the development process. The improved equity in rural income distribution will, in many cases, coincide with a positive benefit for consumers of traditional cassava products, usually the lower income strata. Thus market development, tied to improved cassava-production technology, can set in motion the type of dynamic growth that has occurred in Northeast Thailand over the past 15 years.

Development of cassava markets with elastic demand will depend upon the economy's overall stage of development, as well as on the policy environment for competing substitutes. Two points follow from this. First, the strategy adopted for the development of cassava will vary by continent. No single strategy will apply across tropical Asia, Africa and Latin America. Second, cassava has thus far remained outside the policy-making process, often to its disadvantage. Because of the increasing possibilities for commodity substitution, greater consistency in input, credit and pricing policies is needed across commodities in order to ensure the most efficient utilization of agricultural resources. That cassava production has managed to grow despite these policies is an indication of the existing low production costs for the crop.

The Cassava Economy of Asia

A multiple cassava market system is already well developed in Asia, with cassava uses spanning a range from a basic food source through dried pellets for animal feed to high fructose syrup. Cassava is the second most important starchy staple produced in tropical Asia and is a major cash crop in the upland areas of the region. Cassava has achieved this prominence because of the responsiveness of investment, mostly in small-scale processing capacity, and because of the versatility of cassava as an upland crop (Annex Table 1). Its high-yielding ability makes cassava suitable for the needs of very intensive systems, as reflected in yields reaching as high as 60 t/ha in Tamil Nadu, India. Moreover, cassava is also well adapted to the more extensive systems on the agricultural frontier of tropical Asia and to the spectrum of upland areas with major rainfall or soil constraints.

Rice is the dominant calorie source in the diet of tropical Asia. Like all the other grains, cassava is a secondary staple. As a food source, cassava's main role, particularly in Indonesia and India, has been to augment the calorie consumption of the low-income strata, essentially because of its lower calorie costs. Because of its different forms, cassava has the ability, even as a food commodity, to segment its market, thereby maximizing overall market demand. In Indonesia, for example, the poor consume gaplek, a dried form of cassava. Average income elasticities suggest that gaplek is an inferior good; but because of the positive elasticity in the lower income strata, lower prices and increased supplies of gaplek would target benefits to the very poor. Fresh cassava, on the other hand, has a positive income elasticity and is a more preferred form of consumption; nevertheless, high marketing margins and lack of convenience have limited consumption in urban areas. Finally, a very elastic demand for krupuk, a flavored toasted wafer of cassava starch consumed primarily by the high income strata, has resulted in a positive overall growth in demand for cassava as a food.

Cassava market diversification in Asia over the last two decades has been heavily influenced by the export market. Export prices are set by a preferred (as compared to feed grains) tariff rate for cassava entering the European Economic Community. As a result there is no price integration between world markets for feed grains and for cassava pellets. In general Asian countries have found it more profitable to export cassava and utilize domestic or even imported maize in their animal feed industries. A corollary to this point is that while cassava could have competed in world feed grain markets on a cost basis (Annex Table 2), it could not compete on a price basis; nor did it need to, as the EEC absorbed all that could be produced. The year 1983, however, saw the imposition by the EEC of voluntary export restraints (quotas) on cassava. Thailand was most affected because the quota was below its export capacity. Nevertheless, through effective policy measures, cassava production and exports have continued to grow during the quota period, and farm-level prices were maintained above what could have been achieved by linking the Thai cassava market to the world maize market. Moreover, during this period, when prices of maize and cassava came into line for periods of time, cassava was utilized in the domestic mixed-feed industry in both Thailand and Malaysia. This point is important as it shows that if prices are competitive, cassava

will be used by feed manufacturers in Asia and that cassava prices, for however short a period of time, do sometimes come in line with world feed grain prices.

The world market in most countries in Asia sets a price floor under domestic markets; all major producing countries, except the Philippines, have at some point been exporters. However, in the 1980's, except for Thailand, Asian countries have either reduced export levels or moved to net import positions, especially in cassava starch. Starch demand has been rising rapidly in all these countries, to the extent that countries such as Indonesia and Malaysia have had to import large amounts. Many countries have expanded demand by moving to modified starch production, and Indonesia has begun to produce high-fructose syrups based on cassava starch. Growth markets exist for cassava in Asia, to the point that production is not keeping up with demand.

To date, little improved production technology for cassava has reached the farm level. Declining costs of production could accelerate the diversification of markets in Asia (Table 1), especially into the animal feed market. The market structure already in place has the capacity to

Table 1. Asia: Summary of Market Potential for Cassava by Country.

	Market Potential [1]				
	Food			Animal Feed	
Country	Fresh	Processed	Starch	Domestic	Export
Thailand			++	++	++
Indonesia	+	+	++	*	+
India					
Kerala	+		+		
Tamil Nadu			++		
Semi-Arid		*		*	
Philippines	+		+	*	
China	+		++	++	++
Malaysia			++	++	

[1] Market potential is defined in the following classification:

+ Maintenance of existing consumption levels
++ Growth in existing markets
* Unexploited growth potential due to lack of sufficient production to service all markets

absorb significant increases in production, without drastic declines in prices. This multiple-market structure allows cassava to attain a range of benefits, including simultaneous improvements in the welfare of the low-income consumer (in India and Indonesia) and in the income of the small-scale farmer in the upland areas. Cassava has already been a major source of income growth for farmers in areas such as Northeast Thailand and Lampung, Indonesia. New cassava technology could bring benefits to farmers bypassed by the Green Revolution, especially those that start from a much poorer resource base than those that benefited from the new rice technology.

The Cassava Economy of Latin America

Latin American economies have undergone rapid structural change in the postwar period, accompanied by a number of adjustment problems, as reflected in strains on urban services, high inflation rates, malnutrition among a significant portion of the urban population, a rising external debt, and high rates of unemployment. Many of these problems have been due, directly or indirectly, to the excess rate of rural-urban migration, induced by the very skewed distribution of land resources. The growing number of urban poor has induced an often contradictory agricultural policy, whose two elements have been low urban food prices and income supports to farmers (through intervention in input and output markets). Not surprisingly, policies have often had to resort to subsidies in order to fullfill both objectives.

Cassava has remained outside this policy process; yet it has been strongly affected by policies on grain substitutes. Moreover, cassava has also been affected by the shift in the locus of overall food demand from rural to urban areas. Whereas changing food consumption patterns and restructuring of food markets should have provided an opportunity for growth in market demand for cassava, the fact is that cassava production has stagnated. Unlike Asia, cassava has not been able to make the transition to a multiple market system in Latin America; traditional food markets continue to dominate in the overall demand for cassava.

Prices of substitutes and the "urbanization" of food consumption have been the major influences on overall demand for cassava in Latin America. Only traditional dried cassava products, such as farinha de mandioca in Brazil, are inferior goods (i.e., the income elasticity is negative); and only in Brazil do these products dominate in overall cassava demand. Even here, policy has been the dominant influence on declining consumption, as the very heavy subsidies on wheat flour have completely shifted relative prices and consumption levels for the two commodities (Annex Table 3). For fresh cassava, on the other hand, income elasticities are positive (except in Paraguay), with a very significant elasticity in demand in urban areas. In this case the very high costs of marketing fresh cassava in urban areas have shifted relative prices between rural and urban areas. Per capita consumption levels are much lower in urban than in rural areas although market demand is much more elastic; and with the shift in residence of the population to urban areas, average per capita consumption levels have

declined. However, as the locus of consumption shifts from rural, subsistence consumption to purchased cassava, actual market demand for cassava has been increasing at a significant rate (Annex Table 4). Recent advances in storage technology for fresh cassava promise to lower marketing costs and improve consumer convenience, thereby increasing market demand even further.

Nevertheless, the major potential growth in demand for cassava exists in the market for animal feed components (Table 2). Technical change in

Table 2. Latin America: Summary of Market Potential for Cassava by Country.

	Market Potential[1]				
	Food			Animal Feed	
Country	Fresh	Processed	Starch	On-Farm	Dried
Mexico				*	*
Nicaragua	++				*
Panama	+				*
Cuba	+			*	*
Haiti		++		*	
Dom. Rep.	++	+		*	
Brazil					
Northeast	++	+			*
North		++			
South	++		++	++	
Colombia	++				*
Ecuador	+				*
Peru	++				*
Venezuela	++				*
Paraguay	+	+	++	++	

[1] Market potential is defined in the following classification:
+ Maintenance of existing consumption levels
++ Growth in existing markets
* Unexploited growth potential due to policy or market constraints

animal production and changes in market structure for meats have made this a very expansive market in the last two decades. New breeds and the availability of protein concentrates have made cassava a major on-farm feed source for swine in southern Brazil and eastern Paraguay, and more recently, in southern Mexico. However, the major potential market is for dried cassava in mixed animal feeds. In most tropical Latin American countries, price interventions in the feed grain market have curbed a potential role for cassava. However, with the devaluation of exchange

rates, reduction in subsidies, and rationalization of prices in response to the 1982 debt crisis, cassava is now competitive on a cost basis with domestically produced feed grains in all major producing countries except Venezuela, where a differential exchange rate policy for feed grain imports still makes cassava uncompetitive (Annex Table 5).

Even though economic growth and structural change in Latin America have fostered market diversification in many agricultural commodities, there has been little development of multimarket systems in cassava. This is partly due to policies on substitutes, as well as to lack of efficient price formation within cassava markets. Developing the market for cassava as an animal feed source provides a virtually unique opportunity for developing more well-integrated cassava markets and for raising incomes of small-scale farmers in Latin America, especially those in more marginal agroclimatic areas such as northeastern Brazil, the Atlantic Coast of Colombia, or the coastal plain of Ecuador. Excess capacity exists in these systems because of limited cropping alternatives and inelastic demand for those that are grown. Development of a processing capacity for dried cassava puts a price floor under existing markets, providing the incentive to expand production.

Increased production in turn brings greater price stability to cassava food markets, thereby benefiting consumers. These initial interventions are organized as integrated cassava development projects, which develop the market channels, provide the credit and technical assistance for the processing technology, and extend production technology. Projects are now functioning in Colombia, Ecuador, Panama, Mexico and Brazil. Dried cassava is now being competitively produced for the feed industry in Latin America, and the benefits are being targeted on the small-scale producer.

The Prognosis for Cassava in Africa

Cassava is the most important food crop in sub-Saharan Africa, providing more than 200 calories per day for over 200 million people. Cassava's central role in the African diet takes on special importance as Africa is the only region in the world where per capita food production has been declining. At issue in the short term is the role of cassava in reversing that trend; and in the longer term, the contribution cassava can make to overall development of the agricultural sector in Africa. Yet, analysis and data to address these issues are virtually nonexistent.

Cassava's future in Africa rests upon defining the income and employment generation potential of the crop. Any role here in turn is linked to developing marketable surpluses, on the one hand, and identifying and developing markets, on the other hand. These issues in turn lead to questions about the type of product (there are a wide range of cassava food products in Africa), the demand parameters for the different products, the interventions needed in processing technology and marketing channels, and the effect of pricing policies on substitutes. Cassava has a potential role as a farm income source in current production areas, if marketing channels to growing urban areas can be opened, and as a stabilizing component in farming systems in marginal, food-deficit areas. In order to develop strategies to foster these roles, it is necessary to answer the foregoing questions. To begin to plan for development of cassava in Africa, a joint IITA-CIAT study has been developed to characterize cassava

production, processing, marketing and demand. The three-year project is seen as an integral part of IITA and CIAT's development of a consistent research strategy for cassava on the continent.

ANNEX TABLES

Annex Table 1. Asia: Type of Land Constraint in the Principal Cassava Production Zones

Country	Type of Land Constraint		
	Limited Farm Size	Marginal Agro-Climatic Conditions	Frontier Areas
China	Guangdong	Guangxi	
India	Kerala Tamil Nadu (irrigated)	Tamil Nadu (non-irrigated)	
Indonesia	Java (level sawah)	Java (eroded hillside)	Transmigration schemes
Malaysia		Peat soils	Land development zones
Philippines	Visayas		Mindinao
Thailand	Central Plain	Northeast	Northern region

Annex Table 2. Comparison of Costs of Maize from Major Exporters and Cassava (on a maize equivalent basis) from Thailand, cif Japan.

	Maize			Cassava
	U.S.A. ($/t)	Argentina ($/t)	Brazil ($/t)	Thailand ($/t)
Production Costs				
Variable Costs	60.0	37.9	66.6	52.6
Fixed Costs	59.8	32.9	68.2	7.7
Total Costs	119.8	70.8	134.8	60.3
Marketing and Processing	24.7	25.3	33.9	33.8
F.O.B. Costs	144.5	96.1	168.7	94.1
Freight to Japan	26.0	32.4	34.2	10.0
C.I.F. Costs	170.5	128.5	202.9	104.1
Yield (t/ha)	6.25	3.36	2.22	5.22

Note: All costs are at 1985 prices and exchange rates. Thai cassava costs represent 1981 costs multiplied by the wholesale price index and divided by the 1985 exchange rate. Costs are then put on a maize equivalent basis by dividing by 0.7.

Source: Maize: Ortmann, G., U.J. Stulp, and N. Rask, "International Trade and Economic Development: Examples of Comparative Costs in International Commodities," 1986; and Cassava: CIAT.

Annex Table 3. Brazil: Relationship between farinha de mandioca and wheat flour prices and consumption, 1960-80.

	1960	1970	1980
Farinha Consumption (kg/capita)	26.3	23.5	12.0
Wheat Consumption (kg/capita)	26.2	25.2	45.5
Farinha/Wheat Consumption	1.00	0.93	0.26
Farinha/Wheat Prices	0.61	0.64	2.95

Annex Table 4. Colombia: Disaggregation of Demand Parameters for Fresh Cassava in Rural and Urban Areas, 1983.

Parameters	Rural	Urban
Population Growth	- 0.1	3.7
Income Elasticity	0.28	0.38
Per Capita Income Growth	2.5	1.4
Demand Growth	0.6	4.2
Weighted Average [1]	0.51 (0.6) +	.49 (4.2) = 2.4

[1] Weights are distribution of total consumption between rural and urban areas in 1983.

Annex Table 5. Latin America: Comparison of Production Costs for Dried Cassava and Prices for Cassava and the Principal Feedgrain, 1986

Country	Production Cost [1]	Price [1]		
	Cassava	Cassava	Grain	Cassava/ Grain
Sorghum:				
Colombia	17,044	25,600	32,000	80
Mexico	50,429	64,000	78,000	82
Venezuela	1,279	1,870	2,200	85
Maize:				
Peru	994[2]	2,475	3,300	75
Panama	170	180	230	78
Paraguay	32,406	56,000	70,000	75
Brazil	1,306	1,330	1,705[3]	78

[1] Price and costs in local currency per ton.
[2] Assumes cassava comes under ENCI purchasing system, in which case transport costs are not included.
[3] Maize import price,