SUMMARY PROCEEDINGS OF A WORKSHOP ON TRENDS AND PROSPECTS OF CASSAVA IN THE THIRD WORLD

edited by
J. S. Sarma

International Food Policy Research Institute

Summary Proceedings of a Workshop on Trends and Prospects of Cassava in the Third World

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International Food Policy Research Institute (IFPRI)
Washington, D.C.

July 1989

Published in 1989 by the

International Food Policy Research Institute
1776 Massachusetts Avenue, N.W.
Washington, D.C. 20036
U.S.A.

ISBN 0-89629-311-4

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Foreword

Cassava is a staple food crop cultivated in several developing countries, largely by small farmers. It is a source of subsistence and of cash income to poor farmers as well as a source of rural employment, particularly of women. During the past 20 years, production of cassava expanded rapidly in Asia, especially in Thailand, in response to expanded demand for imports by the European Community, where it is used as livestock feed. There are concerns, however, about the likely decline in demand for cassava as food as incomes rise in developing countries and also about the stability of the European demand. To assess the prospects for cassava in the future, IFPRI has examined the trends and prospects for production, utilization, and trade in Third World countries, under a special project partially funded by the International Development Research Centre (IDRC) of Canada.

In addition to the analyses of international data at the global and regional levels, case studies were taken up in six countries: India, Indonesia, the Philippines, and Thailand in Asia and Nigeria and Zaire in Sub-Saharan Africa. Analyses of cassava's situation and prospects in Africa were done at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and those for Latin America at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. The results of these studies were discussed at a workshop in Washington, D.C. in August 1987, where project researchers, selected cassava scientists, and representatives of international organizations participated. The results of the individual case studies are being published separately as a series of working papers. This volume presents the proceedings of the workshop and includes the papers and summaries of the case studies discussed.

J. S. Sarma

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Overview

J. S. Sarma

The International Food Policy Research Institute (IFPRI) sponsored a workshop on "Trends and Prospects of Cassava in the Third World" in Washington, D.C., August 10-12, 1987. Case studies on cassava in India, Indonesia, the Philippines, Thailand, Nigeria, and Zaire were presented.[1] Papers on overall trends and prospects for the crop in 2000 in the Third World, the yield potentials of cassava, and possible constraints to achieving them were also discussed at the workshop. In addition, the regional problems and prospects relating to cassava in Asia (including China), Africa, and Latin America were also reviewed. The workshop and the cassava case studies were funded by the International Development Research Centre (IDRC) of Canada as a special project.

Workshop participants included the supervisors of each of the case studies from the national research institution or university sponsoring that study, cassava scientists and economists from Centro Internacional de Agricultura Tropical (CIAT), International Institute of Tropical Agriculture (IITA), and IFPRI, and representatives from IDRC, the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the U.S. Agency for International Development (USAID). The list of participants, papers, and the agenda are given in an appendix to this chapter.

IMPORTANCE OF CASSAVA

Cassava grows on relatively poor soils, is high yielding in terms of carbohydrate production per hectare, and is thus a source of cheap calories. The crop is often grown by small farmers and is a source of employment in rural areas, particularly for women, in cultivating and on-farm processing of the crop. It is labor-intensive and inexpensive to produce, as few purchased inputs are used. Its adaptability to diverse climatic conditions, ability to survive long dry spells, and flexibility in harvesting time qualify it for treatment as a food security crop. Cassava is an important subsistence crop as well as a source of cash income for poor farmers, and its development also has equity implications. It has large, untapped genetic potential, which could be exploited through adoption of new technology. Cassava with protein supplements can

[1]Six of the country case studies prepared for the workshop are being published by the International Food Policy Research Institute as a series of working papers on cassava.

substitute for coarse grains in livestock feed and thus partly meet the rapidly rising derived demand for feedgrains in developing countries.

CURRENT SITUATION AND TRENDS IN PRODUCTION

Cultivation of cassava is largely confined to the tropics in the developing countries of Asia, Sub-Saharan Africa, and Latin America.[2] The world's annual output of the crop during 1981-83 averaged 125 million metric tons[3] of fresh roots (equivalent to 38 million tons of wheat) from an area of 14 million hectares. Of this output, about 40 percent was from Sub-Saharan Africa, 37 percent from Asia, and the remaining 23 percent from Latin America, where the crop seems to have originated. Average yield per hectare in Sub-Saharan Africa was the lowest at 7.1 tons, and the yield in Asia was highest at 12.2 tons. That in Latin America was 10.9 tons. The overall average yield per hectare was 9.3 tons.

During the period from 1961-63 to 1981-83, the output of cassava increased at a rate of 2.7 percent a year; nearly 70 percent of this growth was from area increase and 30 percent from yield improvement. Production growth in the first half of this period was faster than that in the second half. The increase in cassava output was most rapid in Asia (4.7 percent) because of a dramatic growth in Thailand, stimulated by import demand from the European Community (EC) for use as an ingredient in livestock feed. Cassava output in Sub-Saharan Africa rose 2.3 percent a year, which was less than the population growth, thus leading to a decline in per capita production. In Latin America, the production of cassava increased by only 1.1 percent a year, largely because of the slow growth in demand, which was influenced by government policies in some countries that discriminated against cassava in favor of cereals.

CURRENT SITUATION AND TRENDS IN DOMESTIC UTILIZATION

Nearly 60 percent of the world output of cassava in 1981-83 was used as food in developing countries. Another 28 percent went to livestock feed; nearly one-third was fed in developing countries and the balance, 20 million tons, was exported to the EC. Other uses include industrial products (starch, tapioca, and so forth), which accounted for roughly 4 percent, and an allowance for wastage.

Of the annual average of 106 million tons of cassava used in developing countries in 1981-83, 78 million tons were used as food and 13 million tons were used as feed; the balance represented industrial uses and wastage. Nearly 55 percent of food use was in Sub-Saharan Africa, whereas nearly 80 percent of feed use was in Latin America.

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[2]Data on cassava grown in Sudan, which is in the North Africa/Middle East region, are included in those for Sub-Saharan Africa.

[3]All tons referred to in this proceedings are metric tons.

Domestic utilization of cassava in the Third World countries rose at 2 percent a year between the early 1960s and early 1980s. Food use increased more rapidly at 2.3 percent a year, with regional rates of growth of 3.0 percent in Asia, 2.4 percent in Sub-Saharan Africa, and 1.1 percent in Latin America. The use of cassava for animal feed increased less rapidly at 1.7 percent overall, which was largely influenced by the growth rate in Latin America of 1.3 percent a year.

Third World exports of cassava increased from an average of 1.7 million tons (in fresh roots) annually in 1961-63 to 20.3 million tons in 1981-83. Of the latter, exports from Thailand accounted for 17.6 million tons (equal to about 6.9 million tons of dried cassava pellets) and the rest was shared by China (1.5 million tons) and Indonesia (1.1 million tons). Total imports by other developing countries amounted to about 250,000 tons, resulting in Third World net exports of about 20 million tons.

The workshop noted that although the output of cassava forms only 4 percent of staple food crop production in the Third World, it represents more than 40 percent of its output of roots and tubers. The crop is important for food security in Sub-Saharan Africa, where it is a major staple, and for increasing employment opportunities and improving incomes of the poor in Asia and Latin America. Thus research and development of cassava deserve priority attention.

RELIABILITY OF STATISTICS

A precise assessment of the current situation and past trends in cassava is handicapped by the poor quality of data on the area and production of cassava, particularly in several countries of Sub-Saharan Africa where even the basic agricultural statistics relating to cereals are poor. Thus reliability of the data on roots and tubers is doubtful. National data are not available in many countries and those that are available lack completeness, reliability, timeliness, and comparability over time. Among the principal problems of data collection are the inaccessible nature of the terrain, shifting cultivation, mixed cropping, subsistence levels of cultivation, and so on. The difficulties of gathering data on cassava are severe. Because the crop is in the field for more than 12 months and because it is harvested as needed, it is sometimes difficult to make a distinction between old and new plantings. Part of the crop may have been harvested, while the rest of the crop is still in the ground. Cassava is often planted mixed with other crops, and the allocation of area in these crop combinations poses problems. In some reporting countries, where a modern sector exists side by side with a subsistence sector, national crop survey data often refer to the latter sector only.

The workshop strongly emphasized the need to improve both reliability and timeliness of the statistics on area and production of cassava. It recommended that national governments take serious steps to organize the needed crop surveys in consultation with FAO. It is further noted that, initially, special studies might be necessary in some countries for designing appropriate data collection methods.

The collection of data on the utilization of cassava for various purposes in the developing countries of Asia and Latin America needs to be expanded. Steps should also be taken to obtain detailed data through periodic surveys. Information on adoption of improved varieties and technologies, consumption, and nutrition are needed for research and development of the crop. As a matter of policy, data collection agencies should increase their commitment to give priority to statistics on cassava and its products, particularly in developing countries where the crop has a large potential.

DELPHI SURVEY

The Delphi Survey for the assessment of potential yields of cassava that was conducted in 1985 as part of this study indicated an overall average current yield of cassava of 9.5 tons of fresh roots per hectare on farmers' fields. This figure closely agrees with FAO's estimate of 9.6 tons for the Third World average for 1985. Analyzed by regions, the average survey yields were 9.4 tons per hectare in Asia, 7.1 tons per hectare in Sub-Saharan Africa, and 11.2 tons per hectare in Latin America.

Cassava yields on fertilized fields are generally 5 tons per hectare higher than those without fertilizer. Respondents agreed that without fertilizer, irrigation alone does not result in higher yields. But with both irrigation and fertilizer, average yields are 11.3 tons per hectare on inferior soils. Yield levels are even higher if cassava is cultivated under optimum soil and climatic conditions. The survey also revealed large differences between the actual yields obtained by farmers, the results of on-farm tests, and the levels obtained at research stations.

The potential yields of existing varieties of cassava in 2000 could range from 13 tons per hectare without fertilizer and irrigation to 22 tons with, in farmers' fields. With improved varieties the corresponding range is from 17.8 to 27.7 tons per hectare. The weighted average of the potential yield for all these input categories is 16.2 tons per hectare for existing varieties and 21.3 tons per hectare for improved varieties.

At the existing levels of research expenditure, significantly higher yields, compared with current levels, are expected in 2000, with increments ranging from 5 tons per hectare without fertilizer and irrigation to about 9 tons per hectare with fertilizer and irrigation. With irrigation alone, the increase is insignificant. With a doubling of research resources, which would enable the development of new varieties and improvement of cultural practices, all input categories show significant increases in yield, ranging from 10 tons per hectare without fertilizer and irrigation to about 13 tons per hectare using both of these inputs.

By doubling research resources, increases in cassava yield of about 5 tons per hectare might be achieved even under conditions of no fertilizer or irrigation or with application of fertilizer alone. However, the expected increases in yields are smaller in the case of irrigated cassava without fertilizer and of cassava where both fertilizer and irrigation are used.

With regard to potential yields in 2000 from existing varieties and those in the pipeline at the current level of research, the gap between the group using no fertilizer or irrigation and that using fertilizer alone is significant but not very different from that in 1985. Where both fertilizer and irrigation are used, the gap is significant and more than twice as large by the year 2000. With doubling of research resources, the differences continue to be significant and the gaps widen further. The differences resulting from use of irrigation alone continue to be insignificant.

The above indications are for applications of inputs and resource investment on the poor soil where much of cassava is grown at present. Similar results but at higher levels of yields are shown for cassava grown under optimum soil and climatic conditions.

The analysis of constraints to achieving potential yields highlights lack of incentives, including low prices, as the most important constraint. The low yield potential of existing varieties is ranked next, followed by output marketing, and then storage and processing problems. Diseases rank fifth. At the regional level, in Asia and Latin America, the ranking of constraints follows the overall pattern, whereas in Sub-Saharan Africa, disease problems are given the first rank, followed by low yield potential of existing varieties and lack of incentives.

The workshop discussed the policy implications of the results of the survey. The wide gaps between the average yields on farmers' fields and those from on-farm tests and research stations under the different input categories call for greater efforts to expand extension services, provide input supplies, credit, and incentives such as remunerative prices to farmers to enable them to adopt the improved cultural practices designed to raise yields. Because fertilizer use alone could raise cassava yields by at least 5 tons per hectare, efforts to encourage fertilizer use could increase the output and income of farmers, especially in Latin America and Asia. A doubling of research resources to evolve improved varieties and agronomic practices will boost cassava yields significantly. However, more resources need to be devoted to improving cassava yields on farms where soils are inferior and input use is low. In order to provide incentives to farmers to increase their production, an improvement in the policy environment for cassava, particularly in relation to cereals, is strongly recommended. Government intervention by way of ensuring incentives to farmers for growing cassava may become necessary, especially in view of its importance to food security and to improving the incomes of the poor. The constraint posed by the low yield potential of existing varieties could be overcome through allocation of adequate research resources for developing varieties that will achieve higher yields and resist pests and diseases, particularly in Sub-Saharan Africa. There is a need to assign higher priority to research on postharvest technology and product development at national and international research centers to meet the problems related to marketing, storing, and processing of cassava output.

FACTORS INFLUENCING USE OF CASSAVA FOR FOOD

Apart from growth in population, other factors influencing the demand for cassava for food include income elasticity of demand, degree of urbanization, level of income, prices of cassava and of alternative foods, different forms of processed cassava, and storability and ease of processing.

The overall income elasticity of demand for fresh cassava is positive and moderately large in rural areas, whereas in the urban areas it is small or even negative. Fresh cassava is very income elastic for low-income rural consumers; it is negative only in the highest quintile. For dried cassava in its various forms, the income elasticity is negative in both rural and urban areas.[4] Cassava starch products and convenience foods have a positive elasticity in urban areas, particularly at higher incomes. The overall income elasticity for cassava therefore depends upon the proportions in which different cassava products are consumed in the rural and urban areas. Apart from income, prices of cassava relative to substitute staples influence its consumption. Past evidence shows that consumption of cassava increased in the Philippines and Indonesia when rice prices were high, and cassava consumption declined in Brazil when wheat was subsidized.

FACTORS INFLUENCING OTHER USES OF CASSAVA

The case studies in Asia show that, whereas cassava cannot substitute for coarse grains in livestock feed at the present levels of yield of cassava and relative prices, with higher yields and lower unit costs, scope exists for greater use of cassava in feed mixes for poultry and pig production. The present prices of protein supplements are also not favorable for extensive use in conjunction with cassava. However, with a view to assessing the future role of cassava in meeting the increasing derived demand for livestock feed, a specific objective of the case studies in Asia was to ascertain the levels of yields of cassava and prices at which cassava supplemented by protein could substitute for maize (corn) or sorghum in poultry and pig feed.

Evidence from India shows that the economic price of Rs 360 per ton of cassava (US$28) is a viable price for farmers with yield levels of 26 tons per hectare obtained from HYVs. The Thailand study shows that a price differential of at least 29 percent is needed between the prices of cassava and maize before the former can substitute for the latter in broiler rations. For pig rations, substitution could occur with a price differential of 10.7-32.5 percent. The general rule of thumb followed in the Philippines is that when the cost of 4 kilograms of cassava combined with 1 kilogram of soybean meal is less than the cost of 4 kilograms of maize, then cassava can compete with maize. In Indonesia, at 1983/84 prices, with the price of soybean meal at US$335 per ton (c.i.f. Jakarta), the price of dried cassava must be US$57 per ton lower than that of maize. In 1984, however, the price of cassava chips was US$82 and that of maize was US$114 per ton. But in the Philippines and Indonesia both, economic forces are operating that

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[4]These conclusions are generally based on a number of studies in Asia and Latin America. No hard evidence is yet available for Africa.

would encourage larger use of cassava as feed if infrastructure facilities could be improved.

Apart from its use as an ingredient in feed mixes, dried cassava may also be used in on-farm feeding of livestock, a practice that prevails in several countries in Latin America, though precise data are not available. With regard to industrial use, significant quantities of cassava are used for starch manufacture in Tamil Nadu, India. In the Philippines, contract farming of cassava is developing whereby manufacturing firms enter into contracts with farmers to grow cassava to be converted into starch. Rapid growth in the demand for cassava starch manufacture is also expected in Indonesia as a result of the import-substitution policy. In Nigeria, small-scale manufacture of cassava flour is increasing; some corporate organizations are encouraging cultivation of cassava using modern methods. In general, the demand for industrial use of cassava depends upon product quality and relative prices of the substitutes.

PROJECTIONS TO 2000

If past trends in area and yield per hectare continue into the future, the output of cassava in the developing countries in 2000 is projected at 200-210 million tons depending upon the level of aggregation used. The projected average yield per hectare is 10.5 tons, although potential yields, as indicated by the Delphi Survey, are much higher.

However, if past trends in per capita income continue, the projected demand for cassava for human consumption would be 115 million tons in 2000; this takes into account decreasing per capita consumption in some of the developing countries because of declining income elasticities. If, on the other hand, future demand is estimated at existing per capita consumption levels, it works out to 121 million tons. The total requirement at the end of the century for feed use is about 20 million tons, by extrapolating from past trends. Other uses (requirements for industrial use and allowance for wastage) would total 25 million tons. And if net exports remain constant at 20 million tons, aggregate demand works out to 180-186 million tons. Thus projected output far exceeds projected demand. The potential surplus in 2000 shows that the expected deficits in food staples for direct food use in Sub-Saharan Africa could be partially filled with cassava.

Further, as already noted, cassava case studies in Asia have shown that, if yields per hectare could be improved and the unit costs of production brought down, cassava with protein supplements could substitute for coarse grains in livestock feed. With this change in the feeding pattern, potential also exists for foreign trade of cassava in Asia as well as Latin America. Because of the debt crisis and foreign exchange constraints, some developing countries would like to rely on cassava pellets as an energy source in livestock feed, instead of importing maize or sorghum, if cassava could be produced at economic prices.

CASSAVA AND THE GLOBAL FOOD SITUATION

Although the supply-demand projections indicate that supply response is not much of a problem, stimulation of demand is a problem. The scope exists, but policy options need to be adapted for developing alternative uses for cassava in livestock feed, convenience foods, and industrial raw materials, apart from its important role in food security in Sub-Saharan Africa.

Earlier IFPRI research has shown that rapid growth in the demand for livestock feed in developing countries is likely with rising per capita incomes, although the situation differs from region to region. Even at present, the proportion of major food crops that are used for feed is only about 15 percent in Asia. In Latin America, it has risen to about 40 percent, and at this already high level of feed utilization, rates of growth of feed use are slower. In North Africa/ Middle East, more than 25 percent of basic staples are used for feed. The proportion is less than 10 percent in Sub-Saharan Africa, where the focus is more on food.

As has been mentioned, cassava is of particular importance in Sub-Saharan Africa because it is a major food staple in the region. Cassava has served as a shock absorber in the face of an extremely poor food production performance in Sub-Saharan Africa during the past two decades. Food production grew at a rate of only 1.7 percent a year, while population grew at about 3 percent and is still rising. The difference between these growth rates tells the seriousness of the food problem in Africa.

In relating cassava development to national goals, how much emphasis a country puts on cassava will depend on how it balances its equity and efficiency objectives. If the country is more concerned with efficiency, then less attention will be paid to the equity aspect. Concern arises because in the current world food situation, the developed countries are battling problems of food surplus while the developing countries are tackling problems of deficit, and it is difficult to reconcile the two. A closer look at the world food problem, however, suggests that it is probably the lack of purchasing power in the developing countries that prevents them from absorbing the available food surpluses of the developed economies. It is here that a potential role can be found for cassava in providing employment and incomes for the poor in developing countries. The policy implications related to development of cassava are significant insofar as donors are concerned, particularly the Consultative Group on International Agricultural Research (CGIAR), whose mandate is to address the food problems of the poor in developing countries. If cassava can be properly included in development plans, based on the equity criterion, it can provide employment and income opportunities for many of the poor, as shown in Thailand and Colombia. The major problem, however, is to increase cassava demand.

The workshop recognized the role of cassava in providing employment opportunities, thus helping to increase incomes that could, in turn, generate increased demand in developing countries. As incomes increase in many of these countries, it is likely that consumption patterns may shift toward more consumption of livestock and poultry products, thus creating a derived demand for feed that can make use of cassava or surplus grains available in world markets.

The participants recognized that a principal objective of cassava development should be the contribution that the crop can make to the welfare of the poorest sectors of the population.

Because of the inherent characteristics of the crop, its development could be a catalyst of growth in rural areas. But for this objective to be achieved, the efforts to increase production should be matched by research and development efforts in the areas of postharvest technology and marketing. Such a focus would allow small producers to benefit from the biological efficiency of the crop.

A question was raised about the need to evaluate cassava's potential in the drier areas of Sub-Saharan Africa, which suffer from recurrent food shortages. Its role as a famine crop is already well recognized, as it can withstand drought better than many of the other food crops. For this reason, there is a basic stability in yields per hectare in these areas.

Policy interventions are likely to be required if cassava is to be an effective instrument for development. In the research area, policies should reflect the importance of postharvest processing and market development, as well as the formulation of appropriate development strategies for small farmers in marginal areas. Agricultural extension and credit services also need to be extended to cassava cultivation.

POLICY ISSUES IN ASIA

Policy objectives of cassava development in Asia differ widely from country to country. In Thailand, for example, although the stimulus for the extension of cassava cultivation came from the export demand for its use as a livestock feed ingredient, the crop is grown in areas that are politically sensitive and where farmers are economically poor. The Thai government is interested in maintaining the incomes of the poor, and proposals for crop diversification in these areas have not been very successful. Any technological breakthrough in cassava that resulted in the improvement of crop yield could make the crop competitive with maize. In light of recent developments in Thailand's cassava trade with the EC, policies to deal with declining foreign exchange earnings from cassava need to be evolved.

Cassava has played two different roles in India: in Kerala, its importance is basically as a security food, whereas in Tamil Nadu, cassava provides the raw material for a processing industry. In Indonesia, the crop played a food security role in the past preventing famine and undue rises in food prices. More recently, with the rapid growth of rice output, its use as a convenience food has increased. In the wake of the success of Thai exports of cassava pellets to Europe, Indonesia also went into cassava exports, but actual exports have been below the quota levels. Poor infrastructure has constrained the development of a cassava market for use in feed manufacture and exports. The area under cassava has been declining, and whatever area expansion had taken place has occurred in areas with poor communications and high transport costs. The cassava situation in the Philippines is similar to that in Indonesia, but its importance to food security is relatively less. The main policy objective in the Philippines is to raise the incomes of low-income farmers but, as in Indonesia, the infrastructure constraint is overwhelming. Cassava's importance in China can be viewed from the angle of resource utilization, although China also exports some cassava to Europe and thus earns foreign exchange from the commodity.

The Asian case studies have shown that there is a potential demand for the use of cassava as a feed ingredient and as a raw material for industry. For its expansion as a feed, supplementation by protein sources is necessary, and for widening its industrial use, more attention to product quality and technology of production is important. In both cases, infrastructure facilities need to be developed for moving the raw material from the producing areas to the manufacturing centers. Cassava markets are often fragmented over space and are not integrated with the feed industry markets. The market integration of these two commodities is needed so that price responsiveness of the compound feed industry is transmitted to the cassava industry and vice versa. Policies that enhance the adoption of improved technology in the processing area also help improve quality.

In areas where cassava is important for food security, it is necessary to take steps to promote its production, through increased yields per hectare achieved by improved varieties and associated agronomic practices. And in countries where the crop is grown in economically poor areas, the development of cassava needs to be promoted as an engine of growth for rural employment and incomes.

POLICY ISSUES IN AFRICA

Cassava is a major staple in the humid and subhumid areas of West and Central Africa. It is an important famine relief crop contributing to food security in the savannah or drier areas of western, eastern, and southern Africa. There are, however, regional and country peculiarities, even in its food uses: both roots and leaves are of major nutritional importance in Zaire, Sierra Leone, and Liberia, whereas in Nigeria and Ghana, cassava is grown mainly for its roots.

Considerable progress has been made in the development of improved cassava varieties and in the elimination of a range of constraints relating to losses due to pests and diseases in Africa. The problems still requiring attention relate to development of technologies for improved soil management, pest control, minimization of labor problems during the production phase, and gender issues that have been neglected in the past. Special attention should be given to the development of improved and more efficient systems for cassava production in various cropping patterns, including rotations, and in emerging agro-forestry systems such as alley cropping. Choices of various commodity characteristics and production systems of cassava should be determined in such a way as to minimize problems in the postharvest phase and utilization of the crop. Input supplies and efficient extension services need to be effectively linked with research and development. With the relatively abundant land in much of Sub-Saharan Africa, expansion of area is the main way of increasing production. Fertilizer use may be limited; hence future research should give greater priority to improved cropping patterns that would improve efficiency in the use of fertilizers.

Greater priority should be given to the development of postharvest technologies, especially those for processing, storing, drying, packaging, and marketing. As mentioned earlier, the trend figures show that with rising per capita incomes, the consumption of cassava declines. Such a decline could be arrested or even reversed if there were postharvest technologies enabling the product to meet the demands of increasingly urban and affluent segments of the population.

There are a number of other issues related to postharvest phases of processing and utilization of cassava that need attention. There is a need to link research in postharvest technology with the development of pilot plants and commercialization of products. Ways of reducing and using waste in cassava processing also should be studied. More studies should be conducted on the competition between commodities. The nutritional effects of different commodity mixes and various products at varying levels of cassava dependency in different geographical and socioeconomic strata should be examined. Cassava flour is already being substituted in different proportions for cereals in bread, and the scope for such substitution in other foodstuffs should be investigated.

The international agricultural research centers, national agricultural research institutes, and universities should pool resources to give greater priority to research on the postharvest phase in such a way that their activities complement each other. Such collaboration should extend to the sharing of information on food processing and on the range of opportunities for cassava utilization.

General policy issues, such as the various nutritional interventions, price control, and self-sufficiency in food production, should be kept continuously under review, in so far as they affect cassava production and utilization. Other problems that need to be addressed include investments in the postharvest phase of production, marketing and distribution of cassava products, labor loads that women carry, increasing relevance of legislation, and implementation of monitoring measures to ensure quality control. It was also noted that in view of the current debt problems in many of the African countries, continuing reliance on high levels of imports of various commodities may not be possible.

The cultivation of cassava has the potential not only to increase the incomes of small farmers but also to ensure more stable incomes, which is particularly important to the lower income groups. Cassava can help achieve this objective because of its basic stability in production. Furthermore, employment in the processing of cassava at the village level has the effect of diversifying sources of income particularly for women.

The commodity characteristics of cassava used for food are different from those for industrial use. The former is often of higher quality and hence commands a higher price, whereas cassava for industrial purposes is of lower quality and lower price. In processing, traditional methods reduce the quality of cassava products; sun-dried cassava chips, for example, may contain a lot of sand and other impurities. Unless the quality of the raw material is good, product quality will be poor with adverse effects on its price and marketability.

APPENDIX

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Workshop on Trends and Prospects of Cassava in the Third World
August 10-12, 1987

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AGENDA

August 10

9:00 - 9:30	I. Opening Session Chairman: Leonardo Paulino Acting Director, IFPRI
	Opening Statement: Leonardo Paulino
9:30 - 10:20	Tea/coffee
	II. Cassava in Asia Chairman: Delane Welsch
	Cassava case study - Thailand
10:00 - 10:20	Presentation by Chaiwat Konjing
10:00 - 11:00	Discussion
	Cassava case study - India
11:00 - 11:20	Presentation by P. S. George
11:20 - 12:00	Discussion
12:00 - 1:30	Lunch
	Cassava case study - Indonesia
1:30 - 1:50	Presentation by Faisal Kasryno
1:50 - 2:30	Discussion
	Cassava case study - Philippines
2:30 - 2:50	Presentation by L. S. Cabanilla
2:50 - 3:30	Discussion
3:30 - 3:45	Tea/coffee
	Prospects for cassava in China
3:45 - 4:00	Presentation by Bruce Stone
4:00 - 4:30	Discussion
4:30 - 5:15	Policy issues arising out of Asian case studies
5:30 - 6:30	Reception at IFPRI

August 11

	III. Cassava in Africa Chairman: B. N. Okigbo
	Cassava case study - Nigeria
9:00 - 9:20	Presentation by S. O. Adamu
9:20 - 10:00	Discussion
10:00 - 10:15	Tea/coffee
	Cassava case study - Zaire
10:15 - 10:35	Presentation by Kamanda Lumpungu
10:35 - 11:15	Discussion
	Economics of cassava in Africa - An Overview
11:15 - 11:35	Presentation by Paul Dorosh
11:35 - 12:15	Discussion
12:15 - 1:00	Policy issues arising out of African case studies
1:00 - 2:30	Lunch
	IV. Cassava in Latin America Chairman: James H. Cock
	Evaluation of food demand for cassava in Latin America
2:30 - 2:50	Presentation by John Lynam
2:50 - 3:30	Discussion
3:30 - 3:45	Tea/coffee
	The potential of cassava as animal feed in Latin America
3:45 - 4:05	Presentation by John Lynam
4:05 - 4:45	Discussion
4:45 - 5:30	Policy issues arising out of Latin American studies

August 12

	V. Trends and prospects for cassava in the Third World Chairman: Leonardo Paulino
	Trends and Prospects for cassava in the Third World
9:00 - 9:20	Presentation by J. S. Sarma
9:20 - 10:00	Discussion
	Delphi survey for the assessment of potential yields of cassava
10:00 - 10:20	Presentation by J. S. Sarma
10:20 - 11:00	Discussion
11:00 - 11:10	Tea/coffee
	VI. Closing session Chairman: Leonardo Paulino
11:10 - 12:00	Presentation of policy issues arising in Sessions II to V by the respective chairmen
12:00 - 12:50	Discussion on the policy issues
12:50 - 1:00	Closing remarks by chairman
1:00 - 2:00	Lunch

LIST OF PAPERS

1. Analysis of Trends and Prospects for Cassava in Thailand,
   Chaiwat Konjing

2. Cassava Production and Utilization in India,
   P. S. George

3. Analysis of Trends and Prospects for Cassava in Indonesia,
   Faisal Kasryno

4. Trends and Prospects for Cassava in the Philippines,
   Liborio Cabanilla

5. Dynamic Characteristics of Supply and Demand for Cassava in China,
   (Handout material)
   Bruce Stone

6. Trends and Prospects for Cassava in Nigeria,
   S. O. Adamu

7. Excerpts from the Report on the Cassava Case Study in Zaire,
   Kamanda Lumpungu

8. Economics of Cassava in Africa - An Overview,
   Paul Dorosh

9. Cassava Consumption in Evolution in Latin America: Staple or Vegetable?,
   John Lynam

10. The Meat of the Matter: Cassava's Potential as a Feed Source in Tropical Latin America,
    John Lynam

11. Trends and Prospects for Cassava in the Third World,
    J. S. Sarma and Darunee Kunchai

12. Delphi Survey for the Assessment of Potential Yields of Cassava,
    J. S. Sarma, Vasant Gandhi, and Darunee Kunchai

2
Trends and Prospects for Cassava in the Third World

J. S. Sarma and Darunee Kunchai

WORLD OUTPUT

World average annual output of cassava during 1981-83 was 126 million metric tons, equivalent to 38 million tons of wheat.[1] This formed about 2 percent of world staple food crop production and nearly 29 percent of the output of roots and tuber crops. Cassava was grown on 14 million hectares out of the 47 million hectares of land devoted to roots and tubers in the world. The entire cassava-growing area is in the developing countries and confined largely to Sub-Saharan Africa, Asia, and Latin America, as shown in Table 1.[2]

Table 1--Distribution of area, production, and yield per hectare of cassava (average 1981-83)

Region	Area	Production[a]	Yield/ hectare[a]
	(million hectares)	(million metric tons)	(metric tons)
Asia	3.8	46.5	12.2
Sub-Saharan Africa[b]	7.0	50.1	7.1
Latin America	2.7	29.5	10.9
Total	13.5	126.1	9.3

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.

Note: Excludes small island states, the aggregate production of which is reported to be 135,000 metric tons.

[a]In fresh roots.

[b]Cassava is also grown to a small extent (45,000 hectares) in Sudan, but this figure is included under the Sub-Saharan region in the rest of the paper.

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[1]Cassava is converted to wheat on the basis of calorie content.

[2]The output increased to 136.5 million tons in 1985. The data given in the table refer to the average for 1981-83, which is the period for which data on domestic utilization were available for all the study countries at the time of this analysis.

About 40 percent of the Third World production of cassava was from Sub-Saharan Africa, followed by 37 percent from Asia, and the remaining 23 percent from Latin America. The area under cassava in Sub-Saharan Africa was a little more than half of the Third World total, but the yield per hectare in that region was 60 percent of that in Asia and was the lowest among the three regions. The overall yield per hectare of cassava was 9.3 tons.

WORLD UTILIZATION

Nearly 60 percent of the world production of cassava during 1981-83 was used as food in the developing countries (Table 2). Another 28 percent was used as feed, of which nearly two-thirds was exported to the developed countries, where it was used as an ingredient of compound feed mixtures. These developed countries--mostly in the European Community (EC)--import cassava in the form of dried pellets or chips from Asia. Other uses include industrial purposes, roughly 4 percent, and an allowance for wastage. Less than 1 percent was used for the manufacture of ethyl alcohol, mostly in Brazil.

Table 2--Distribution of utilization of cassava, average 1981-83

Utilization	Developing Countries[a]	Developed Countries	Total
	(million metric tons)		
Food	74.9	nil	74.9
Feed	12.8	22.1	34.9
Other uses including allowance for wastage	18.3	0.4	18.7
Net export	+20.1[b]	-22.5	-2.4[c]
Total output	126.1	...	126.1

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.
Note: In fresh root equivalents.

[a]Data relate to 69 study countries.
[b]Includes exports of 416,000 metric tons to noncassava producing developing countries, such as the Republic of Korea and Hong Kong.
[c]Represents the difference between total exports and total imports and is treated as a statistical discrepancy.

Developing countries exported nearly 20.3 million tons of cassava in fresh root equivalents on average during 1981-83, of which 17.6 million tons were from Thailand. The imports into these countries from other developing countries were about 0.25 million tons. Thus the net exports were 20 million tons.

DATA

The analysis of the current situation and trends in area, production, and utilization of cassava is based on the data base of the Food and Agriculture Organization of the United Nations (FAO). For purposes of this analysis, the developing countries are divided into 14 subregions as indicated in Table 3.

Table 3--Classification of cassava-growing countries into subregions

Region/Subregion	Countries
Asia	
South Asia	Burma, India, Sri Lanka
China	China
Indochina and Pacific Islands	Fiji, Kampuchea, Laos, Papua New Guinea, Vietnam
Thailand	Thailand
Asean Countries (excluding Thailand)	Indonesia, Malaysia, Philippines, Singapore
Sub-Saharan Africa	
Semiarid tropics	Burkina Faso, Chad, Gambia, Mali, Niger, Senegal, Somalia, Sudan
Humid lowland and coastal tropics	Angola, Benin, Cameroon, Ghana, Guinea, Cote d'Ivoire, Liberia, Madagascar, Mauritius, Mozambique, Nigeria, Sierra Leone, Togo
Equatorial wet tropics	Central African Republic, Congo, Gabon, Zaire
Modified tropics	Burundi, Kenya, Malawi, Reunion, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe
Latin America	
Seasonally dry tropics	Colombia, Ecuador, Venezuela
Subtropics	Argentina, Paraguay
Wet tropics	Bolivia, Peru, Surinam
Brazil	Brazil
Mexico, Central America, and Caribbean	Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago

DISTRIBUTION OF OUTPUT

Out of the 69 countries in the three regions included in the study, 5 countries, namely Brazil (19 percent), Thailand (14 percent), Zaire (11 percent), Indonesia (10 percent), and Nigeria (9 percent), share nearly 63 percent of total cassava production in 1981-83. In each of these countries cassava production exceeded 10 million tons a year.

Estimates of area, production, and yield per hectare of cassava by subregions are given in Table 4. In Asia, the Asean subregion, excluding Thailand, produced about 15 million tons of cassava on an average during 1981-83. India which is included in the South Asia subregion produced 5.5 million tons out of the subregional total of 6.2 million tons. Cassava yields in South Asia, Thailand, and China exceeded 15 tons per hectare. Yields in the Indochina and Pacific Islands subregion were the lowest in Asia.

Table 4--Area, production, and yield per hectare of cassava in Third World countries, by subregions, 1981-83 average

Region/Subregion	Area	Production	Yield/Hectare[a]
	(million hectares)	(million meteric tons)	(metric tons)
Asia	3.81	44.46	12.18
South Asia	0.38	6.17	16.33
China	0.24	3.63	15.46
Indochina and Pacific Islands	0.52	3.20	6.20
Thailand	1.12	18.17	16.28
Asean (excluding Thailand)	1.57	15.29	9.75
Sub-Saharan Africa	7.03	50.11	7.13
Semiarid tropics	0.16	0.72	4.49
Humid lowland and coastal tropics	3.37	23.11	6.85
Equatorial wet tropics	2.45	15.77	6.43
Modified tropics	1.04	10.52	10.10
Latin America	2.70	29.48	10.94
Seasonally dry tropics	0.26	2.42	9.38
Subtropics	0.16	2.26	14.05
Wet tropics	0.05	0.56	11.08
Brazil	2.07	23.39	11.29
Mexico, Central America, and Caribbean	0.15	0.85	5.48
Developing countries	13.54	124.05	9.31

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.

[a] In fresh roots.

In Sub-Saharan Africa, area under cassava in the semiarid tropics subregion was relatively small. The bulk of the cassava in this region is grown in the humid lowland and coastal tropics and in the equatorial wet tropics. The yield per hectare in the modified tropics was relatively high at about 10 tons compared with the average for Sub-Saharan Africa as a region.

In Latin America, apart from Brazil, the seasonally dry tropics and subtropics subregions shared nearly 5 million tons of cassava output during 1981-83. Yield per hectare in the subtropics of South America was high at 14 tons, whereas in the other two subregions the yields were around 11 tons or about the same as the regional average.

TRENDS IN CASSAVA PRODUCTION

Figure 1 shows the annual area and production and Figure 2 the yield per hectare of cassava in developing countries from 1961 to 1983.

Figure 1--Area and production of cassava in developing countries, 1961-83

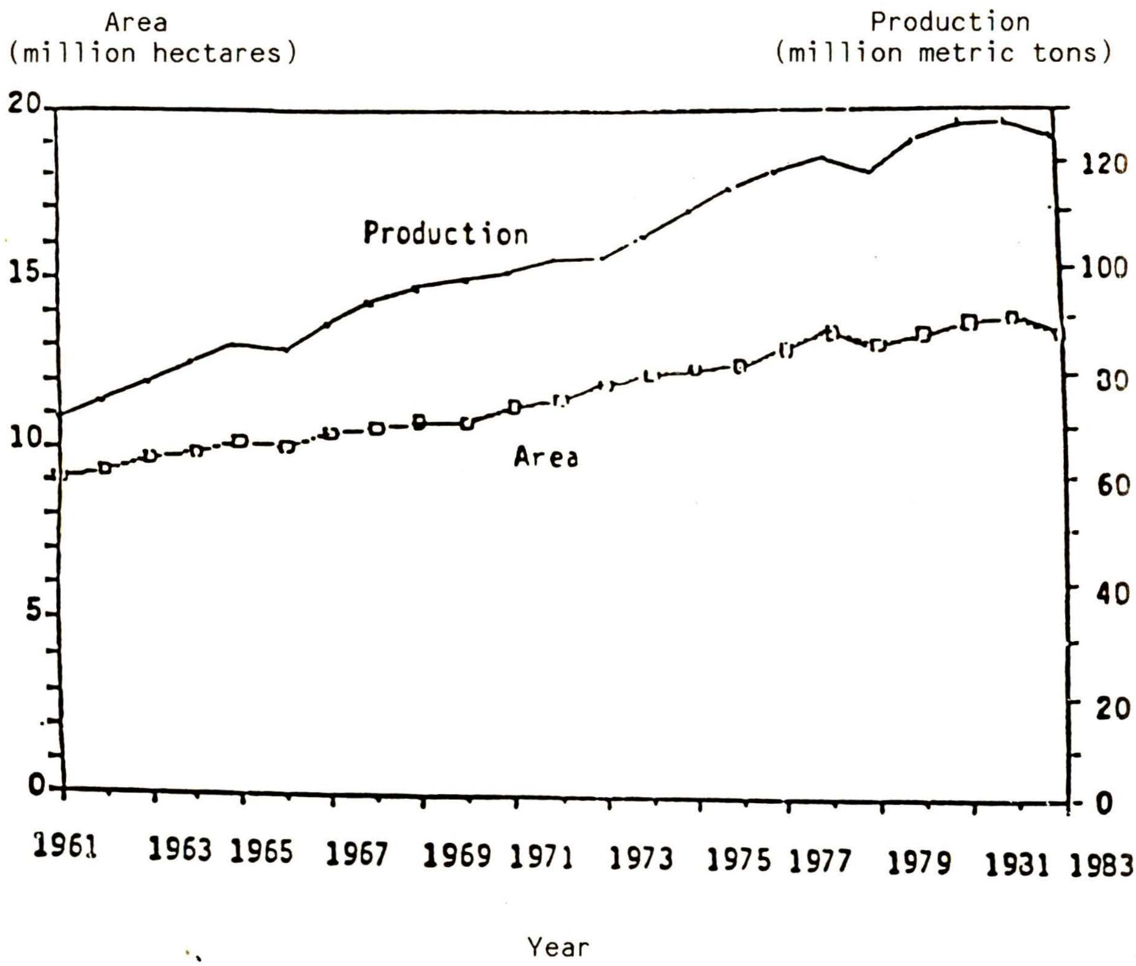
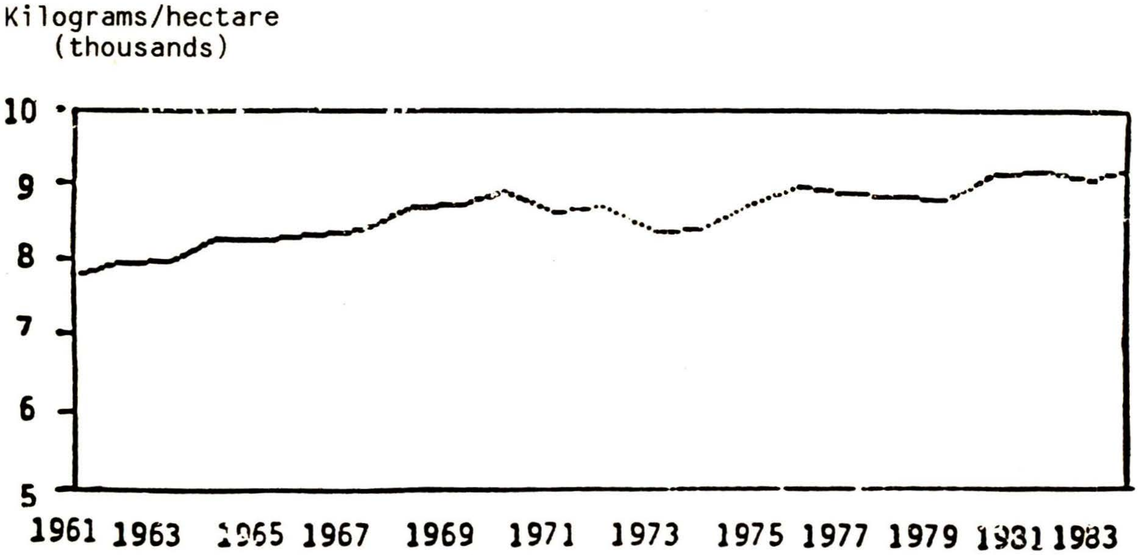


Figure 2--Yield per hectare of cassava in developing countries, 1961-83



The average yearly output of cassava increased from 74.0 million tons of fresh roots in 1961-63 to 126.1 million tons in 1981-83, or at an average rate of 2.7 percent a year. During the same period, the area sown with the crop increased from 9.4 to 13.5 million hectares, or at an average rate of 1.9 percent a year. This implies an improvement in the yield per hectare from 7.9 tons in 1961-63 to 9.3 tons in 1981-83, or an average growth of 0.8 percent a year.

Of the increase of 52 million tons in the annual cassava output of developing countries during the two decades, 28 million tons came from Asia, 18 million tons from Sub-Saharan Africa, and about 6 million tons from Latin America. The largest single contribution to the output increase came from Thailand where average yearly output rose from about 2 million tons in the early 1960s to 18 million tons in the early 1980s. Nearly half of the increase in area came from Sub-Saharan Africa where the cultivation of cassava expanded, as it was the main staple food in some of the subregions. But because the yields per hectare were low, its contribution to increased output was much lower. For the Third World countries as a whole, increase in area contributed 70 percent to the growth of output, while improved yields contributed only 30 percent.

Table 5 gives the growth rates in area, production, and yield per hectare of cassava by regions and by subperiods 1961-63 to 1971-73 and 1971-73 to 1981-83, as well as the overall growth rates between the early 1960s and the early 1980s. It is evident from this table that, for the Third World countries as a whole, the growth rates in all the indicators decelerated during the 1970s compared with the 1960s by about a fifth in each case.

Table 5--Area, production, and yield per hectare of cassava in Third World countries, by region, 1981-83 average, and growth rates

Region	Average, 1981-83	Average Annual Growth Rate 1961-63 to 1971-73	1971-73 to 1981-83	1961-63 to 1981-83
		(percent/year)		
Asia				
Area (million hectares)	3.81	1.41	3.78	2.59
Production (million metric tons)	46.46	3.14	6.32	4.71
Yield (tons/hectare)	12.18	1.70	2.45	2.07
Sub-Saharan Africa				
Area (million hectares)	7.03	1.81	1.36	1.58
Production (million metric tons)	50.11	2.33	2.26	2.29
Yield (tons/hectare)	7.13	0.51	0.89	0.70
Latin America				
Area (million hectares)	2.70	3.45	-0.08	1.67
Production (million metric tons)	29.48	3.81	-1.55	1.09
Yield (tons/hectare)	10.94	0.35	-1.48	-0.57
Developing countries				
Area (million hectares)	13.54	2.07	1.65	1.86
Production (million metric tons)	126.05	3.02	2.37	2.70
Yield (tons/hectare)	9.31	0.93	0.70	0.82

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.

In Asia, however, the area under cassava rose two-and-a-half times faster in the 1970s compared with the 1960s, largely because of the rapid increase in Thailand. Output expanded at 6.3 percent a year in the 1970s, which was nearly twice the growth rate in the 1960s. Yields expanded rapidly in the 1960s in India as a result of the introduction of new varieties. The Philippines reported rapid increases in yields in the 1970s.

The causes that led to rapid expansion of cassava area and output in Thailand are well known. When the Common Agricultural Policy was introduced in the EC, the favorable tariff binding that cassava received through GATT negotiations in 1968 and high relative prices of maize in the EC countries caused the demand for cassava for use as cattle feed to increase rapidly. Thailand responded to this demand by increasing the area and production of cassava. It exported dried chips in the mid-1960s, "native" pellets toward the end of the 1960s, and hard pellets early in the 1980s. Other conditions were also favorable for the expansion of cassava cultivation in Thailand. Subsequently, however, the government of Thailand entered into a Voluntary Agreement with the EC restricting the exports to prefixed quotas on a sliding scale. This put a limit on further expansion of cassava output in the country. In the case of Indonesia, the output of cassava expanded rapidly in the 1970s, mainly as a result of rising yields, although the area under cassava was stagnant or slightly declining.

FAO estimates of output of cassava in China show an increase from less than 1.0 million tons in the early 1960s to 3.6 million tons in the early 1980s. Average yields rose from 11.6 tons to 15.5 tons per hectare over the same period. Cassava production in the Indochina and Pacific Islands also increased but mainly as a result of an increase in area.

In Sub-Saharan Africa, output increased about 2 percent a year in both the humid lowland and coastal tropics and the equatorial wet tropics. In the former subregion, Nigeria was the main country that influenced the growth rate. In the equatorial wet tropics, Zaire was the principal country; the output of cassava rose 50 percent, from 8.9 million tons in 1961-63 to 14.0 million tons in 1981-83. Most of the increase in production in Zaire is constituted by area increase. Yield levels remained between 6.5 and 7.0 tons per hectare during the two decades. In the modified tropics, Tanzania, and Uganda are the principal cassava-growing countries. In Uganda, production of cassava trebled from 1.1 million tons to 3.4 million tons, largely through increased yields per hectare. In Tanzania, area under cassava is reported to have declined in 1981-83, compared with 1961-63, but yield per hectare in 1981-83, at 12.1 tons per hectare, was nearly two-and-one-half times the yield in 1961-63. It is not clear to what extent these differences are due to data reporting problems.

In Brazil, area under cassava increased from 1.5 million hectares in the early 1960s to 2.0 million hectares in the early 1970s; it stayed more or less stagnant at this level in the early 1980s. The yield per hectare increased marginally to 13.9 tons per hectare by 1971-73 but declined to 11.3 tons in the next decade. Consequently output, which reached 29 million tons during 1971-73, declined to 23.4 million tons partly because of declining relative profitability of the crop and partly because of decreasing overall demand for it.

Both in the seasonally dry tropics and the subtropics, the output of cassava increased at an annual rate of 3 percent a year over the reference period. In the latter subregion the increase was mostly due to expansion in area, whereas in the former, improvement in yield per hectare contributed equally to increased production.

DOMESTIC UTILIZATION OF CASSAVA

Out of an average production of 126 million tons of cassava, expressed in terms of fresh roots, 20 million tons were exported to developed countries, leaving a total domestic utilization of 106 million tons during 1981-83 in the 69 Third World countries included in this study (see Table 6). About 70 percent of this amount was used as food, 12 percent as feed, 5 percent in industry, and the balance represented wastage.

Table 6--Domestic utilization of cassava in Third World countries, 1981-83 average

Region/ Subregion	Food Use	Feed Use	Other Uses Including Waste	Total Availability[a]
	(million metric tons)			
Asia	21.10	1.38	4.00	26.48
South Asia	5.59	...	0.56	6.15
China	1.59	0.66	0.06	2.31
Indochina and Pacific Islands	2.71	0.30	0.18	3.19
Thailand	0.61	...	...	...
Asean (excluding Thailand)	10.59	0.42	3.20	14.21
Sub-Saharan Africa	41.27	0.98	7.82	50.07
Semiarid tropics	0.64	0.01	0.06	0.71
Humid lowland and coastal tropics	19.16	0.58	3.22	22.96
Equatorial wet tropics	12.66	0.10	2.92	15.68
Modified tropics	8.81	0.28	1.62	10.71
Latin America	12.56	10.41	6.52	29.49
Seasonally dry tropics	1.49	0.57	0.40	2.46
Subtropics	0.62	1.41	0.23	2.26
Wet tropics	0.43	0.06	0.07	0.56
Brazil	9.45	8.27	5.67	23.39
Mexico, Central America, and the Caribbean	0.57	0.10	0.16	0.83
Developing countries	74.93	12.77	18.34	106.04

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.

Notes: Cassava is expressed in fresh root equivalents. The ellipses indicate a nil or negligible amount.

[a]Total availability is production minus net trade and change in stocks.

A little less than 50 percent of the total domestic utilization was in Sub-Saharan Africa, and the remaining was distributed between Asia and Latin America. Of the 50 million tons of cassava used in Sub-Saharan Africa, 41 million tons were used for food. Feed use was less than 1 million tons. In Latin America, food use was about 12.6 million tons or nearly 43 percent, while feed use was next at 10.4 million tons. In Asia, 80 percent of domestic utilization was for food. Feed use was small at about 1.4 million tons.

Cassava is consumed as food in a variety of forms; it may be cooked fresh and eaten or consumed processed, mainly as flours and meals, which are known by different names in different countries. The total food use, converted into fresh root equivalents, was 75 million tons, of which 41 million tons were consumed in Africa (55 percent) and 21 million tons in Asia (28 percent). Eighty percent of feed use of cassava was in Latin America, mostly in Brazil. Of the 18.3 million tons reported for other uses, 7.8 million tons were used in Sub-Saharan Africa, and largely represent an allowance for wastage. The 6.5 million tons reported under this category in Latin America included 2.5 million tons in industrial use for starch and gasahol, while the rest was wastage.

The average per capita consumption of cassava as food during 1981-83 works out to 29 kilograms per year for the study countries as a whole. Within the regions, there were considerable differences. The average consumption in Sub-Saharan Africa was 125 kilograms, in Latin America, 32 kilograms, and in Asia nearly 10 kilograms. The Asian average was low because in India and China, cassava cultivation and its direct consumption as a food staple are confined to limited areas. A better idea of per capita consumption can be obtained from the following frequency distribution of the countries with specified levels of per capita cassava consumption in terms of fresh roots (Table 7).

Table 7--Distribution of per capita consumption of cassava in the Third World countries, 1981-83 average

Average Per Capita Consumption	Number of Countries
(kilograms)	
Less than 10	23
10-49	24
50-99	5
100-199	10
200 and above	7
Total	69

Source: Derived from Food and Agriculture Organization of the United Nations "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.

Sixteen out of the 17 countries with per capita consumption of 100 kilograms and more are in Sub-Saharan Africa. The highest per capita consumption of cassava is reported in Zaire--about 400 kilograms a year.

TRENDS IN DOMESTIC UTILIZATION

Total domestic utilization of cassava in Third World countries rose about 2 percent a year between the early 1960s and the early 1980s; the growth in the first half of the period was faster than that in the second half. This can be attributed to the trends in Latin America, where food and feed uses of cassava declined in absolute terms during the second half of the reference period. But, even in that region, the domestic use rose very rapidly between the early 1960s and 1970s, and consequently the overall growth between 1961-63 and 1981-83 was positive though small at 1.1 percent a year (see Table 8). Domestic use of cassava for food and feed rose rapidly in Asia, particularly in the 1970s. In Sub-Saharan Africa, the total domestic use, as well as food use, rose at 2.4 percent a year, which is less than the population growth. Hence the per capita consumption declined in this region.

The growth rate in feed use of cassava in Asia was rapid, though the base was low. In all three regions, feed use grew more rapidly than food use, but for the Third World as a whole, the growth rate in feed use was about 70 percent of that of food use. A growth rate of more than 10 percent a year in feed use in Sub-Saharan Africa in the 1960s seems to be a statistical discrepancy. In the modified tropics subregion, feed use of cassava, which was reported at 15,000 tons in 1961-63, rose to 870,000 tons in 1971-73 but declined to 278,000 tons in 1981-83. This re-emphasizes the difficulty of trend analysis with a poor data base.

NET TRADE

As mentioned earlier, the average annual net exports of cassava from developing countries were about 20 million tons in fresh root equivalents during 1981-83. Exports were 20.3 million tons, out of which Thailand alone exported 17.6 million tons. The two other major exporters were China (1.5 million tons) and Indonesia (1.1 million tons). Indonesia, like Thailand, exported dried cassava for livestock feed. Also, Malaysia reported exports of 29,000 tons. Exports of cassava from Latin America were 48,000 tons, and those from Sub-Saharan Africa amounted to 36,500 tons in fresh root equivalents.

Imports of cassava into the study countries totaled 250,000 tons a year during the reference period. Indonesia (160,000 tons), Singapore (65,000 tons), and Malaysia (19,000 tons) account for the bulk of these imports. In addition noncassava-producing countries, mainly the Republic of Korea and Hong Kong, also imported cassava from other developing countries. The average imports of cassava into developed countries during 1981-83 were 22.8 million tons, the difference between net exports of developing countries and net imports of developed countries can be attributed to statistical

Table 8--Domestic utilization of cassava in Third World countries, 1983-85 (average)

Country Group	Food Use	Feed Use	Other Uses Including Waste	Total Domestic Utilization[a]
	(million metric tons)			
Asia	22.16	1.45	3.32	26.92
South Asia	5.76	...	0.58	6.34
China	1.47	0.75	0.11	2.32
Indochina and Pacific Islands	2.72	0.30	0.18	3.20
Thailand	0.64	...	...	0.64
Asean (excluding Thailand)	11.57	0.40	2.45	14.42
Sub-Saharan Africa	43.34	1.14	9.27	53.75
Semiarid tropics	0.69	0.01	0.06	0.77
Humid and lowland coastal tropics	20.20	0.65	4.46	25.31
Equatorial wet tropics	13.47	0.17	3.13	16.76
Modified tropics	8.98	0.31	1.62	10.90
Latin America	12.20	9.97	6.01	28.18
Seasonally dry tropics (South America)	1.39	0.29	0.33	2.01
Subtropics (South America)	0.64	1.71	0.28	2.63
Wet tropics (South America)	0.47	0.08	0.08	0.63
Brazil	9.08	7.79	5.19	22.05
Mexico, Central America, and the Caribbean	0.61	0.10	0.15	0.85
69 study countries	77.69	12.56	18.60	108.85

Source: Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986; and Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," Rome, 1987 (computer printout).

Notes: Cassava is expressed in terms of fresh root equivalent.
Parts may not add to totals due to rounding.
Ellipses indicate a negligible amount.

[a]Total domestic utilization is production minus net trade and change in stocks.

discrepancy. The principal importers are the Netherlands (7.6 million tons), Federal Republic of Germany (7.0 million tons), and Belgium and Luxembourg (3.3 million tons). France and the United Kingdom imported less than 2 million tons each.

PROJECTIONS TO 2000

To obtain projections of output of cassava in 2000, the annual data on country area and production of cassava during the period 1961 to 1983 were each aggregated for a subregion, and the subregional yield was calculated. The semilogarithmic trend growth rates were then computed separately for area and yield for each subregion. These trends were extrapolated to 2000. The projected area and yield per hectare thus obtained were multiplied for each subregion to obtain the projected output in 2000. In the case of Thailand, where the past growth in area was rapid, the future growth of cassava area was constrained to 1 percent a year. In other subregions, where the growth rates in area or yield per hectare were negative, it was assumed that there would be no further decline in them and the projected value for 2000 was kept the same as the trend value for 1983. The subregional areas and outputs were aggregated to give the totals for regions and for the Third World countries as a whole. The resulting projections are given in Table 9. If past trends in area and yield per hectare continue, the total output of cassava in 2000 is projected to be nearly 197 million tons from an area of 19 million hectares, giving an average yield of 10.4 tons per hectare.

Table 9--Projections of output of cassava to 2000

Region	Area	Average Yield/ Hectare	Output
	(million hectares)	(metric tons)	(million metric)
Asia	5.4	13.7	74.3
	(29)	(132)	(38)
Sub-Sahara Africa	9.6	8.1	78.0
	(51)	(78)	(40)
Latin America	3.9	11.5	44.4
	(20)	(110)	(22)
Total or average	18.9	10.4	196.7

Source: Computed by the International Food Policy Research Institute.

Note: The figures in parentheses represent the percentage of the total.

As an alternative to projecting the area and yield per hectare at the subregional level, the annual output of cassava in each of the 25 countries with 1981-83 average production exceeding 500,000 tons was projected to 2000. The annual output for the remaining 44 countries was aggregated, and the aggregate output was similarly projected. Here again the growth rate in output in the case of Thailand was constrained to 1.2 percent a year. This method gives a projected output of 211 million tons in 2000. Thus if past trends are assumed to continue, the projected output of cassava in 2000 would range from 197 million to 211 million tons, unless the yields per hectare increase at an accelerated rate, compared with past trends.

Projected demand for cassava as food in 2000 was calculated on two bases: the first is a continuation of 1961-83 trends in per capita income, and the second is a constant trend estimate of per capita cassava consumption in 1983, which assumes that the income elasticity of cassava for food is zero. In both cases, the United Nations' medium variant population projections for 2000 were used for each country. Estimates of income elasticity of demand were taken from FAO's Parameters of Demand Functions.

The projected demand for cassava for food is 115 million tons under the first method and 121 million tons under the second method (see Table 10). The latter suggests that the income elasticity of demand for food is negative for some countries.

Table 10--Projected demand for cassava for food in 2000 based on two methods of projection

Region	Demand Based on Trend Income Growth	Demand Based on 1983 Trend Per Capita Consumption
	(million metric tons)	
Asia	27.2	29.7
Sub-Saharan Africa	70.7	72.2
Latin America	16.8	18.9
Total	114.7	120.7

Source: Computed by the International Food Policy Research Institute.

Sixty-two percent of the projected demand for cassava would be from Sub-Saharan Africa compared with its current share of 55 percent. The projected food use forms nearly 58 percent of the projected output in 2000. Details by subregion are given in Table 11.

Table 11--Projections of production and total domestic utilization of cassava, Third World countries, by subregion, 2000

Agroclimatic Region	Production Projection to 2000: Area	Yield	Production	Projected Use in 2000: Food	Feed	Other Uses	Total	Projected Surplus/ Deficit in 2000
	(million hectares)	(tons/ hectare)	(million metric tons)					
Asia	5.42	13.69	74.26	27.21	3.49	6.33	37.02	37.24
South Asia	0.64	23.41	15.01	8.99	0.00	1.36	10.35	4.67
China	0.66	16.69	11.04	2.20	2.03	0.18	4.41	6.63
Indochina and Pacific Islands	1.38	7.05	9.73	3.94	0.82	0.55	5.31	4.42
Thailand	1.18	15.50	18.24	0.71	0.00	0.00	0.71	17.53
Asean countries (excluding Thailand)	1.57	12.93	20.24	11.38	0.64	4.23	16.25	3.99
Sub-Saharan Africa	9.63	8.10	78.01	70.65	1.42	8.23	80.31	-2.30
Semiarid tropics	0.17	4.37	0.74	1.02	0.08	0.06	1.16	-0.42
Humid lowland and coastal tropics	4.88	7.14	34.88	33.85	0.71	4.86	39.42	-4.54
Equatorial wet tropics	3.33	6.56	21.98	20.78	0.14	0.17	21.10	0.89
Modified tropics	1.22	16.69	20.41	15.01	0.49	3.14	18.64	1.77
Latin America	3.87	11.46	44.37	16.81	15.02	9.68	41.51	2.84
Seasonally dry tropics	0.48	12.40	5.91	2.34	3.12	0.97	6.43	-0.52
Subtropics	0.22	14.44	3.24	0.76	2.01	0.33	3.10	0.14
Wet tropics	0.05	13.17	0.69	0.75	0.07	0.09	0.91	-0.21
Brazil	2.89	11.47	33.19	12.06	9.64	8.04	29.74	3.46
Mexico, Central America, and Caribbean	0.23	5.87	1.33	0.90	0.18	0.25	1.33	-0.01
Total	18.92	10.39	196.64	114.67	19.93	24.24	158.84	37.80

For projections of feed use of the commodity, annual time series data on cassava used as feed were obtained from FAO's Agricultural Supply/Utilization Accounts and these were aggregated at the subregional level. The projected feed use in each subregion in 2000 was obtained from an extrapolation of the semilogarithmic trend equation fitted to the annual data for 1961 to 1983. These were aggregated to give the regional and Third World projections.

If the past trends continue and the relative prices of cassava in relation to alternative feed sources remain unchanged, the study countries are projected to utilize about 20 million tons of cassava in 2000 as livestock feed. Of this amount, 75 percent would be in Latin America, 17.5 percent in Asia, and the balance in Sub-Saharan Africa.

Projection of the residual category, namely, other uses including allowances for wastage, is relatively more arbitrary. For estimating this, the proportion of the "other use" to total production in each subregion was calculated for 1981-83, and the same proportion was applied to the projected output for 2000. The aggregate quantity for other uses including allowance for wastage works out to 24.2 million tons.

Under the assumptions made in the study, the overall supply-demand balances, in broad magnitudes, would be as follows:

Projected area under cassava	19 million hectares
Projected yield per hectare	10.4 tons
Projected output (supply)	197 million tons
Projected food use	115 million tons
Projected feed use	20 million tons
Projected other uses	25 million tons
Total demand	160 million tons

These output and demand projections for the study countries show the projected aggregate output of cassava exceeds total demand by 38 million tons in 2000. Led by Thailand, with 18 million tons, all subregions in Asia are projected to have output exceeding demand. Sub-Saharan Africa will most likely have a small net deficit. In Latin America the supply-demand gap will also be positive, largely due to Brazil. If net exports continue at the present level of 20 million tons, other markets will need to be found for an additional 20 million tons by expanding other uses.

It should be emphasized that the above projections are not forecasts. They present a possible scenario of the cassava situation by the end of the century, based essentially on past trends in the growth of production and utilization of the commodity and on unchanged relative prices. The latter is important in view of the number of substitutes for cassava, both as food and as feed. Nonetheless, built from the existing available information on the commodity and guided by the assumptions employed in these projections, the results can serve as a basis for initiating actions on the policy alternatives for cassava in the years ahead.

3
Delphi Survey for the Assessment of Potential Yields of Cassava in the Third World

J. S. Sarma, Vasant Gandhi, and Darunee Kunchai

A Delphi Survey for the assessment of potential yields of cassava in the developing countries was carried out by the International Food Policy Research Institute as part of the study, "Past Trends and Prospects of Cassava in the Third World." The method essentially consisted of ascertaining the views of cassava scientists about the yield potentials of the crop.[1] A simple questionnaire designed to seek information on the current (1985) levels and potential yields of cassava in 1990 and 2000 under different soil and climatic conditions and agronomic practices was sent to about 400 scientists in the disciplines of plant breeding, agronomy, plant physiology, agricultural extension, and social sciences in 57 countries. Details sought included average yields and yield ranges on farmers' fields, in on-farm tests, and at research stations, with and without application of fertilizer, with and without irrigation on inferior soils, and under optimum soil and weather conditions. With regard to potential yields, a distinction was drawn between levels attainable with existing varieties and those in the pipeline and the levels that could be obtained with the improved varieties and agronomic practices likely to evolve if research resources were doubled.

In response to the survey, 153 replies were received of which 123 were usable; the rest did not furnish the information (see Tables 1 and 2).[2] Preliminary results of average yields on inferior

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[1]The Delphi method was devised, in experiments conducted at the Rand Corporation, to obtain the most reliable opinion consensus of a group of experts by subjecting them to a series of in-depth questionnaires interspersed with controlled opinion feedback. This survey was designed along these lines initially, and the results of the first round were sent to the respondents for comments. But only a few replies were received, all of which agreed with the results.

[2]The analysis of the 30 replies received from respondents who could not furnish the requisite information in the questionnaire showed that more than half of them were not knowledgeable enough to fill them in, as their specialization was in postharvest technology, entomology, water requirements, or economics. (Where the selection of scientists was based on the lists furnished by the directors of national research institutions, the fields of specialization were known; in other cases, these were not known.) Further, some stated that they were out of touch with cassava research and development. One respondent did not find the survey useful and suggested that review of literature on cassava response to fertilizer should be done.

Table 1--Distribution of responses analyzed by country

Region/ Country	Number of Res- ponses	Region/ Country	Number of Res- ponses	Region/ Country	Number of Res- ponses
Asia		Sub-Saharan Africa		Latin America	
Australia	1	Benin	2	Brazil	20
China	5	Cameroon	2	Colombia	11
India	6	Ghana	1	Costa Rica	1
Indonesia	8	Côte d'Ivoire	4	Ecuador	1
Malaysia	4	Kenya	1	Guatemala	1
Philippines	6	Madagascar	1	Haiti	1
Sri Lanka	5	Malawi	2	Honduras	1
Thailand	3	Nigeria	9	Jamaica	1
		Seychelles	1	Panama	1
		Sierra Leone	1	Paraguay	4
		Tanzania	7	Peru	1
		Togo	1	Venezuela	1
		Uganda	3		
		Zambia	2		
		Zaire	1		
		Zimbabwe	1		
Subtotal	38	Subtotal	39	Subtotal	46
Total					123

soils and under optimum conditions based on these returns are presented in Figures 1 and 2, respectively. The overall average yields are given in Table 3. The yields represent the informed opinions and judgments of cassava experts around the world.

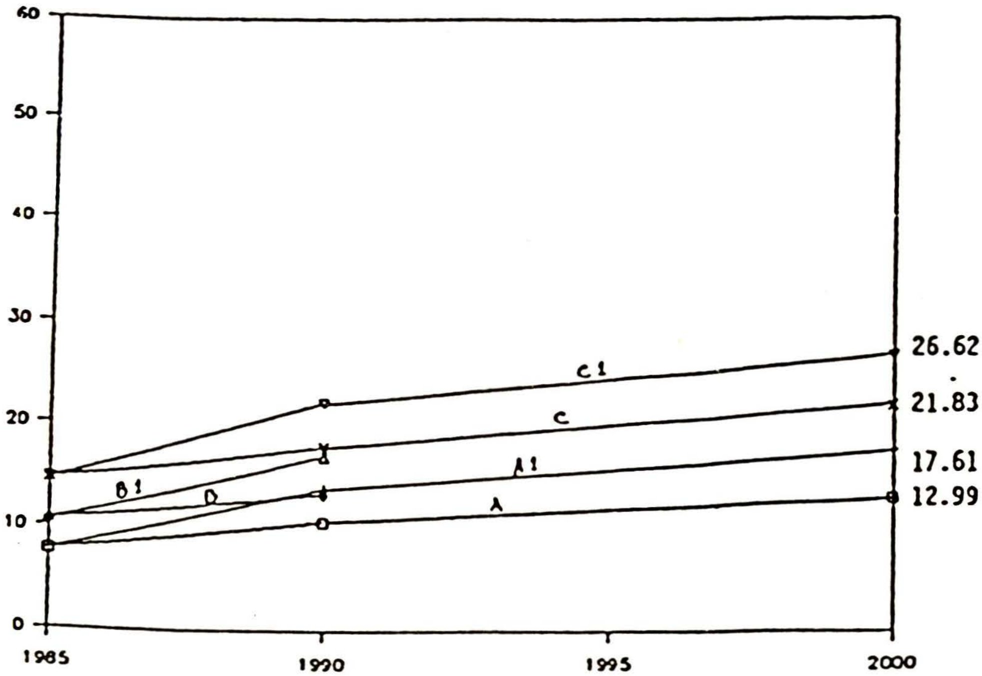
Table 2--Distribution of nil responses or other replies that could not be used.

Country	Number of Responses	Country	Number of Responses
Australia	1	Malaysia	1
Bolivia	1	Mexico	1
Brazil	3	Nigeria	2
China	1	Philippines	1
Colombia	5	Trinidad and Tobago	1
Congo	2	United Kingdom	2
Côte d'Ivoire	3	United States	5
		Total	30

Figure 1--Current and potential yields of cassava by input categories on inferior soils

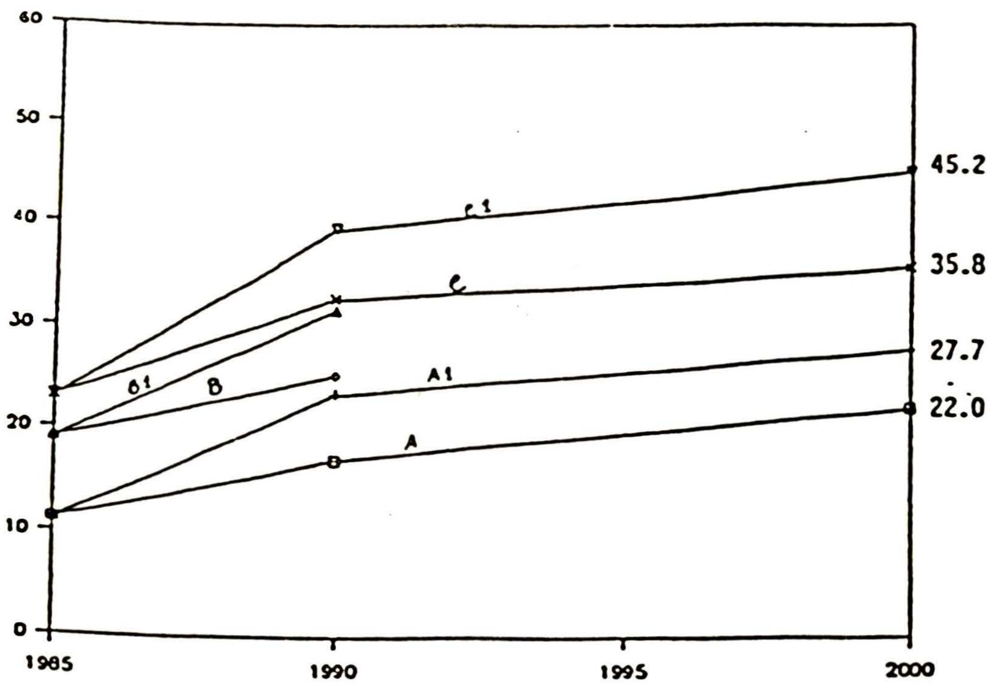
Without fertilizer and irrigation

Yield in metric tons/hectare



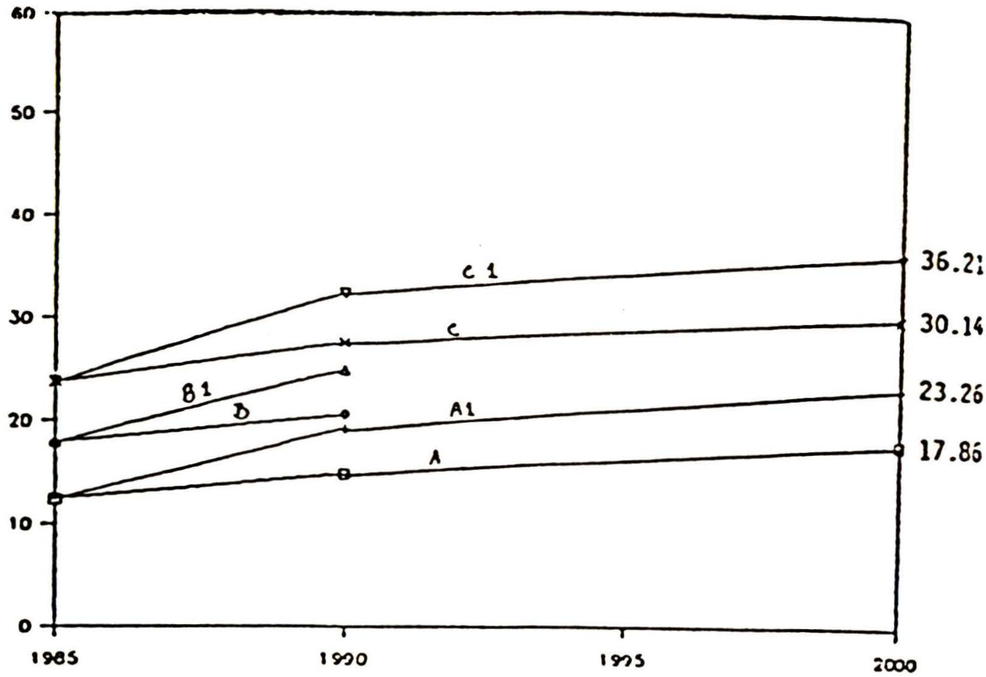
With fertilizer, without irrigation

Yield in metric tons/hectare



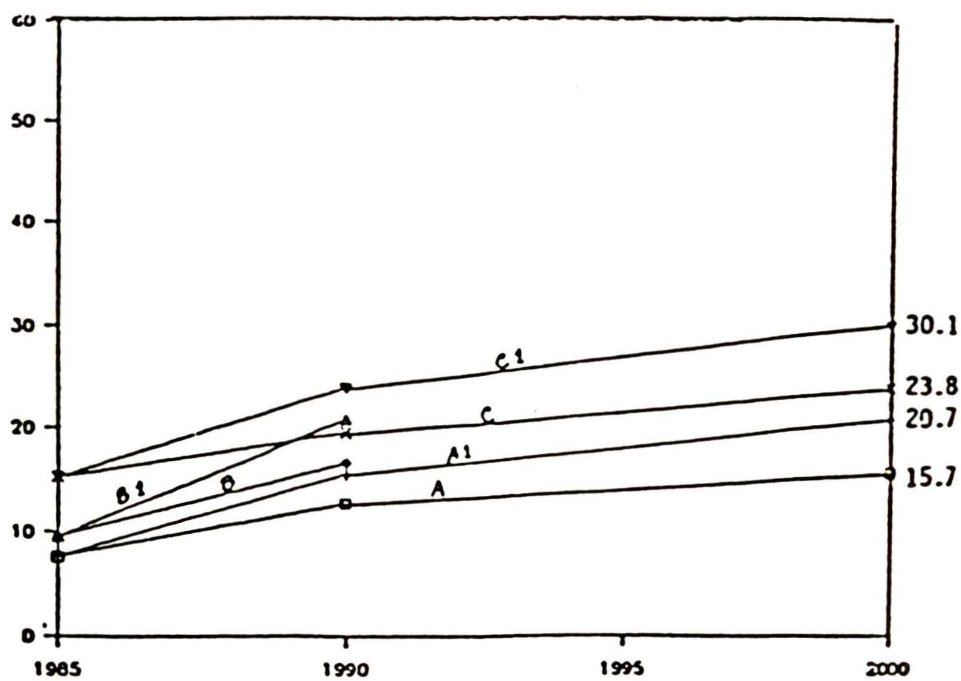
With fertilizer and irrigation

Yield in metric tons/hectare



Without fertilizer, with irrigation

Yield in metric tons/hectare



With existing varieties:

- A: Farmers' fields
- B: On-farm tests
- C: Research stations

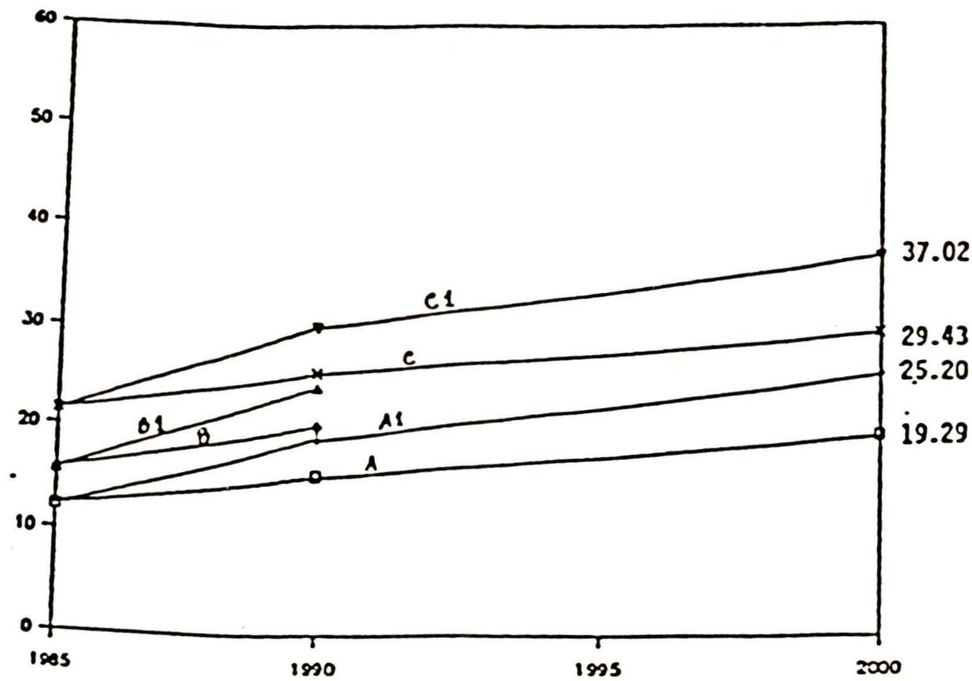
With doubling research resources

- A1: Farmers' fields
- B1: On-farm tests
- C1: Research stations

Figure 2--Current and potential yields of cassava by input categories on optimum soils

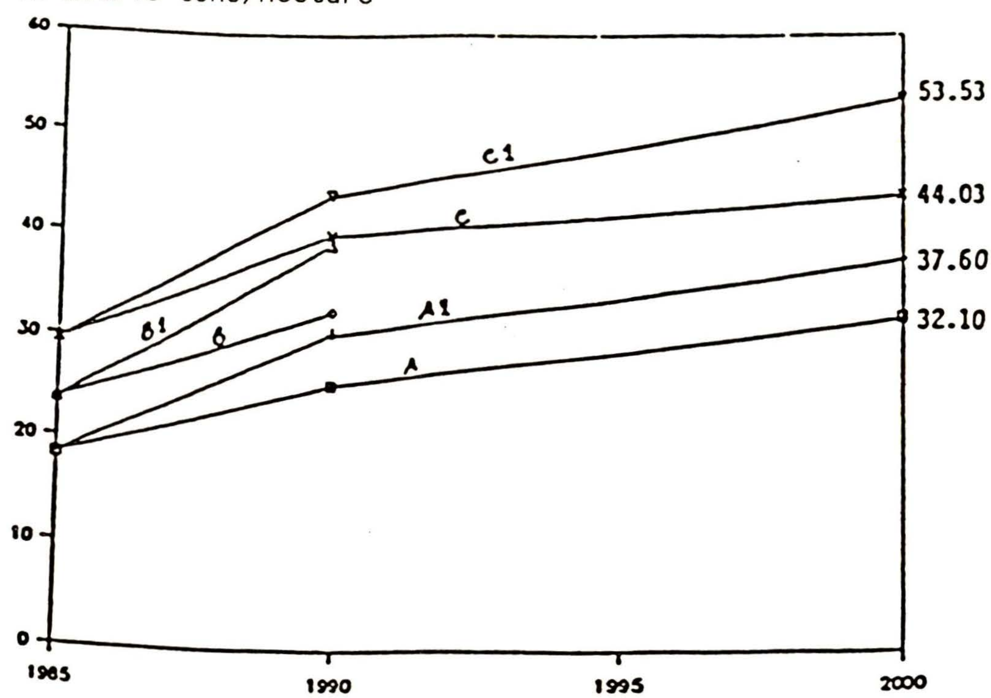
Without fertilizer and irrigation

Yield in metric tons/hectare



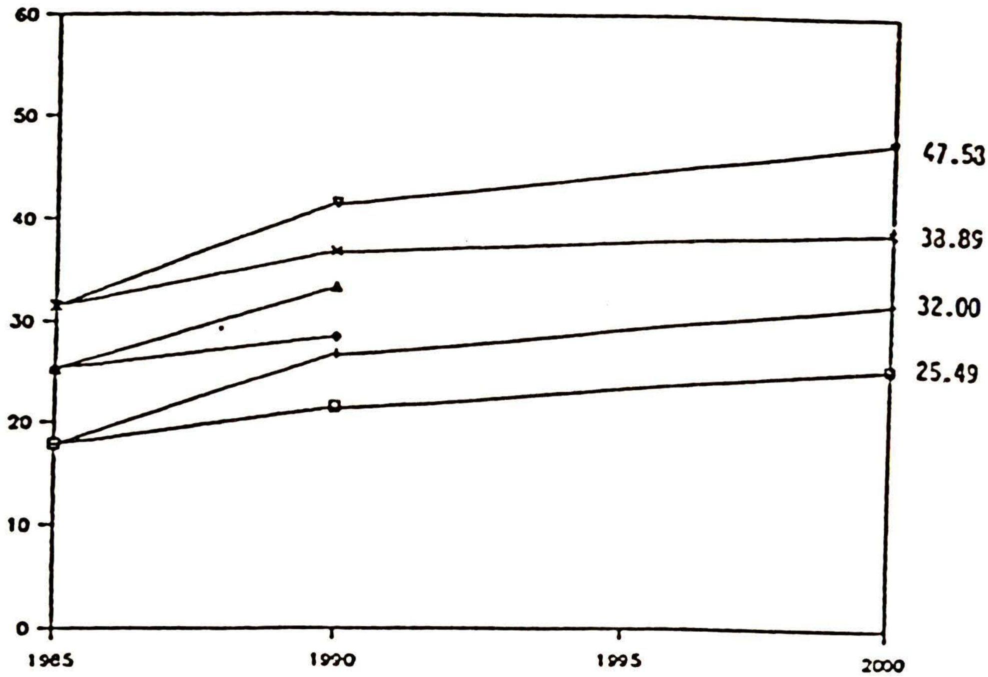
With fertilizer, without irrigation

Yield in metric tons/hectare



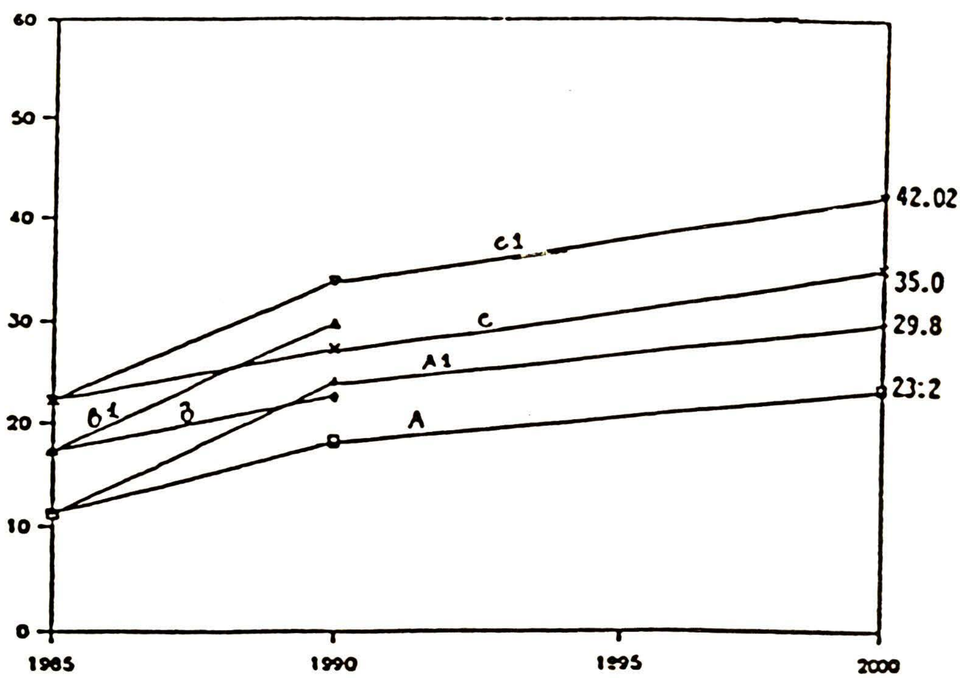
With fertilizer, without irrigation

Yield in metric tons/hectare



Without fertilizer, with irrigation

Yield in metric tons/hectare



With existing varieties:
- A: Farmers' fields
- B: On-farm tests
- C: Research stations

With doubling research resources
- A1: Farmers' fields
- B1: On-farm tests
- C1: Research stations

Table 3--Current and potential yields of cassava--all input categories

Category	Current Yields 1985		Potential Yields 2000: Existing Varieties		Potential Yields 2000: Improved Varieties	
	Yield	Number	Yield	Number	Yield	Number
(tons/	(tons/ hectare)		(tons/ hectare)		(tons/ hectare)	
Inferior soils						
Farmers' fields	9.44	168	16.09	165	21.12	158
On-farm trials	14.10	142	x	x	x	x
Research stations	19.07	169	26.58	156	32.58	152
Optimum soils						
Farmers' fields	14.44	140	23.68	154	29.46	145
On-farm trials	20.19	127	x	x	x	x
Research stations	25.91	153	35.21	157	43.10	151

AVERAGE YIELDS ON INFERIOR SOILS

Current Yields

The overall average current yield of cassava on inferior soils, weighted by the number of responses in each input category, came to 9.4 tons of fresh roots per hectare on farmers' fields, which compares well with the estimate of 9.6 tons per hectare of the Food and Agriculture Organization of the United Nations for the Third World average yield in 1985. This indicates that the scientists are broadly aware of current yields of cassava, and that the sample as a whole is representative of cassava cultivation in the Third World. Analyzed by regions, the average survey yields were 9.4 tons per hectare in Asia, 7.2 tons per hectare in Sub-Saharan Africa, and 11.2 tons per hectare in Latin America.

Current yields of cassava on farmers' fields without application of fertilizer and irrigation (f_oi_o) averaged about 7.7 tons per hectare. This level represented nearly two-thirds of the average yield obtained in on-farm tests and half of that for research stations under similar conditions. It shows the gap between the potential and realized yields that could at least partly be filled by supplying extension services, inputs, and other incentives. With fertilizer application, even without irrigation (f_1i_o), current yields averaged 12.6 tons on farmers' fields. This estimate is again two-thirds of that for on-farm tests and half of the average attained in research stations. Cassava yields with fertilizer and irrigation (f_1i_1) at research stations averaged 23 tons per hectare, which is double that on farmers' fields (11.3 tons). Average yields on farmers' fields of irrigated cassava without fertilizer (f_oi_1) were low.

Potential Yields in 2000

Estimates of potential yields of cassava in 2000 ranged overall from 13 tons per hectare on farmers' fields for the f_oi_o category with existing varieties to 45 tons per hectare at research stations for the f_1i_1 category, with further improvement in varieties and agronomic practices made possible by doubling of research resources. Average yields in 2000 for all input categories taken together amounted to 16.1 tons per hectare for existing varieties and 21.1 tons per hectare for improved varieties, compared with the corresponding current yield level of 9.4 tons. Potential yields with fertilizer indicated levels that are 5-6 tons higher than those without fertilizer. Improved varieties without fertilizer and irrigation could yield as much as 17.6 tons per hectare in 2000, which is 2.3 times the 1985 level.

The figures also show that the scientists expect larger differences between current yields in 1985 and potential yields in 1990 than between the potential yields in 1990 and 2000. This may partly be because they are more aware of the prospects within the next 5 years than those for the 10 years thereafter. Thus their estimates may be more conservative for the latter period.

Yield Differences Between Different Categories

Analyses of variance tests[3] were carried out to test the differences between (1) current yields under different input categories, (2) current yields and potential yields in 2000 with existing and improved varieties, (3) potential yields under existing and improved varieties under different input categories, and (4) potential yields under different input categories. Several other differences could also be tested with the data, but those above were of particular importance. The results given in Table 4 lead to the following conclusions:

- Application of fertilizer brings a significant increase in the yields of cassava of the order of 5 tons per hectare (from about 8 tons per hectare to 13 tons per hectare). This result holds statistically both in the presence and absence of irrigation. The tests also show that cassava yields with irrigation alone are not significantly higher than those without irrigation.
- Even at the existing level of research, significant increases compared with current yields are expected in 2000, ranging from 5 tons per hectare without fertilizer and irrigation to about 9 tons per hectare with fertilizer and irrigation. The increase under irrigation alone is not significant, partly due to the relatively

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[3]Whereas the average yields in Figures 1 and 2 are based on all the reported responses, the analysis of variance is based on paired comparisons. The number of responses is given in Column 2 of Table 4.

Table 4--Results of analysis of variance of average yields of cassava, various categories, on inferior soils

Input Categories	Number of Responses	Base Mean	Treatment Mean	Difference	F-Stat	Level of Significance
		(tons/hectare)				
Comparison of current yields under f_oi_o and other input categories						
f_1i_o	45	7.8	12.7	4.9	33.2	S
f_oi_1	6	5.3	8.1	2.8	2.4	NS
f_1i_1	9	7.3	12.0	4.7	6.1	S
Comparison of current yields with potential yields in 2000 under under different input categories						
With existing varieties and those in the pipeline						
f_oi_o	68	7.8	12.8	5.0	31.7	S
f_1i_o	39	12.7	18.7	6.0	24.9	S
f_oi_1	5	8.9	13.4	4.5	4.3	NS
f_1i_1	7	11.6	20.2	8.6	5.2	S
With improved varieties and agronomic practices likely to result from doubling of research resources						
f_oi_o	66	7.9	17.4	9.5	98.0	S
f_1i_o	37	13.0	24.2	11.2	88.9	S
f_oi_1	4	7.4	17.1	9.7	47.8	S
f_1i_1	7	11.6	24.9	13.3	7.0	S
Comparison of potential yields in 2000 with existing varieties and those with improved varieties and agronomic practices						
f_oi_o	66	13.0	17.8	4.8	17.6	S
f_1i_o	50	18.8	23.7	4.9	17.3	S
f_oi_1	13	17.7	21.2	3.5	1.5	NS
f_1i_1	18	22.6	27.8	5.5	2.5	NS
Comparison of yields in 2000 under f_oi_o and other input categories						
With existing varieties and those in the pipeline						
f_1i_o	51	12.4	17.9	5.5	22.1	S
f_oi_1	15	13.2	16.7	3.5	1.8	NS
f_1i_1	19	12.3	22.3	10.0	18.3	S
With improved varieties and agronomic practices likely to result from doubling of research resources						
f_1i_o	48	17.3	23.5	6.2	20.8	S
f_oi_1	13	16.5	20.9	4.4	2.6	NS
f_1i_1	20	15.5	28.2	12.7	22.8	S

Notes: f_oi_o = without fertilizer and irrigation; f_1i_o = with fertilizer but without irrigation; f_oi_1 = without fertilizer but with irrigation; and f_1i_1 = with fertilizer and irrigation. S = significant at 5 percent level; NS = not significant at the 5 percent level. All yields are on farmers' fields on inferior soils.

small number of observations. With doubling of research resources, all input categories are expected to show a significant increase in yield, ranging from 10 tons per hectare without fertilizer and irrigation to about 13 tons per hectare with both these inputs.

• By doubling research resources, a significant increase in yield can be achieved due to new varieties and improved practices; even under conditions of no fertilizer and no irrigation and also with application of fertilizer alone, an increase of about 5 tons per hectare can be realized. However, under irrigation alone and under both fertilizer and irrigation, the increases in yields do not seem to be significant.

• For potential yield in 2000 under the current level of research, the gap between the no-fertilizer-and-irrigation category and the fertilizer-alone category is significant but not very different from that in 1985. For the fertilizer-and-irrigation-using category, the gap is significant and more than twice as large in the year 2000. With doubling of research resources, the differences continue to be significant and the gaps widen further. The differences resulting from irrigation alone continue to be not significant.

Average Yields by Specialization, 1985 and 2000

In order to see whether there are any significant differences in yields reported by the scientists in different fields, separate average yields were calculated for each group of scientists.

When the 123 scientists whose replies were analyzed are classified by their specializations, their distribution is as follows:

Plant breeders	38
Agronomists	52
Plant physiologists	4
Extension specialists	9
Social scientists	13
Others	7
Total	123

The average current and potential yields ($f_o i_o$) on farmers' fields and at research stations, classified by specialization, are given in Table 5. The results do not show any consistent and significant differences by specialization. In the case of responses by other scientists, the number of responses on which the average were based is too small.

AVERAGE YIELDS UNDER OPTIMUM SOIL AND CLIMATIC CONDITIONS

Current Yields

The overall current yield of cassava in farmers' fields under optimum soil and climatic conditions came to 14.5 tons per hectare based on 138 observations. The average yield in Latin America, at

Table 5--Current and potential yields of cassava on inferior soils classified by the specialization of the respondents

	Current Yields 1985		Potential Yields 2000			
			Existing Varieties		Improved Varieties	
Respondent	Yield	Number	Yield	Number	Yield	Number
	(tons/ hectare)		(tons/ hectare)		(tons/ hectare)	
Farmers' fields						
Breeders	8.35	29	13.34	24	17.97	24
Agronomists	7.62	38	13.15	30	18.09	30
Research stations						
Breeders	13.91	26	21.48	24	25.76	24
Agronomists	13.95	34	20.92	30	27.39	29

Note: Data relate to the no-fertilizer, no-irrigation category.

17.6 tons per hectare, was about 5 tons higher than that in Sub-Saharan Africa. Yields in Asia averaged 13.1 tons. Cassava yield without fertilizer and irrigation, at 12.3 tons per hectare, was about two-thirds of that with fertilizer. Yields on farmers' fields with fertilizer and irrigation are only half a ton higher than those with fertilizer and no irrigation. As in the case of inferior soils, the gaps between the yields in farmers' fields, on-farm trials, and research stations are large.

Potential Yields in 2000

Potential yields of cassava on optimum soils averaged to 23.7 tons per hectare--ranging from 19.3 tons without fertilizer and irrigation to 32.1 tons with both fertilizer and irrigation. Yields on farmers' fields without irrigation but with fertilizer application were 25.5 tons per hectare, about 6.2 tons per hectare higher than those without fertilizer and irrigation. These are with existing varieties.

With doubling of research resources and the use of improved varieties, average yields of 29.5 tons per hectare were reported on farmers' fields. Such yields have been obtained in Tamil Nadu State in India. With irrigation and fertilizer use the average yields rose to 37.6 tons per hectare, almost one-and-a-half times those without irrigation and fertilizer.

Yield Differences Between Different Categories

The results of analysis of variance tests applied to yields under optimum soils on farmers' fields are given in Table 6.

As expected, the average yield levels on optimum soils are higher than those on inferior soils, and the various differences are also somewhat larger. At the current levels of yields, in

Table 6--Results of analysis of variance of average yields of cassava, various categories, on optimum soils

Input Categories	Number of Responses	Base Mean	Treatment Mean	Difference	F-Stat	Level of Significance
			(tons/hectare)			
Comparison of current yields under $f_o i_o$ and other input categories						
$f_1 i_o$	40	11.7	17.9	6.2	19.7	S
$f_o i_1$	5	8.7	13.0	4.3	6.0	NS
$f_1 i_1$	7	10.8	17.7	6.9	14.2	S
Comparison of current yields with potential yields in 2000 under different input categories						
With existing varieties and those in the pipeline						
$f_o i_o$	56	12.7	19.0	6.3	17.3	S
$f_1 i_o$	32	17.3	25.0	7.7	15.4	S
$f_o i_1$	4	13.8	21.0	7.2	2.6	NS
$f_1 i_1$	7	17.7	29.0	11.3	6.9	S
With improved varieties and agronomic practices likely to result from doubling of research resources						
$f_o i_o$	58	12.9	24.8	11.9	62.7	S
$f_1 i_o$	29	17.9	32.8	14.9	46.5	S
$f_o i_1$	3	12.3	28.3	16.0	2.6	NS
$f_1 i_1$	6	15.4	34.3	18.9	12.1	S
Comparison of potential yields in 2000 with existing varieties and those with improved varieties and agronomic practices						
$f_o i_o$	59	19.5	25.5	6.0	12.3	S
$f_1 i_o$	46	25.9	32.6	6.7	13.9	S
$f_o i_1$	12	25.5	30.9	5.4	1.3	NS
$f_1 i_1$	18	31.9	37.6	5.7	1.8	NS
Comparison of yields in 2000 under $f_o i_o$ and other input categories						
With existing varieties and those in the pipeline						
$f_1 i_o$	45	18.9	25.8	6.9	14.8	S
$f_o i_1$	15	20.2	25.0	4.8	2.1	NS
$f_1 i_1$	18	19.6	32.4	12.8	16.0	S
With improved varieties and agronomic practices likely to result from doubling of research resources						
$f_1 i_o$	44	25.1	32.5	7.4	14.9	S
$f_o i_1$	13	24.6	29.8	5.2	1.4	NS
$f_1 i_1$	17	24.7	38.4	13.7	11.4	S

Notes: $f_o i_o$ = without fertilizer and irrigation; $f_1 i_o$ = with fertilizer but without irrigation; $f_o i_1$ = without fertilizer but with irrigation; and $f_1 i_1$ = with fertilizer and irrigation. S = significant at 5 percent level; NS = not significant at the 5 percent level. All yields are on farmers' fields on optimum soils.

comparison with the no-fertilizer, no-irrigation category, all the input categories show increments in yields that are significant. The increases with fertilizer are somewhat larger--of the order of 6-7 tons per hectare. Except for the irrigation-alone category, significant increases in yield are expected by the year 2000 both at current levels of research and with doubling of research resources. In the latter case, the increases appear to be about twice as large. However, analysis of variance between yields in year 2000 under current research and under doubling of research resources shows that returns to this doubling (in yields) appear to be significant only for the no-fertilizer, no-irrigation category and the fertilizer-alone category, and not for the other two. The results also show that, compared with the current yield differences, there is no great widening of the yield gap between the three categories, no fertilizer and no irrigation, fertilizer alone, and irrigation alone, by the year 2000, but the gap widens for the category where fertilizer and irrigation are both used.

Yields at the Research Stations

Results from analysis of variance applied to yields at the research stations were similar, with a few exceptions. The levels of yields were, as expected, much higher, but the magnitude of the response to inputs was also much greater. Yield increases from doubling of research resources were, however, not substantially larger than those at the farm-level. Increases in yields by the year 2000 on the no-fertilizer-with-irrigation category as well as the with-fertilizer-and-irrigation category were fairly large but statistically not significant, both at current research levels and under doubling of research resources. The latter results are, however, based on only a few paired observations.

CONSTRAINTS TO INCREASING PRODUCTION

The Delphi Survey also sought the opinion of the scientists on what are the most important constraints to the realization of higher production of cassava at the farm level. The following 12 constraints were listed and the experts were asked to rank them in the order they considered most important:

1. Low-yield potential of existing varieties
2. Poor fertilizer response
3. Nonavailability of fertilizer
4. Inadequate moisture
5. Pests
6. Diseases
7. Insufficient labor
8. Inadequate extension service
9. Output marketing problems
10. Storage and processing problems
11. Lack of incentives (including low prices)
12. Others

Ranking by Constraints

Of the 123 respondents, only 65 provided complete rankings (which is not surprising given the knowledge and time demands of the task).

The ranks were converted to scores by assigning a score of 12 to rank 1, 11 to rank 2, and so on up to a score of 1 for rank 12. The total scores were then calculated for each constraint and the constraints were ranked on the basis of the total score received by each. The results are given in Figures 3 and 4. In addition, the percentage of responses under each rank was calculated for each constraint and these are given in Tables 7 and 8.

Figure 3--Combined ranking by total score of different constraints, all responses on inferior soils

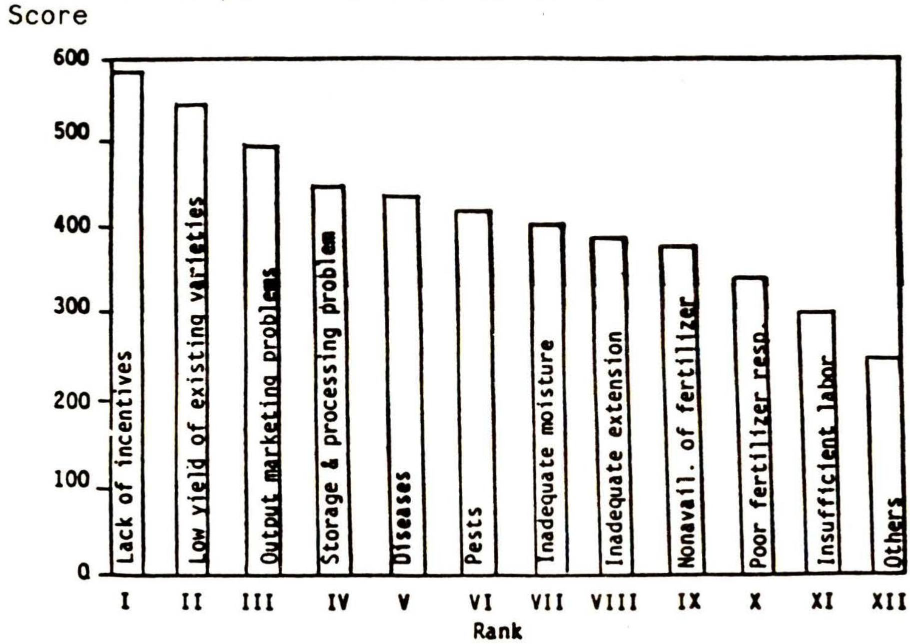

Figure 4--Combined ranking by total score of different constraints, all responses on optimum soils

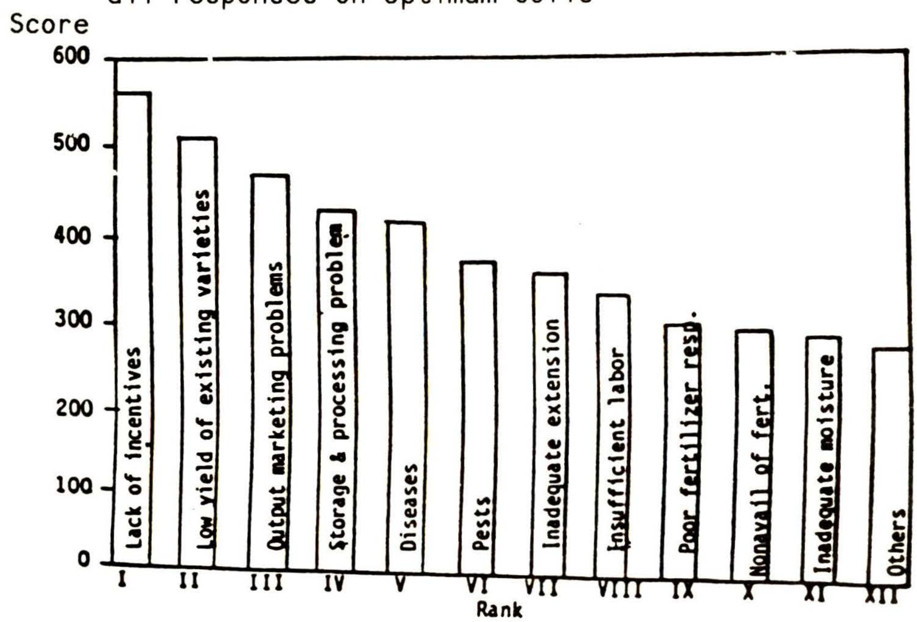

Table 7--Total and average scores of different constraints and percentage response in each rank to total, all responses on inferior soils

Combined Rank	Constraint/ Rank	Total Score	Average Score	Percentage of Responses in Each Rank to Total											
				1	2	3	4	5	6	7	8	9	10	11	12
1	Lack of incentives (11)	588.0	9.0	24.6	13.8	7.7	16.9	6.2	12.3	9.2	6.2	0.0	1.5	0.0	1.5
2	Low yield potential of existing varieties (1)	543.0	8.4	24.6	10.8	12.3	9.2	9.2	4.6	4.6	7.7	4.6	3.1	6.2	3.1
3	Output marketing problems (10)	497.0	7.6	10.8	15.4	12.3	6.2	9.2	13.8	6.2	3.1	9.2	6.2	1.5	6.2
4	Storage and processing problems (10)	447.0	6.9	1.5	10.8	16.9	4.6	12.3	10.8	9.2	9.2	6.2	4.6	12.3	1.5
5	Diseases (6)	440.0	6.8	4.6	13.8	7.7	7.7	12.3	1.5	10.8	12.3	12.3	9.2	3.1	4.6
6	Pests (5)	425.0	6.5	6.2	10.8	9.2	3.1	6.2	16.9	7.7	9.2	10.8	4.6	9.2	6.2
7	Inadequate moisture (4)	408.0	6.3	7.7	4.6	10.8	10.8	7.7	6.2	9.2	7.7	7.7	3.1	16.9	7.7
8	Inadequate extension (8)	399.0	6.1	1.5	6.2	4.6	9.2	9.2	9.2	15.4	16.9	7.7	13.8	4.6	1.5
9	Nonavailability of fertilizer (3)	397.0	6.1	6.2	4.6	12.3	6.2	10.8	7.7	4.6	4.6	10.8	13.8	13.8	4.6
10	Poor fertilizer response (2)	355.0	5.5	4.6	4.6	3.1	16.9	1.5	6.2	6.2	9.2	13.8	6.2	16.9	10.8
11	Insufficient labor (7)	309.0	4.8	0.0	3.1	3.1	3.1	9.2	9.2	10.8	4.6	12.3	26.2	10.8	7.7
12	Others (12)	264.0	4.1	7.7	3.1	0.0	4.6	6.2	1.5	6.2	9.2	4.6	7.7	4.6	44.6

Note: Figures in brackets show the serial number of constraint in question 7 of the questionnaire. Total number of responses = 65.

Table 8--Total and average scores of different constraints and percentage response in each rank to total, all responses on optimum soils

Combined Rank	Constraint/ Rank	Total Score	Average Score	Percentage of Responses in Each Rank to Total 1	2	3	4	5	6	7	8	9	10	11	12
1	Lack of incentives (11)	562.0	9.4	31.7	18.3	15.0	3.3	3.3	6.7	8.3	8.3	1.7	0.0	0.0	3.3
2	Low yield potential of exist varieties (1)	508.0	8.5	30.0	8.3	11.7	6.7	6.7	6.7	6.7	10.0	0.0	5.0	5.0	3.3
3	Output marketing problems (10)	472.0	7.9	11.7	18.3	11.7	1.7	15.0	11.7	6.7	3.3	6.7	5.0	5.0	3.3
4	Storage and processing problems (10)	434.0	7.2	5.0	8.3	15.0	20.0	6.7	6.7	8.3	6.7	5.0	5.0	10.0	3.3
5	Diseases (6)	421.0	7.0	1.7	10.0	15.0	10.0	10.0	15.0	3.3	6.7	11.7	13.3	3.3	0.0
6	Pests (5)	386.0	6.4	1.7	10.0	10.0	6.7	15.0	8.3	10.0	10.0	6.7	5.0	6.7	10.0
7	Inadequate extension (8)	376.0	6.3	3.3	3.3	1.7	10.0	11.7	13.3	18.3	13.3	8.3	13.3	3.3	0.0
8	Insufficient labor (7)	342.0	5.7	0.0	6.7	3.3	11.7	8.3	8.3	15.0	6.7	15.0	8.3	8.3	8.3
9	Poor fertilizer response (2)	305.0	5.1	0.0	1.7	10.0	5.0	6.7	8.3	3.3	13.3	16.7	10.0	25.0	0.0
10	Nonavailability of fertilizer (3)	301.0	5.0	6.7	5.0	0.0	8.3	8.3	3.3	10.0	5.0	6.7	11.7	20.0	15.0
11	Inadequate moisture (4)	296.0	4.9	3.3	8.3	1.7	5.0	5.0	8.3	5.0	8.3	11.7	16.7	6.7	20.0
12	Others (12)	284.0	4.7	5.0	1.7	5.0	11.7	3.3	3.3	6.7	10.0	10.0	5.0	6.7	31.7

Notes: Figures in brackets show the serial number of constraint in question 7 of the questionnaire. Total number of responses = 60.

Scientists rank lack of incentives, including low prices, as the most important constraint to achieving yield potentials on both inferior soils and under optimum soil and climatic conditions. Low yield potential of the existing varieties is ranked next, followed by output marketing and storage and processing problems. Diseases rank fifth.

An analysis of the constraints at the regional level shows that in Asia and Latin America the ranking of constraints follows the overall pattern, but in Sub-Saharan Africa, disease problems were given the first rank, followed by low-yield potential of existing varieties and lack of incentives.

Nearly a quarter of the scientists gave lack of incentives as the most important constraint on inferior soils; another 14 percent gave it a second rank. About 25 percent of respondents indicated low potential of existing varieties as the main constraint; another 23 percent gave this a second or third rank. Under optimum soil and climatic conditions, lack of incentives was ranked most important by 32 percent of the respondents. Another 18 percent gave it a second rank.

In a portion of the questionnaire reserved for remarks, the respondents gave additional explanations for the low yields, such as the practice of growing cassava as a mixed crop and low plant densities. Also, the existing varieties that have good eating qualities and are white in color are generally lower-yielding than others. In some countries where cassava leaves are plucked and eaten periodically, the yields of the tuber are low.

Concordance Coefficients

Some tests were also done to measure the degree of agreement between scientists on ranking of the constraints. This was done by measuring the degree of concordance between them by calculating the coefficient of concordance (W) and the H-statistic. The results are presented in Table 9. The value of the coefficient is low for all the responses taken together, showing that the agreement among scientists is not very great. The coefficients with respect to each region are somewhat higher.

Table 9--Measure of concordance between rankings

Response by Region	Concordance Coefficient W		H-Value	
	Inferior Soils	Optimum Soils	Inferior Soils	Optimum Soils
Total responses	0.1556	0.1871	111.29	123.49
Asia	0.2420	0.2497	55.90	57.68
Sub-Saharan Africa	0.2771	0.2277	67.06	55.11
Latin America	0.2335	0.3019	56.50	56.45

According to Meddis (1984), the coefficient of concordance W is defined as

$$W = \frac{H}{m\ (k-1)},$$

where $H = \frac{12}{mk\ (k+1)}.$

H is a distributed chi-square with (k-1) degrees of freedom and

m = number of rankings available (65),
k = number of issues ranked (12), and
Rj = sum of ranks for each issue; the order or ranks is reversed to be consistent with the definition of the formula.

The null hypothesis of substantial agreement was rejected in all cases by the H-statistic test, which confirms the lack of agreement among the scientists. This may in part reflect the heterogeneity of conditions under which the crop is cultivated in the different agro-economic environments.

POLICY IMPLICATIONS

The gaps between the average yields of cassava on farmers' fields, in on-farm tests, and at research stations are large under all of the different input categories. This indicates that greater efforts are called for in expanding extension services, providing input supplies, and initiating incentives to farmers so that they will adopt the improved cultural practices designed to reduce these gaps. Use of fertilizer alone will raise the yields of cassava by at least 5 tons per hectare, therefore efforts to encourage fertilizer use can increase the output as well as the net income of the farmers.[4] Doubling of research resources to evolve improved varieties and associated agronomic practices will improve the yields of cassava significantly. However, more resources need to be devoted to improving cassava yields under inferior soils and under low input use. Lack of incentives is found to be the most commonly reported constraint to increased production. This calls for an improvement in the policy environment for cassava, particularly in relation to cereals. Government intervention to ensure incentives to farmers for growing cassava, such as remunerative prices, processing, storage and marketing facilities, extension, and credit, may become necessary, especially in view of its importance for food security and incomes of the poor. The constraint of low yield potential of existing varieties needs to be overcome through allocation of adequate research resources for development of

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[4]Generally, all root crops respond well to fertilizer use. The profitability of cassava depends upon the relative prices of cassava and fertilizer. Their actual use also depends on the knowledge of the farmer of the fertilizer response; on net returns to the use of fertilizer on different crops; and on the prevailing facilities for fertilizer promotion, distribution, supply, and credit.

improved varieties with higher yields and resistance to pests and diseases, particularly in Sub-Saharan Africa. Output marketing and storage and processing problems were also reported to be major constraints. To remove these, higher priority should be given to research on postharvest technology and product development at national and international research centers.

This survey has also shown the feasibility of adopting the Delphi method for a quick assessment of potential yields and constraints of a hitherto neglected yet important crop like cassava.

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4
Economics of Cassava in Africa

Paul Dorosh

Cassava (Manihot esculenta Crantz) is one of the most important food crops of Sub-Saharan Africa, where it is a major staple for about 160 million people, about 40 percent of the population. Even in areas where cassava is not a major staple, it often plays an important role in household food security because of its resistance to drought and many pests. In many parts of Africa cassava is predominantly grown by women, whereas men cultivate cash crops and, in West Africa, yams.

Cassava is often grown on degraded soils and is in many places a major staple of poor, malnourished people. Because of this, the crop has often been falsely maligned as causing soil degradation and malnutrition. In truth, cassava is grown on degraded soils because other, less hardy crops will not produce adequate yields there, and it is often eaten by the poor because it is a cheap source of calories. Fresh cassava also contains some cyanide which in extreme situations has led to outbreaks of paralysis and even death, but these cases are extremely rare. Cyanide content is normally reduced to acceptable levels through processing. Finally, high levels of cassava consumption are correlated to some extent with goiter, because cyanide in cassava inhibits the body's use of iodine. However, in areas where dietary intake of iodine is high, goiter is not widespread in spite of very high levels of cassava consumption.[1]

In this paper, economic aspects of cassava production and utilization are explored in order to begin to assess the future role of cassava in Africa. Statistical information on cassava production is summarized, and major factors influencing cassava production are briefly discussed. The section on utilization of cassava includes a description of major consumption forms, an analysis of the major factors influencing consumption, and the prospects for other end uses of cassava in Africa. The role of cassava in enhancing food security is also considered.

CASSAVA PRODUCTION

Statistical Overview

Statistics on agricultural production in Africa must be viewed cautiously. Production estimates from different data sources can vary by a factor of 2 or even 10! In almost all countries

[1]The above paragraph draws heavily from Hahn (1986).

production figures are based on extremely small samples. Few systematic surveys have been done, in part because of the government's lack of trained personnel and funds. When surveys are attempted, poor roads often make access to rural areas time-consuming and costly. Moreover, complex intercropping systems make crop production estimates difficult for most crops. Cassava production is especially hard to estimate because it is usually not harvested all at once and in many areas it remains in the field for more than one year.

Despite the approximate nature of the data, it is clear that in terms of gross production cassava is by far the most important root crop in Africa. As shown in Table 1, cassava production in Africa is more than twice that of yams and more than 10 times that of sweet potatoes or cocoyams.[2] In terms of world production cassava is still the leading tropical root crop, although production of sweet potatoes, grown extensively in the People's Republic of China, is only slightly lower. Cassava's dominance in Africa as a whole is less pronounced in coastal West Africa, which is the center of world yam production (accounting for more than 90 percent of the total). (See Table 1 for a list of the countries included in Coastal West Africa and Central Africa.)

Zaire and Nigeria are Africa's leading cassava producers, accounting for 29 and 23 percent of production respectively for the period 1980-84.[3] The next four largest producing countries are all located in East and Southern Africa: Tanzania, Mozambique, Madagascar, and Angola. The actual magnitude of cassava production in these countries is especially uncertain though. Overall, coastal West Africa and Central Africa each accounts for about one-third of production, and East and Southern Africa accounts for most of the remainder. (Less than 5 percent of cassava in Africa is produced in the semiarid regions of West Africa).

According to data of the Food and Agriculture Organization of the United Nations (FAO), cassava production has been increasing in Africa as a whole but at a rate slower than population. Data on growth rates of production of cassava are of course dependent on the underlying FAO estimates of production, which for several major

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[2]Measured in terms of edible calories produced, cassava production is about three times that of yams (for which as much as one-fourth of the crop is used as seed yams).

[3]Estimates of cassava production by Nigeria's Federal Office of Statistics (FOS) are smaller than the FAO figures. It is almost certain that the FAO numbers are much closer to the actual magnitudes because (1) the FOS data for cassava (and most other staples) implies a very low national per capita consumption, which is contrary to observations of the importance of cassava in the diets of the roughly one-half of Nigeria's population living in the southern part of the country; and (2) the FOS production series shows a sharp decline in cassava production for the 1970-84 period overall, though it is generally agreed by informed experts that cassava production in Nigeria increased during this period. A detailed analysis of the problem of cassava production estimates is found in World Bank (1985).

Table 1--African and world production of roots and tubers, 1982-84 average production

Region	Cassava	Yams	Sweet Potatoes	Coco-yams[a]
		(million metric tons)		
World	126.0	24.7	113.0	6.4
Africa	49.8	23.7	5.2	4.1
(as percent of world)	(39.5)	(95.8)	(4.6)	(64.3)
Coastal West Africa[b]	16.5	22.6	0.6	3.6
(as percent of Africa)	(33.1)	(95.3)	(11.1)	(89.1)
Central Africa[c]	17.3	0.5	2.1	0.3
(as percent of Africa)	(34.8)	(2.1)	(40.3)	(7.1)
East and Southern Africa	15.3	...	2.4	0.1
(as percent of Africa)	(30.7)	(...)	(46.5)	(2.3)

Source: Food and Agriculture Organization of the United Nations, FAO Production Yearbook, 1984 (Rome: FAO, 1985).
Note: The ellipses indicate a nil or neglible amount.
[a]Includes root crops not elsewhere specified for Cameroon and Gabon.
[b]Includes Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea, Liberia, Nigeria, Serra Leone, and Togo.
[c]Includes Burundi, Central African Republic, Congo, Equatorial Guinea, Gabon, Rwanda, and Zaire.

countries, including Zaire and Nigeria, are apparently based on assumed growth rates derived from population growth estimates and other factors.

Average cassava yields in Africa are 6.8 tons per hectare, but yields vary widely, ranging from 3 to 15 tons per hectare.[4] One of the most important factors explaining the large variation in average yields between countries is planting density, which can vary greatly because cassava is often intercropped. Incidence of pests and diseases, soil type and other agroecological factors, length of

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[4]Reported cassava yields in Cameroon (1.6 tons per hectare) and Togo (18.4 tons per hectare) are of dubious accuracy and are questioned by researchers familiar with production of cassava in these countries.

growing season before harvest (which can range from 9 months to several years), and cassava variety are also major contributing factors.

Many of the improved varieties developed by the International Institute of Tropical Agriculture (IITA) yield 15-25 tons per hectare on experimental test plots (without fertilizer) in the forest and derived savannah zones in Nigeria (IITA 1984, 120). On farmers' fields, a limited sample of farmers in the derived savannah near Ibadan had an average yield of 20.3 tons per hectare, using an IITA variety (TMS 30572), and 16.0 tons per hectare for a common local variety (Ikpi et al. 1986, 45).[5] All the reported yields greatly exceed average yields in Nigeria. Cultural management (especially weeding and plant density) may be one of the major factors explaining the discrepancy in yields between the measured yields above and estimates of average yields in Nigeria.

Major Factors Influencing Production

Several factors that have encouraged the expansion of cassava production in the past are likely to continue to be major influences on production trends in the future.[6] These factors include cassava's low labor input requirements, ability to produce a crop on degraded soils, and drought-tolerance.

Low labor requirements for production have been an important factor determining cassava's role in farming systems. Cassava's low labor requirements (and flexibility in the timing of labor inputs) free scarce farm labor for other activities. Thus in areas where export crop production limits the labor available for food production (such as cotton cultivation areas in northern Mozambique and the Lake Victoria area in Tanzania and cocoa areas in southwestern Nigeria), cassava increased in importance. Low labor requirements relative to yams have also contributed to increased cassava production in the forested part of the yam zone in West Africa.

Declining soil fertility caused by increasing population pressure on the land and shorter fallows favor cassava production over other crops that require more fertile soils for profitable production. Scarce fertile soils can then be reserved for less hardy crops. Cassava's ability to produce a crop on even poor soils is another factor accounting for its growth in export crop areas where the best soils are reserved for the cash crops.

Drought tolerance allows the plant to survive through dry periods and enables the crop to be left in the ground throughout the dry season thus making cassava an important food security crop in areas of uncertain rainfall. In recent years cassava has become increasingly important in the drier areas of both West and East Africa.

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[5]The yields of cassava on some of the test plots probably benefited from residual effects of fertilizer applied to the maize intercrop. The cassava was harvested at an age of 12 to 18 months.

[6]This section summarizes material from Dorosh (forthcoming) on constraints on cassava production in various cassava production zones in Africa.

Thus even without technical change in cassava production, it is likely that cassava production would continue to increase by expanding into new areas of low soil fertility (especially in areas with access to major urban markets) and drought risk. There is, however, much potential for increasing average yields of cassava in Africa.

Spread of New Technology

Considerable increases in production and yield are theoretically possible with the disease-resistant varieties already developed at IITA. Currently, improved cassava varieties account for considerably less than 1 percent of cassava production in almost all major cassava-producing countries in Africa, including Zaire, Tanzania, Mozambique, Cameroon, and Ghana. Only in Nigeria is there a significant rate of adoption of improved varieties. Estimates of the spread of IITA varieties range from the view that they are found only in pockets near Ibadan and along major roads to an estimate of 200,000 hectares (Hahn 1984). Even this latter figure represents only about 20 percent of total area of cassava harvested in Nigeria.[7]

Lack of adequate extension services is currently one constraint on the spread of this new technology. In most African countries, extension services are seriously underfunded and understaffed. Most extension agents are men, while the majority of cassava farmers are women; problems in communicating may be the result. Facilities are usually not available to multiply cuttings of new varieties. Projects funded by the International Fund for Agricultural Development (IFAD) and the United Nations Children's Fund (UNICEF) in several countries may help overcome these constraints, especially the multiplication problem.

Another constraint may exist as well. It is still uncertain whether improved disease-resistant varieties will be accepted by a majority of farmers outside Nigeria. Because national research programs on roots and tubers in most countries have only been started recently, there has been little selection of material for local conditions or on-farm testing to date. More work needs to be done in understanding how cassava currently fits into the major farming systems in an area and in selecting and testing improved cassava varieties that are compatible with these systems.

CONSUMPTION, MARKETING, AND OTHER END USES

Farmers often choose to relegate cassava to inferior lands because of their own preference for food crops grown on more fertile

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[7] It should be noted that most farmers prefer to grow several varieties of cassava in the same field, so that the percentage of farmers who grow a given variety of cassava is likely to be considerably higher than the percentage of total area planted of a given variety. Also distinguishing between different cassava varieties in the field can be very difficult, so that estimates of adoption of new varieties, if based solely on field observations, are likely to be quite inadequate.

land or because of market demand, which makes returns from producing other crops on the fertile land higher than the return from cassava. A large increase in producer prices would likely bring about a substantial increase in cassava production since labor and especially land could be bid away from other activities. In this sense, inadequate demand is a primary constraint on cassava production.

In this section trends in cassava demand and factors influencing these trends are analyzed. First, statistical data on per capita consumption is presented as well as an overview of the end uses of cassava in Africa. Second, the major forms in which cassava is consumed as food in Africa are described and the major factors influencing future consumption are discussed. Third, the role of cassava in improving food security is highlighted. Finally, the potential for nonfood uses of cassava is explored.

Statistical Overview of Consumption and Other End Uses

In Africa, most cassava is consumed as human food. Although, worldwide, more than 10 percent of cassava is used as animal feed, in Africa less than 2 percent is used in this way (Table 2). Most of the cassava undergoes some form of processing (in addition to cooking) before consumption. In Africa, cassava exports account for less than 0.1 percent of total production.

The role of cassava in the diet varies across major regions in Africa. Per capita consumption of cassava in central Africa is the highest in all of Africa. Cassava accounts for about 1,200 calories per capita per day (about half of total calories) in Zaire and the Congo, and more than 900 calories per capita per day in the Central African Republic.[8] Per capita production and consumption is much lower in coastal West Africa, ranging from 235 calories per capita per day in Cameroon to 470 in Benin. Cassava is generally a major staple only in the forest and southern moist savannah regions in West Africa, areas in which only about half of the populations of Nigeria, Ghana, and Côte d'Ivoire live. Also, the diet is more diverse in the southern regions of these countries than in Central Africa (yam and maize are also major staples in these regions). Further west in coastal Liberia and Guinea, cassava is the second most important staple food after rice. National per capita consumption of cassava is also high in east and southern Africa in Angola, Madagascar, Mozambique, and Tanzania. Since cassava is mainly consumed in certain regions of these countries (for example, in northern Mozambique and Angola), the national average consumption is somewhat misleading. In the highlands of eastern Zaire, Rwanda, Burundi, and Uganda, sweet potatoes and bananas are also major staples, so that cassava consumption in these areas accounts for about 15 percent of total calorie intake.

A rough estimate of the number of people consuming cassava as a major staple can be made using consumption estimates from the food

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[8]The FAO Food Balance Sheet for 1979-81 shows 1,141 calories per capita per day for the Congo, but it assumes only 3 percent losses. More realistic loss figures of about 10 percent give an estimate of 1,063 calories per capita per day.

Table 2--Cassava utilization, 1980-84

Use	Africa	Percent of Total Use	World	Percent of Total Use
	(1,000 metric tons)		(1,000 metric tons)	
Food				
Direct consumption	18,700	38.1	39,988	31.9
Processed	24,387	49.7	36,873	29.4
Total	43,087	87.7	76,681	61.2
Feed				
Unprocessed	695	1.4	12,235	9.8
Processed	38	0.1	22,875	18.3
Total	733	1.5	35,110	28.0
Waste	5,334	10.9	13,327	10.6
Production	49,116	100.0	125,298	100.0
Trade				
Exports	38	0.1	31,055	24.8
Imports	1	...	30,046	24.0

Source: Calculated from Food and Agriculture Organization of the United Nations, "FAO Agricultural Supply/Utilization Accounts Tape, 1984," Rome, 1986.
Note: Cassava use is given in fresh root equivalents.

balance sheets, population figures, and some basic information on which parts of a country consume the most cassava.[9] In all, there are perhaps 40 million people living in central Africa and Mozambique whose average daily cassava consumption exceeds 600 calories per day, and another 120 million people (throughout Africa) whose average daily cassava consumption exceeds 200 calories per day.

CONSUMPTION OF CASSAVA AS HUMAN FOOD

Cassava in Africa is consumed in a wide variety of forms. In many areas, the roots are consumed as a major staple, although in some places boiled fresh roots of cassava are eaten as a vegetable. In large parts of Africa (particularly central Africa) the leaves

[9]For example, for Nigeria, it was assumed that about half of the population lives in the southern area of the country, where cassava production is high, and that relatively little cassava is consumed in the north. Thus average per capita consumption in the south is about 400 calories per capita per day, and a large majority of these people would average at least 200 calories per capita per day from cassava.

are also consumed as a vegetable. Because cassava contains a cyanogenic glucoside, linamarin, the roots must be processed to hydrolyze the cyanide. For low-cyanide varieties (usually having a less bitter taste), processing may consist of simply peeling and boiling the root. Some low-cyanide varieties are reportedly occasionally eaten raw. High-cyanide varieties (usually more bitter), require more processing to remove the cyanide. Several steps are involved, which vary according to the product made but usually include some of the following: peeling, soaking the root in water for several days, grating, pounding, and drying or roasting. Likewise, cassava leaves have a high-cyanide content and must be processed (commonly pounded and boiled) before eating.

Although the main etiological factor in endemic goiter is iodine deficiency, the ratio of iodine to thiocyanate (I/SCN) in the diet has been shown to be related to the development of goiter. As noted, processing of cassava removes most of the cyanide, but the amounts remaining in food (especially food processed from high-cyanide varieties) can contribute to endemic goiter in areas where dietary intake of iodine is relatively low. Goiter is a serious public health problem in parts of Zaire where cassava intake is high, but iodine intake is low. In other parts of the same country, where both cassava and iodine intake are high, there is little or no problem with goiter (see Delange et al. 1983).

The most common form of cassava consumption in West Africa is gari, a dry granular food made from fermented cassava. There are many local variations in the processing of cassava into gari, but in general the cassava roots are peeled and grated before being dehydrated (by pressing out the water) and left in sacks to ferment for several days. The fermented mash is then sieved and fried. Consumption of gari may account for more than 70 percent of cassava consumption in Nigeria,[10] 40-50 percent of consumption in Cameroon, 40 percent of consumption in Ghana,[11] and 30 percent in Côte d'Ivoire.[12] Gari consumption may thus account for about 60 percent of cassava consumption in West Africa. Attieke (consumed widely in Côte d'Ivoire) is fermented, pulverized cassava, but unlike gari it is steamed, not fried, in its final processing stage and therefore has a very short shelf life.

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[10] Ngoddy estimate quoted in Hahn, et al. (1979), 202.

[11] The Cameroon and Ghana estimates are based on discussions with national researchers.

[12] A 1979 Côte d'Ivoire consumption survey (Enquete Budget Consommation) reported consumption of cassava in kilograms per person per year as follows: fresh cassava, 60.5, farine de manioc, 7.8 and attieke, 2.4. Assuming the farine de manioc category is gari and that the reported numbers of farine de manioc and attieke are dry weight, gari consumption is 31.3 kilograms per person per year in fresh root equivalent out of a total of 101.2 kilograms per person per year of cassava consumed (using a conversion rate of 1 kilogram fresh weight = 0.25 kilogram of dry weight for processed products). The survey results indicate rather low consumption of attieke and surprisingly high consumption of fresh roots.

Other common forms of consumption in Nigeria are sun-dried cassava flour (called lafun in southwest Nigeria) and a sticky dough or porridge made from fermented cassava (Nigerian fufu).[13] Boiled, sweet cassava is the predominant form in which cassava is consumed in northern Nigeria and may account for about 10 percent of Nigeria's cassava consumption (Oben and Menz 1980). Pounded, boiled cassava (Ghanaian fufu), also made from sweet varieties, is widely consumed in some rural areas and may account for about 20 percent of cassava consumption in Ghana. Consumption of fresh roots accounts for about 60 percent of cassava consumption in Côte d'Ivoire, according to the national consumption survey (see footnote 12).

In central Africa, the great majority of the cassava is fermented before being consumed. One of the most common products is a fermented and sun-dried flour, processed in the same way as lafun in Nigeria, but called fufu in Zaire. Another major product, chickwangüe, is made from fermented cassava, which is then pounded into a paste and wrapped in large leaves, bound firmly, and steamed or boiled. Chickwanque can be stored up to about a week and is a common traveller's food (Ashraf 1982). Young cassava leaves (pondu) are an important vegetable and source of protein in Zaire and other parts of Central Africa. The leaves are usually crushed and boiled before eating, a process that effectively removes most of the cyanide.

In East Africa, cassava is commonly made into a flour from dried roots or chunks of roots. In Tanzania, the roots are peeled, sliced, dried, and then ground into a flour. Bitter varieties are fermented before being dried. Most of the cassava in Tanzania is sweet cassava, which can also be eaten as fresh root after boiling, frying, or roasting. Flour made from bitter varieties is less preferred than that from sweet varieties in urban areas. In Mozambique, both the roots and leaves are eaten. Harvested roots are usually cut into long pieces and sun-dried, and later pounded into flour and mixed with boiling water. Both bitter and sweet cassava varieties are eaten, but bitter roots are sun-dried for a longer period: two to three weeks. During the severe drought of 1981 an epidemic of spastic paraparesis (paralysis) caused by ingestion of high-cyanide cassava broke out in northern Mozambique. At that time, roots of bitter varieties (which were more tolerant to the drought and therefore more abundant) were being cut in small pieces and dried for only one or two days, and may have been eaten without boiling (Rosling 1986).

Factors Influencing Consumption

Obviously as the population of Sub-Saharan Africa increases, total food consumption will have to increase to prevent worsening

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[13]In Oyo Local Government Area near Ibadan, lafun is made from fermented roots that are pulverized and then sun-dried. Nigerian fufu is made from pulverized, fermented cassava roots that are sieved and packed in plastic bags to drain (Ikpi et al. 1986, 59). In other parts of Nigeria, the methods for producing these products differ slightly. Many other minor products also exist (see Etejere and Bhat 1985).

malnutrition. But, except in situations of extreme poverty or distress, consumers will choose what they consume based on a number of factors including taste, income, prices of food commodities, ease of preparation, and the form of the product.

Apart from growth in population, probably the most important factor influencing the level and form of cassava consumption in Africa is urbanization. The World Bank estimates that the percentage of urban population in Nigeria increased from 15 to 22 percent from 1965 to 1983. The increases in other countries were even more pronounced. Urban population increased from 19 to 38 percent in Zaire, 23 to 44 percent in Côte d'Ivoire, and 26 to 38 percent in Ghana in the same period (Davidson 1986). For urban populations storability of food products is essential to enable food to be transported from producing areas. Goods that are not easily stored have high losses in storage and transport and marketing, substantially adding to their cost. Also, ease of processing the purchased food into its final consumption form is particularly important in urban areas, since in many households all adult members work outside the home for much of the day, and children are likely to be in school and unavailable for household labor.

Storability and ease of processing are two factors that have made gari an important form of cassava consumption in urban areas in West Africa. Jones (1976) argues that consumption of wet, fermented forms of cassava that cannot be easily stored or transported is likely to gradually disappear as urbanization continues in Nigeria. The same argument applies to the rest of Africa; as countries become more urbanized, cassava will increasingly be consumed in forms that are easily transported, stored, and processed by the final consumer.

Income level is another primary determinant of cassava demand. It seems likely that in much of Africa most traditional cassava products have a slightly negative income elasticity of demand--that is, as per capita income increases, per capita consumption decreases.[14] Traditional forms of cassava consumption such as gari in West Africa and cassava flour in East Africa, are not preferred staples. Rice and/or yams are generally preferred over gari in West Africa and maize is preferred over cassava flour in much of East Africa. In central Africa where cassava accounts for more than 40 percent of total calorie consumption for much of the population, per capita consumption of cassava is likely to decrease as incomes rise, ceterus paribus, not because of a dislike for cassava products, but rather because of consumers' desire to diversify their diets.

The price of cassava also helps determine cassava demand, although it is usually argued that the own-price elasticity of demand for cassava is small. This implies that a decline in cassava

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[14]Estimates of income elasticity of demand for cassava based on large sample surveys are not available for African countries, but Dixon (1984) estimated an expenditure elasticity of demand for dried cassava (gaplek) of -0.58 for Indonesian households (weighted average of all expenditure groups). For fresh cassava (which is consumed after boiling the roots), the expenditure elasticity estimate was 0.29.

consumer prices, holding other prices constant, will not induce much additional consumption. The sharp fluctuations in the real price ofgari in the past 10 years in Nigeria provide evidence consistent with an inelastic price elasticity of demand. Relatively small increases in production may have caused large drops in market prices in order to induce consumers to consume more cassava. However, since the actual size of the production fluctuations is not known, it is not possible to estimate the price elasticity of demand with econometric techniques.

Prices of alternative foods also affect cassava demand. In much of Africa in the early 1980s prices of imported food goods were made artificially low relative to domestically produced goods either by an explicit food subsidy (or food aid) or because of an over-valued exchange rate, which made the prices of imported rice and wheat cheap relative to domestically produced food. The price of wheat in a number of countries was less than the price of dried cassava (gari), whereas on the world market the price of wheat was generally two-to-three-times higher than that of dried cassava. Devaluations in a number of African countries (such as Ghana, Sierra Leone, Tanzania, and Zaire) may help restore the competitiveness of domestically produced food crops like cassava relative to imports. In most countries in coastal West Africa, grain imports represent a rather large fraction of total food supply compared with that supplied by cassava. Total calories supplied by grain imports were greater than total calories supplied by cassava in Nigeria in 1979-81. In Central Africa the importance of imported grain relative to cassava is smaller: calories from imported grain were about 25 and 8 percent of calories supplied by cassava in the Congo and Zaire, respectively, in the 1979-81 period.

New forms of cassava consumption could provide a large increase in per capita cassava consumption. Cassava flour is already used to a limited extent as a substitute for wheat flour in baking bread and other foods. Substitution of up to 25 percent cassava flour for wheat flour is possible without a significant reduction in bread quality. Since demand for bread increases with increasing income and urbanization (partly because bread is easy to use and store), the demand for cassava flour could rise substantially. The potential for substitution for wheat flour in baking depends crucially on trade and exchange rate policies, however, which will determine the relative prices and availability of cassava and wheat flours. Apart from use in baking, there is also sizable potential for snack foods made from cassava for urban consumers.

In general, then, it seems likely that consumption of traditional forms of cassava that require extensive processing by the consumer and are difficult to store is likely to become less important as urbanization increases. Per capita consumption of storable products such as gari and cassava flour is also likely to decline slightly as per capita income rises, but the large expected increases in total population in Africa imply significant increases in total consumption of these products. Changes in the prices of other major food staples--maize in east Africa, and yams and rice in West Africa--would also have a major effect on cassava consumption. The scope for significant increases in per capita demand for cassava as food depends on the growth in consumption of new products--especially cassava flour used in baking.

Consumption as Animal Feed and Other End Uses

One potentially large use of cassava is as a calorie source for animal feed. As shown in Table 2, use of cassava as animal feed accounts for only about 2 percent of cassava utilization in Africa. In Europe, however, about 6 million tons of dried cassava pellets are used each year as animal feed (mainly for pigs and poultry). Cassava is part of least-cost feed rations in the European Community (EC) because of the EC's Common Agricultural Policy, which imposes a high variable levy on imported maize but nil or negligible levies on imported cassava, soybean cakes, or maize gluten (the latter two commodities being protein supplements). Approximately four parts of dry cassava and one part of soybean meal substitute for five parts of maize in feed rations (Nelson 1984a). Without a levy on maize imports, imported maize is a cheaper source of calories and protein than the cassava/soybean mixture; therefore, cassava is rarely used by the feed industry in countries where agricultural pricing policy does not result in artificially high maize prices. In Africa, the lack of suitable low-cost protein supplements also inhibits use of cassava as animal feed. Palm kernel cake is in abundant supply in West Africa, but is not a suitable protein supplement to cassava in feed rations for young chicks or layers (which account for about 90 percent of feed consumption in Nigeria) because of its high fiber content and other nutritional qualities. On a small scale, fresh roots of low-cyanide varieties of cassava are fed directly to pigs in Nigeria as well as in Brazil.

The export potential of cassava from Africa as animal feed is less promising. The EC, the major market for dried cassava chips and pellets, is almost saturated, and the EC has placed quotas on imports of cassava from Thailand. (Quotas on other cassava exporters such as Indonesia also exist, but these are nonbinding because Indonesia's exportable surplus is less than their allocated quota.) Competing with Thailand for exports to the limited EC market would be difficult given the low costs of cassava production in Thailand and the economies of scale in shipping from Thailand on large ships. Overvalued exchange rates in most African countries have ensured that domestic cassava prices are far above world export prices. Tanzania has exported dried cassava at a loss in recent years to dispose of government stocks that were deteriorating in storage.

Cassava is also used to make industrial starch in a number of countries. The process requires little technology and can be done on a village level if clean water (necessary to produce white starch) is available. Starch was produced for export in Togo in the 1950s and early 1960s, but the world market for cassava starch has declined markedly due to lower cost alternatives in major consuming countries--maize and potato starch in the United States, Europe, and Japan, for example.[15]

Another potential use of cassava is the production of high fructose syrup (a sugar substitute) from cassava starch. Refined

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[15]Government trade policies in the importing countries is one factor that makes domestic starch cheaper than imported cassava starch.

sugar imports by Nigeria were 645,000 tons in 1984, equivalent to fructose produced from 3.2 million tons of cassava (about 30 percent of Nigeria's production). Production of fructose from either cassava or maize is more expensive than sugar at world prices, though. A small-scale cassava fructose plant in Indonesia could produce fructose at about 20 cents per pound in U.S. currency, compared with a projected long-run world sugar price of 12 cents per pound (Pearson 1987). Ethanol can also be produced from cassava, but as in the case of high fructose syrup, this process is more expensive than the cost of imports. Brazil has produced small amounts of ethanol from cassava, but world oil prices would have to rise substantially above their 1985 levels to make ethanol production from cassava competitive with imported oil.[16]

THE ROLE OF CASSAVA IN FOOD SECURITY

Food insecurity typically threatens the poorer income groups of a country, groups that are often major producers and consumers of cassava. Two aspects of food security are considered here: chronic food insecurity--"a continuously inadequate diet caused by the inability to acquire food" and transitory food insecurity--"a temporary decline in a household's access to enough food (that) results from instability in food prices, food production or household incomes" (World Bank 1986, 1).

Alleviating Chronic Food Insecurity

That cassava is a major staple in many of the countries of tropical Africa that suffer from chronic food insecurity does not imply that cassava is the cause of the food insecurity; on the contrary, because cassava products are among the cheapest sources of calories available in many countries, the crop has a major role in mitigating chronic food insecurity for the poor. For example, the average price per calorie of gari in Nigeria from 1982 to 1984 was equal to that of dried maize, less than half that of rice and about one-quarter the price per calorie of yams. The low price of cassava reflects the relatively low overall labor requirements, flexibility in the timing of labor inputs, and the ability of cassava to produce a crop on marginal lands. The availability of a low-priced staple food like gari is especially important for the food security of lower-income households whose food expenditures make up a large portion of their total incomes.

Increasing production and consumption of cassava is one policy option for countries facing chronic food insecurity. Because cassava can be grown on poor soils with no purchased inputs (such as fertilizers and pesticides), it is suitable for the poorest households. Its flexibility and low labor requirements help to limit peak labor demands and the need to hire outside labor. New production technology is already available for some ecologies, but

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[16]See Nelson (1984b) for further details on the world starch market and ethanol production.

in many cases further research may be required to increase production. Improved marketing and processing facilities may also be needed in some areas. A strategy to increase cassava production should be complemented by an increase in production or availability of other foods with higher concentrations of protein.

Subsidized food imports are an alternative means of improving food security, especially in urban areas. As noted above, direct food subsidies and trade and exchange rate policies have made the price per calorie of imported rice or wheat even less than that of cassava products in major urban centers in many parts of Africa (FAO 1986). Because the lower cost of imported calories is in most cases the result of direct or indirect subsidies, the continued availability of low-cost imports is uncertain, especially in light of foreign exchange shortages in many African countries. Thus a reliance on subsidized imports entails a significant measure of risk for poor urban consumers.

Cassava may play an increasing role in overall food supplies and food security even without explicit government policies. Because of its relative tolerance to poor soils, it may become an increasingly larger part of farming systems in areas of high population pressure on land resources.

Transitory Food Insecurity

Whereas cassava can and does play a role in alleviating chronic food insecurity, the crop is especially well-suited for reducing transitory food insecurity, which in Africa is often caused by drought, disease, and pest attacks on crops. The ability of cassava to produce a crop even under adverse conditions lessens the risk of shortfall of the total food supply. Because the roots of many varieties can be left in the ground unharvested for a period of months or even a few years without deteriorating in quality, a cassava field can provide a safe food bank for a farm household for use as need arises throughout the year. Where markets are available, cassava products may also be sold for cash to purchase other food when other crops fail.

In much of the humid forest zone where cassava is the major staple, there is little risk of drought or serious pest attack. Because cassava is also relatively tolerant to diseases (notwithstanding yield losses due to cassava mosaic virus and cassava bacterial blight), the role of cassava in reducing fluctuations in the total food supply is easily taken for granted, even though cassava is the dominant source of calories. In parts of East Africa where in some years drought greatly reduces production of other staples (especially maize), the importance of cassava in the food security of a region is more obvious. Cultivation of cassava (and sorghum) significantly reduces the risk of drought-related total crop failure.

The importance of cassava in reducing the influence of weather, disease, and pests is heightened in more isolated areas that depend on local production for most, if not all, of their food supplies and that lack substantial trade links with outside food markets. An example is the 1981 drought that affected parts of Nampula Province in northern Mozambique, where locally produced cassava was essentially the only food source available after other crops failed (Rosling 1986).

Cassava's role in food security must not be exaggerated however. Because the edible roots are low in protein and important nutrients, cassava cannot by itself provide food security. And despite its hardiness, the crop is not immune to insect or disease damage or drought.

CONCLUSIONS

Because of the scarcity of reliable data on agricultural production and consumption in Africa, it is difficult, if not impossible, to accurately quantify trends in cassava production and utilization. This paper has instead focused on major factors that have influenced supply and demand in the past and are likely to be key determinants of future trends. The ecological and socioeconomic diversity of Africa ensures that cassava's role in the food system will vary across regions, but cassava is likely to continue to be one of the major food staples in Africa as a whole.

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5
The Evaluation of Cassava Consumption in Latin America

John K. Lynam

Unlike other parts of the developing world, Latin America does not depend on a single carbohydrate staple as the backbone of its diet. Thus while rice is the basic staple in tropical Asia, wheat in temperate Asia and the Near East, maize in East Africa, and cassava in Central Africa, all these starchy staples as well as potatoes are important in Latin America, yet none dominates over the whole region. The reasons for this are many, but two stand out. First, a staple achieves a dominant role in the diet because of its low relative cost, especially as an energy source. In rural areas, cost advantage is usually determined principally by yield advantage, and thus agroclimatic conditions tend to be a principal determinant of food subsistence patterns. Because agroclimatic conditions are quite variable in Latin America and because at least three major starchy staples (cassava, maize, and potatoes) were domesticated in the region, each starchy staple achieved its own niche in the diet and cuisine of rural societies in Latin America.

The other distinguishing characteristic of Latin America, when compared with Africa or Asia, is that the population of the former is predominantly urban. The urbanization process has a distinct effect on food consumption patterns. First, relative prices of food staples change between rural and urban areas. Second, convenience in food purchase and preparation becomes a principal concern in urban-family time allocation. Third, income growth in an urban setting, while leading to some increase in quantity consumed, principally is reflected in more diversity in the diet. Finally, urban areas, at least in South American countries, draw migrants from rural areas where different staples dominate. Although buffered by the other influences, food habits are transferred to an urban setting. The result is significant diversity in consumption patterns both within and across major urban areas.

Staples exist but are not defined at the continental level and only rarely at the country level. Thus, only in Mexico, Honduras, Guatemala, and El Salvador does a single commodity, maize, make up more than 35 percent of average national calorie consumption. Rather, the food staple in a Latin American context is defined by region, rural residence, and income strata. It is at this level that the current role of cassava as a food staple will be discussed.

HIGHLY PROTEAN CASSAVA: THE DIVERSITY OF CONSUMPTION FORMS

Cassava is consumed in Latin America in three principal forms: as fresh root, which is either boiled or fried; as a roasted flour called farinha de mandioca; and as a type of unleavened bread called casabe. Consumption of the processed forms is culturally defined. Casabe is only consumed in the Caribbean basin, particularly the island countries of Haiti, the Dominican Republic, and Jamaica (where it is known as bammies), and on the continent from eastern Venezuela through Guyana and Suriname. Consumption of farinha de mandioca is almost solely confined to Brazil, although it is also found to a limited extent on the border areas of Paraguay and northern Argentina and among the indigenous Indian population in the Amazon basin areas of Venezuela, Colombia, Ecuador, and Peru. Although all are identified as cassava, their consumption form makes them distinctly different foods. They are analogous to the differences between bread and pasta in the case of wheat and choclo and tortillas in the case of maize.

Consumption form is a dominant factor in the role cassava currently plays in the diet and its future prospects, especially in urban food consumption. Form influences preferences, marketing costs, consumer convenience, and use within the meal. The functional role of form in production, marketing, and consumption of cassava is best analyzed if the fresh root is distinguished from the processed products.

Fresh cassava has all the salient characteristics of the root and tuber crops. The cassava root is about two-thirds water, although this still results in a starch content significantly higher than all the other major root and tuber crops. In its cooked form, cassava has an energy density as high or higher than polished rice. The disadvantage of this high water content lies in the higher marketing and storage costs for this bulky, low-value product. These costs are exacerbated by a very short shelf-life for cassava roots. When exposed to oxygen, usually as a result of wounding during harvest, the roots develop a blue-black pigmentation in the vascular tissue accompanied by the desiccation of the starch containing cells (Janssen and Wheatley 1985). From 24 to 72 hours after harvest, this process makes the fresh root unacceptable for human consumption. Costs increase dramatically the further the consumption point is from the production point. Although consumption of fresh roots is found throughout tropical Latin America, consumption is high only in rural areas where cassava production is widely diffused.

Processing eliminates the water, stabilizes the product, and vastly improves its marketing characteristics. Consumption of processed products is thus more diffused, although still limited by its cultural boundaries. Processing also reduces the cyanide (HCN) content of the roots, a necessity with "bitter" varieties--those having cyanide levels in the parenchyma exceeding 100 milligrams/kilogram (on a dry weight basis). The production of casabe and farinha de mandioca are, to a large extent, based on bitter varieties. Both casabe and farinha de mandioca are of ancient origin: archaeological finds in Venezuela of clay griddles for making casabe have been dated at 3000-7000 B.C. (Renvoize 1972). That processing to eliminate the HCN was necessary for the domestication of the crop is a reasonable hypothesis. Lathrap (1973) and Spath (1973), however, both argue that the original purpose of cassava processing was not to remove the HCN per se but rather to support trade networks in the Amazon and Orinoco basins.

From the earliest times, the reason for processing has principally been to improve cassava's marketing characteristics and not necessarily to improve its consumption characteristics. A reverse pattern is found in grains. Processing of grains takes place nearer to the consumption point than the production point, and the reason is principally to transform the grain to a form that is usable by the consumer. Rice milling, the production of wheat flour, or the grinding of maize meal or dough (called nixtamal in Mexico) are prime examples of forward linkages between grain staple production and industrial development. In cassava, those linkages are forged at the production point. Unlike the grains, production and processing of cassava have developed as an integrated system. The marketing system that results is thus specific to the cassava product that is produced.

Form is essential to understanding the role of cassava in the agricultural economy. It is also essential to understanding cassava consumption. Although fresh roots, farinha de mandioca, and casabe are the principal forms in which cassava is marketed and consumed, a large number of other forms also exist. Tapioca pearl is produced in Brazil and is used to make a large wafer called beiju. In Pará State in Brazil, farinha de tapioca is produced. This is a puffed tapioca pearl that is eaten in the larger cities of the Amazon Basin. Artisanal production of starch also occurs in many areas of Latin America. In Colombia, the starch is fermented and combined with cheese to make a bread called pandebono. In Paraguay, the unfermented cassava starch forms the basis of a bread form called chipa. As reviews by Schwerin (1971) and Lancaster et al. (1982) attest, the forms in which cassava is consumed are multifarious, and all follow from variations in the form of processing.

The antiquity and multiplicity of consumption forms and the relatively well-defined consumption boundaries of each raise the issue of what has constrained their diffusion throughout the whole of Latin America and, conversely, whether there is potential for consumption of these products in areas where they are not currently eaten. Since there are no definite answers, one can only hypothesize. As cassava is grown throughout tropical Latin America, there is no lack of knowledge concerning production of the crop. The processing technology is simple and easily transferable, and it is reasonable to suppose that there is a sufficient amount of intercourse between regions to facilitate the transfer of processing knowledge. The answer seems to derive most logically from a certain rigidity in preference for the basic local carbohydrate staple. Indigenous cuisines developed around the preferred local staple evolved in rural areas. Differences in food preparation methods, complementary foods, and the structure of the meal reflect in large part the particular characteristics of the staple. The difference between Mexican cuisine based on the tortilla and the food habits of the Brazilian northeast, where the base is farinha de mandioca, illustrate first, the central role of the staple and, second, the difficulty in substituting another staple. How rice and wheat have come to play a larger role in urban diets is discussed later but the conclusion here is that traditional cassava products, that is casabe and farinha de mandioca, will not be consumed outside their current areas of influence.

CURRENT PATTERNS OF CASSAVA CONSUMPTION

Identifying where cassava is consumed will define both its current role in the diet and present constraints on increased consumption. By 1980, cassava was a dominant caloric staple on a national basis in only one country, Paraguay (Table 1). In that country, it was second only to maize as a calorie source and contributed 13 percent of total food energy supplies. In Brazil and Colombia, cassava is an important but not dominant carbohydrate source in the national diet, contributing more than 5 percent of national calorie requirements. Cassava is of minor importance in the maize-based diets of Mexico and Central America. In all the rest, cassava adds significantly to the diversity of the national diet but does not reach the importance of the three principal grains--maize, rice, and wheat.

Table 1--Daily calorie consumption derived from principal starchy staples, Latin America, 1979-81

Country	Total Calories/ Day	Cereals			Roots and Tubers	
		Wheat	Rice	Maize	Cassava	Potato
		(calories/capita)				
Bolivia	2,082	463	1081	277	69	159
Brazil	2,578	350	418	207	183	24
Colombia	2,494	140	387	289	118	108
Costa Rica	2,653	303	371	208	3	20
Dominican Republic	2,130	194	442	47	37	3
Ecuador	2,114	199	255	176	41	60
Guatemala	2,138	205	36	977	2	9
Haiti	1,905	218	145	258	66	3
Honduras	2,135	130	75	878	5	5
Jamaica	2,544	556	204	101	23	7
Mexico	2,890	323	56	1,061	22	2
Panama	2,338	201	480	207	36	10
Paraguay	2,839	277	128	445	372	5
Peru	2,195	386	297	219	42	140
Venezuela	2,646	351	251	339	28	24

Source: Food and Agriculture Organization of the United Nations, Food Balance Sheets, 1979-81 Average (Rome: FAO, 1984).

Disaggregating consumption gives a clearer picture of cassava consumption distribution. Table 2 indicates distinct differences in consumption levels depending on agroclimatic conditions and on rural-urban residence. For fresh cassava, the highest consumption levels are consistently found in the rural areas. High rates of consumption are found in the jungle areas of Ecuador and Peru, extending into the Santa Cruz area of Bolivia.

Table 2--Annual per capita consumption of cassava by region and rural-urban status in Colombia, Peru, and Brazil

Country and Region	Rural	Urban: Town	Urban: City	Average
		(kilogram)		
Colombia (1981)				
Atlantic Coast	72.7	42.3		54
Eastern Region	39.0	23.5		31
Bogota	...	7.2		7
Central Region	35.4	12.5		20
Pacific	17.3	8.3		12
Peru (1971-72)				
North Coast	11.0	10.6	9.7	11
North Sierra	18.0	7.5	...	17
Central Coast	n.a.	n.a.	n.a.	4
Central Sierra	n.a.	n.a.	n.a.	2
South Coast	n.a.	n.a.	n.a.	5
South Sierra	n.a.	n.a.	n.a.	1
High Jungle	82.2	14.2	...	71
Low Jungle	101.8	78.6	15.5	65
Metro Lima	...	...	4.0	4
Brazil (1975)				
Fresh cassava				
North	n.a.	1.8	0.4	2
Northeast	5.2	3.4	1.9	4
Southeast	4.7	2.8	1.7	3
South	23.2	7.0	5.7	16
Center-West	n.a.	8.2	2.6	16
Farinha				
North	n.a.	49.0	45.5	54
Northeast	55.0	31.9	21.4	44
Southeast	10.5	3.3	2.2	5
South	4.4	3.2	0.5	4
Center-West	n.a.	3.7	2.2	4

Sources: Luis Sanint et al., "Analisis de los Patrones de Consumo de Alimentos en Colombia a Partir de la Encuesta de Hogares DANE/DRI de 1981," Revista Planeacion y Desarrollo 17 (1985): 39-68; P. Lizardo de las Casas Moya, "A Theoretical and Applied Approach Towards the Formulation of Alternative Agriculture Policies in Support of the Peruvian Agricultural Planning Process." (Ph.D. dissertation, Iowa State University, 1977); and Fundaçao Instituto Brasilero de Geographia e Estadistica, Estudo Nacional da Despesa Familiar (Rio de Janeiro: IBGE, 1977).

The highly populated eastern part of Paraguay has possibly the highest per capita consumption of fresh cassava in Latin America, and this belt of fresh cassava consumption continues across northern Argentina and into southern Brazil and Mata Grosso do Sul, although consumption levels are lower than in Paraguay. The third belt of fresh root consumption extends along the Atlantic coast of Colombia into the western part of Venezuela, and in Colombia from the coastal region up the Magdalena River valley into the Santanderes.

In all these areas, fresh root consumption declines dramatically moving from rural areas to towns and to large metropolitan areas. An in-depth study on the Atlantic coast of Colombia (Janssen 1986) found that this relationship characterized root crops in general (Table 3), but was especially marked in cassava. The cost of moving a bulky, perishable product significantly increases retail prices, causing consumption levels to be lower.

Table 3--Annual per capita consumption of root crops by residence on the Atlantic coast of Colombia, 1983

Residence	Consumption		Cassava
	Yam	Cassava	Price
	(kilograms)		(US$/ kilogram)
Cassava producer	85.7	170.4	0.10
Rural village	41.9	82.9	0.21
Intermediate town	30.8	53.5	0.27
Metropolitan area	30.5	30.5	0.44

Source: Willem Janssen, "Market Impact on Cassava's Development and Potential in the Atlantic Coast Region of Colombia" (Ph.D. dissertation, Agricultural University of Wageningen, 1986).

Consumption patterns of *farinha de mandioca* are influenced more by regional preferences in Brazil than by rural-urban residence. Thus *farinha* consumption declines dramatically moving from north to south and rather more moderately moving from rural to urban areas. *Farinha* is the major calorie source in the north and northeast of Brazil and makes up about a quarter of average daily calorie intake. Even in urban areas in the north and northeast, *farinha* is a major calorie source, contributing 25 percent of average daily calorie intake in Belem, Pará, and 16 percent in Salvador, Bahia. Thus, in the poorer regions of Brazil, cassava has become a dominant staple, essentially by linking cassava's high productivity under marginal conditions with processing at production points.

THE RAVAGES OF TIME: TRENDS IN CASSAVA CONSUMPTION

Per capita consumption of cassava as a direct food source has declined in Latin America over the past two-and-a-half decades. Cassava is not alone in this regard. Consumption of beans and maize for direct human consumption have also declined. Historical analyses of consumption trends of caloric staples in countries such as the United States and Japan suggest that this is a natural tendency in the process of development. Rising incomes and the urbanization process lead naturally to a greater demand for diversity in the diet. Almost by definition, the food that declines as a percentage in the diet is the principal carbohydrate source.

Charting the size of the changes in cassava consumption is difficult, given the unreliability and scarcity of data on cassava. The weakest data source is food balance sheets, essentially because they depend on accurate production estimates as a starting point, and for cassava these are known to be highly unreliable. These estimates probably do represent basic trends, however, and by comparing 1960 to 1980 figures (Table 4), the tendency over the period was for cassava consumption to decline. These rather crude approximations, nevertheless, are supported by those few cases where food budget surveys can be compared over time (Table 5). In Peru, per capita consumption between 1965 and 1972 declined moderately in every sector except the urban areas of the eastern rainforest. There, as road infrastructure improved, cassava was obviously developing as a major food source supplying the expanding cities in the region. In Colombia, on the other hand, cassava consumption in all the principal metropolitan areas declined between the late 1960s and early 1980s. Finally, in Brazil between the early 1960s and 1975, except for fresh cassava in urban areas in the south, consumption of both _farinha_ and fresh cassava have declined, especially _farinha_ in the south and southeast of the country.

Table 4--Trends in the per capita consumption of cassava derived from the food balance sheet estimates, selected countries, 1964-66 and 1979-81

Country	1964-66	1979-81
	(kilograms)	
Costa Rica	6.2	1.3
Cuba	21.8	19.0
Dominican Republic	27.4	13.5
Brazil	107.4	79.9
Colombia	25.8	49.4
Peru	29.6	17.0
Bolivia	24.7	27.8
Venezuela	25.1	11.5
Paraguay	180.8	156.6

Sources: Food and Agriculture Organization of the United Nations, _Food Balance Sheets, 1979-81 Average_ (Rome: FAO, 1984).

Table 5--Changes in consumption of cassava from the 1960s to the 1970s as portrayed in food budget surveys in Colombia, Peru, and Brazil

Country and Region	Annual Per Capita Consumption 1960s	1970s
	(kilograms)	
Colombia (1968 and 1981)		
Bogota	10.4	7.2
Medellin	13.4	9.8
Cali	18.2	7.3
Barranquilla	29.4	27.2
Peru (1964 and 1971)		
Coast		
Rural	11.5	8.4
Urban	7.3	5.5
Sierra		
Rural	n.a.	6.2
Urban	2.8	1.5
Selva		
Rural	111.6	89.2
Urban	10.9	20.4
Brazil (1960 and 1975)		
Fresh cassava		
North		
Cities	0.4	0.4
Northeast		
Rural areas	10.3	5.2
Towns	n.a.	3.4
Cities	1.1	1.9
Southeast		
Rural areas	15.8	4.7
Towns	3.6	2.8
Cities	3.7	1.7
South		
Rural areas	68.7	23.2
Towns	4.1	7.0
Cities	1.6	5.7
Farinha		
North		
Cities	58.9	45.5
Northeast		
Rural areas	69.6	55.0
Towns	n.a.	31.9
Cities	26.2	21.4
Southeast		
Rural areas	19.1	10.5
Towns	4.9	3.3
Cities	4.3	2.2
South		
Rural areas	16.2	4.4
Towns	5.6	3.2
Cities	3.0	0.5

Source: National Food Budget Surveys compiled by Centro Internacional de Agricultura Tropical, Cali, Colombia.

At issue then is not the fact that cassava consumption has been declining in Latin America, but rather the reasons behind these trends. From an understanding of causes, a prognosis can be made about the future of cassava as a food source in the Latin American diet. Cassava has long been painted as an inferior food and a food of the poor, but there has been little rigorous analysis to test this hypothesis. Moreover, income effects on consumption in many cases may be dominated by other factors, especially substitution due to changes in relative prices and the effects of urbanization. The discussion, thus, turns to an analysis of these issues.

THE INFERIOR GOOD DEBATE: IN SEARCH OF AN ELASTICITY

The most direct means of estimating price and income elasticities is through the use of time-series data. In cassava, this is restricted by the quality of the national supply and utilization estimates. Nevertheless, though absolute values may be unreliable, relative change from year to year is probably more accurately captured within the series. Estimates of demand functions for cassava using national, time-series data were attempted for a number of countries (Table 6) (Sanint 1986). Besides income, own price, and the price of substitutes, an urbanization variable was also included. Urbanization, in those countries where cassava is consumed in the fresh form, is expected to have a particularly strong impact on national demand for cassava, essentially because of the difference in relative price of cassava and caloric substitutes in rural versus urban settings.

Table 6--Time series estimates of demand elasticities for fresh cassava, selected countries, 1965-84

Variable	Colombia	Ecuador	Paraguay	Peru
Own price	-0.30	-2.08	-0.10	-0.20
Income	1.60	1.38	-0.13	0.03
Urbanization	-0.16	-0.99	-0.13	-1.03
Wheat price	n.a.	0.45	0.07	0.11
Rice price	n.a.	2.42	...	0.64

Source: Estimates provided by Centro Internacional de Agricultura Tropical, Cali, Colombia.

The results of these estimates are remarkably good, since all the elasticities are of a theoretically correct sign and the majority are statistically significant. Not too much stock should be put in the absolute value of these estimates, but the overall picture that arises is correct (to be supported later by additional analysis). The first conclusion that can be drawn is that cassava in these countries is not in general an inferior good. Only in

Paraguay, where consumption levels virtually approach a biological limit, is the income elasticity negative. In Ecuador and Colombia, the data would suggest that cassava is even income elastic. This result follows essentially because demand has been corrected for the effects of urbanization, which are all negative and, except in Colombia, highly significant. Unlike grains, urbanization completely changes the structural nature of the cassava market. Most of these elasticities are high. In Paraguay, urban consumption levels are high because of a well-developed marketing system for cassava, and here the effects of urbanization are not as pronounced.

The own-price elasticity for cassava is generally low, but highly significant. However, even more than the own-price response, cassava demand responds significantly to changes in the prices of other caloric substitutes. Any decline in the price of grain substitutes, due, for example, to technical change or to policy intervention, has as well a significant effect on consumption of cassava. In summary, then, the declining consumption of cassava is not due to a view of the commodity as an inferior good, but rather to more fundamental changes in the overall economy and the structure of food demand, which in turn have influenced the pricing of competing grain staples.

A more reliable data base on which to base elasticity estimates is consumer budget surveys. Unfortunately, those with national coverage that include both expenditure and quantity or price data are rare. Colombia has most recently carried out such a survey. Elasticity estimates for cassava based on this survey (Sanint et al. 1985) support the cross-section estimates in Table 7, that indicate cassava is not an inferior good and its demand is relatively price-responsive. The income elasticity (also corrected with dummy variables for rural-urban residence) is somewhat lower and the price elasticity significantly higher in absolute value, when compared with the time series estimates for Colombia. Although these estimates give a truer picture of the value of the elasticities, they nevertheless support the conclusions drawn from the time-series estimates.

Table 7--Cross-section estimates of demand elasticities for fresh cassava by income strata, Colombia, 1981

Income Quintile	Fresh Cassava	
	Price	Income
1	-0.84	1.47
2	-0.92	1.23
3	-0.93	0.27
4	-0.92	0.64
5	-0.83	-0.04

Source: Luis Sanint et al., "Analisis de los Patrones de Consumo de Alimentos en Colombia a Partir de la Encuesta de Hogares DANE/DRI de 1981," <u>Revista Planeacion y Desarrollo</u> 17 (1985): 39-68.

Moreover, the cross-sectional data allow estimates by income strata; as expected, the income elasticity varies significantly between income strata. Cassava is very income elastic in the two lowest income quintiles and only in the highest income stratum does the income elasticity become slightly negative (although this coefficient is not significantly different from zero). Thus, all but the most wealthy will increase cassava consumption as their incomes rise. The poor, who still have calorie consumption levels below minimum standards (Sanint et al. 1985) are especially responsive to changes in income and will increase their consumption of cassava at a greater rate than the rate of increase in income.

The responsiveness of cassava consumption of the poor to changes in price and income is supported by results from the Dominican Republic (Musgrove 1985). Per capita cassava consumption on average is higher in the Dominican Republic than in Colombia, and the poor are much more responsive to cassava price changes than income changes, though the response to income is still significantly positive. The Colombian and Dominican Republic results suggest a general tendency for cassava consumption to be more responsive to income than to price changes, the lower the existing level of per capita consumption. Also, although the data are limited, consumers appear to be more responsive to price at higher general levels of consumption, suggesting a marked tendency to substitute for other caloric staples. This result reflects the greater diversity in the Latin American diet, whereas in Asia, for example, this degree of substitution does not occur in rice, the dominant staple, even at high consumption levels.

Purchase and consumption of different foods is contingent on those commodities meeting basic consumer needs, such as taste, nutrient needs, minimal preparation time, and diversity in the diet. This fact gives rise to differences in preferences between commodities and to perceived differences in quality for most food commodities; these differences in turn lead to price differentials. Thus, consumers' perception of cassava in many countries is not in terms of a single, generalized commodity with quality gradations as is the case for rice. Rather, _farinha_ and _casabe_ are distinctly different food commodities from the fresh root. In any analysis of demand for cassava where different products are consumed, it is critical that the different products be analyzed independently before making an assessment of future demand for cassava as a whole.

The need to discriminate between cassava products is particularly important in Brazil, where both the fresh root and the processed product, _farinha de mandioca_, are major items in the diet. In Brazil, the distinction between products is maintained from production to consumption. Farmers distinguish between the low-cyanide or sweet, varieties called _aipim_, and the high-cyanide or bitter varieties, called _mandioca_. They are kept separate, virtually as distinct crops, from production through marketing and consumption. _Farinha_ is the major consumption item, essentially because of its storability and lower marketing margins, and is the principal source of calories in the northeast.

Farinha behaves as the classic staple. Because it is significantly cheaper than any other carbohydrate source, consumption levels are high among the poor. As incomes increase, consumers tend to diversify their source of calories. In Brazil, _farinha_ does have a negative income elasticity (Table 8); yet in the lower income strata, consumption of farinha increases as incomes rise. Particularly in the northeast of Brazil, income levels among the poor are not sufficient to maintain adequate levels of calorie consumption. Thus, with increasing income, the poor will consume more farinha. However, these same consumers are very responsive to changes in farinha prices, again indicating a desire to diversify when the opportunity arises.

The substitution process is further supported by significant cross-price elasticity between farinha and wheat flour. In evaluating commodity substitution in Brazil, it is necessary to separate substitution due to short-term swings in relative prices of caloric staples from the effects of a long-term change. The introduction of a subsidy on wheat in the early 1970s resulted in a long-term shift in the relative price of calories between farinha and wheat products. The effect has been to speed up the substitution process and, through more basic structural changes in tastes and the diet, to limit the potential degree of reverse substitution should the subsidy be lifted.

Demand parameters for fresh cassava in Brazil, however, follow a similar pattern to those presented for other countries. That is, fresh root consumption responds positively to increasing income, with the lower income strata being particularly responsive. Moreover, consumers are responsive to price changes in fresh cassava, as exhibited by the estimated price elasticity of -1.9. Thus, in Brazil, a duality of sorts exists in the demand for cassava: farinha exhibits the characteristics of an inferior good, and fresh cassava, the characteristics of a normal good.

Is cassava then an inferior good in Latin America? In a very narrow sense, yes. Farinha de mandioca in Brazil does have a negative income elasticity, and since farinha makes up 90 percent of cassava consumption as a food source in Brazil, and Brazil in turn makes up about 75 percent of food consumption of cassava in Latin America, then a weighted income elasticity for cassava as a food source in Latin America would likely be slightly negative. This conclusion, however, extends a result based essentially on the extreme importance of farinha in the north and northeast of Brazil (these two areas account for 86 percent of Brazilian consumption of farinha) to cassava in Latin America as a whole. Outside this limited area, the conclusion does not hold that cassava is an inferior good because cassava is consumed principally in a fresh form. The available evidence suggests that there is significant elasticity in the demand for fresh cassava. Thus, to explain the decline in the consumption of fresh cassava, it requires a more in-depth analysis of the effects of urbanization and of changes in relative prices.

THE URBANIZATION OF CASSAVA CONSUMPTION: THE PRICE PAID FOR MARKETING

The most striking feature about consumption patterns of fresh cassava is the difference between rural and urban areas. Not only is the pattern universally consistent, but the differences in per capita consumption are indeed large (Table 9).

Table 8--Income and price elasticities for *farinha* by income strata in Brazil

Elasticity/Income Level	South		Southeast		Northeast		North
	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Income							
Lowest income group	-0.2703	0.3236	-0.8612	0.3236	0.0026	-0.0254	0.3670
Second income group	-0.3441	0.0037	-0.7111	0.0037	-0.1813	-0.1893	0.0976
Third income group	-0.4180	-0.3163	-0.5610	-0.3163	-0.3651	-0.3532	-0.1719
Fourth income group	-0.5156	-0.7393	-0.3627	-0.7393	-0.6081	-0.5699	-0.5280
Highest income group	-0.5656	-0.9562	-0.2609	-0.9562	-0.7327	-0.6811	-0.7101
Own price							
Lowest income group	-1.3984	-2.1398	-0.3085	-2.1398	-0.6734	-0.5306	-0.0037
Second income group	-1.1371	-1.1451	-0.2480	-1.1451	-.6451	-0.4897	-0.1679
Third income group	-0.8758	-0.1503	-0.1875	-0.1503	-0.6169	-0.4488	-0.3321
Fourth income group	-0.5304	0.0000	-0.1075	0.0000	-0.5796	-0.3947	-0.5492
Highest income group	-0.3533	0.0000	-0.0664	0.0000	-0.5604	-0.3670	-0.6606
Price of rice							
Lowest income group	1.1079	0.8977	2.5697	-.8977	0.6524	0.3622	1.3133
Second income group	0.9213	-0.3869	2.2233	-0.3869	0.1959	0.2762	1.0589
Third income group	0.7347	-1.6715	1.8770	-1.6715	-0.2606	0.1901	0.8045
Fourth income group	0.4881	-3.3696	1.4191	-3.3696	-0.8641	0.0764	0.4683
Highest income group	0.3616	-4.2407	1.1842	-4.2407	-1.1736	0.0181	0.2958
Price of wheat							
Lowest income group	1.5431	2.0210	1.5332	2.0210	0.0000	-0.5599	0.7813
Second income group	0.9480	1.3265	1.1311	1.3265	0.0550	-0.1411	0.1220
Third income group	0.3530	0.6321	0.7291	0.6321	0.5006	0.2777	-0.5373
Fourth income group	-0.4336	-0.2860	0.1976	-0.2860	1.0896	0.8313	-1.4089
Highest income group	-0.8371	-0.7569	-0.0750	-0.7569	1.3917	1.1153	-1.8560

Notes: Elasticities were estimated using cross-sectional data and a translog functional form. Elasticities were evaluated at the following income levels: lowest = ½ minimum salary; second = 1 minimum salary; third = 2 minimum salaries; fourth = 5 minimum salaries; and highest = 8 minimum salaries.

Table 9--Estimates of average per capita consumption of fresh cassava in rural and urban areas of selected countries

Country/Year	Consumption	
	Rural	Urban
	(kilograms)	
Brazil (1975)	10.6	3.1
Colombia (1981)	41.1	17.2
Peru (1972	18.3	5.6
Paraguay (1986)	340.0	120.0
Venezuela (1975)	27.4	5.0
Dominican Republic (1975)	42.3	20.0

Source: John Lynam and Douglas Pachico, Cassava in Latin America: Current Status and Future Prospects (Cali, Colombia: Centro Internacional de Agricultura Tropical, 1982).

The pattern is most clear in the data for certain regions, especially where cassava can be compared with other starchy staples. Such data exist for the Atlantic coast of Colombia (Table 3). In this region, cassava consumption declines precipitously from the point of production so that consumption in the large cities is less than 20 percent of that of cassava producers. Neither plantain nor rice show such differences, and potato, an imported commodity in the region, exhibits the opposite pattern. These differences in cassava consumption based on residence are not due to any significant difference in how cassava is used in the home (Table 10). Cassava is eaten at the same meals and prepared in the same manner, but the number of meals per week at which cassava is served and the size of the portion per serving vary. The primary causes of these differences are price and convenience. Cassava is more than five times more expensive in metropolitan areas than the opportunity cost to cassava producers. Moreover, implicit costs in buying cassava daily in urban areas make cassava a far less convenient food than, say, rice.

The price difference between cassava producer and metropolitan consumer reflects the significant marketing margin for the crop. These margins derive from a marketing structure that must move a bulky, perishable crop from many small-scale producers to consumers who buy their cassava in small lots at convenient locations. A comparison of implicit marketing margins for cassava versus rice in major Latin American cities shows that the price that cassava consumers must pay for marketing services is in general higher than that for rice on an absolute basis (Table 11). Considering that the marketing margin for rice also includes a milling component, the costs of cassava marketing are high indeed. On a relative basis (that is, as a percent of the retail price), the cost of marketing services is significantly higher for cassava. From 50-90 percent of

Table 10--Distribution of cassava consumption over various meals, by rural or urban residence, Atlantic Coast, Colombia, 1983

Item	Metropolitan Urban Areas	Intermediate Urban Areas	Rural Areas	Producers
Percent of total consumption of cassava consumed at breakfast	30.0	53.5	50.2	42.3
Most important form of preparation	boiled	boiled	boiled	boiled
Percent of total consumption of cassava consumed at lunch	69.0	43.6	39.7	49.1
Most important form of preparation	in soup	in soup	in soup	in soup
Percent of total consumption of cassava consumed at dinner	1.0	3.0	10.0	8.6
Most important form of preparation	boiled/ fried	boiled/ fried	boiled/ fried	boiled/ fried
Number of meals per week including cassava	4.9	6.3	8.3	11.0
Average portion of cassava served per person (grams)	118	158	191	313
Price (US$/kilogram)	0.45	0.27	0.26	0.08
Number of observations	80	80	160	160

Source: Willem Janssen, "Market Impact on Cassava's Development Potential in the Atlantic Coast Region of Colombia" (Ph.D. dissertation, Agricultural University of Wageningen, 1986).

the eventual consumer price for fresh cassava is allocated to marketing services. These margins essentially reverse the relative price of cassava and competing starchy staples between rural and urban markets. In rural production zones, cassava is normally the most inexpensive source of calories, especially compared with grain crops. In urban areas, on the other hand, fresh cassava is significantly more expensive on a per calorie basis than competing grains. Clearly, consumption levels adjust to this market change in relative prices.

Table 11--Marketing margins for fresh cassava in principal Latin American countries

Country/ Region	Retail Price	Marketing[a] Margin	Margin as Percent of Retail Price	Retail Price	Marketing[a] Margin	Margin as Percent of Retail Price
Brazil (1983)						
Pernambuco	125.2	110.9	89	326.5	146.5	45
Rio de Janeiro	163.2	143.4	88	353.7	176.7	50
Sao Paolo	175.0	161.3	92	319.5	131.5	41
Rio Grande do Sul	112.7	89.1	79	320.2	167.2	52
Paraguay (1983)						
Country average	28.0	18.0	64	143.0	60.0	42
Venezuela (1983)						
Caracas	3.6	2.1	59	5.0	2.6	51
Panama (1983)						
Country average	0.3	0.2	75	0.7	0.4	50
Dominican Republic (1984)						
Country average	0.5	0.3	61	0.9	0.2	27
Jamaica (1986)						
Country average	1.9	0.9	49	2.8[b]	0.9	31
Colombia (1981)						
Bogota	24.9	19.2	77	40.2	18.8	47

Source: Data provided by Centro Internacional de Agricultura Tropical.

[a]The marketing margin is the difference between the farm-level and retail price.

[b]Maize instead of rice.

The implication of the high price for urban cassava on trends in aggregate consumption have been markedly negative in the rapidly changing economic environment that existed in Latin America throughout the postwar period. During that time, Latin America shifted from being principally rural-based to being an urban-based economy. High rates of rural-urban migration have shifted the population distribution in Latin America from almost 60 percent in the rural sector in 1950 to 30 percent in 1985. The urbanization process has completely changed the structure of starchy staple consumption in Latin America, with consumption patterns shifting from staples such as cassava, maize, plantains, and potatoes, to distinctly urban staples such as rice and wheat. With rural population barely growing in most countries, and urban population growing rapidly, aggregate per capita consumption of cassava has declined over time.

Nevertheless, in spite of the negative effect of urbanization, total demand for cassava should continue to increase, although at a rate lower than that suggested solely by growth in population and income. Disaggregating the growth components in total demand, as is done for Colombia in Table 12, clearly shows the importance of the consumption weights on growth in total demand. More importantly, however, though total demand may be growing at a modest rate, the data would suggest that demand for marketable surpluses is growing at a very rapid rate indeed. As cassava consumption shifts from principally a subsistence orientation to one based on purchased roots, the implication is that market demand is growing very rapidly indeed. Thus, aggregate trends in cassava consumption can significantly mask the dynamics of actual cassava markets. Because of the nature of the crop, however, there is little available data on marketed surpluses, and therefore little scope for rigorous price analysis in fresh-cassava markets.

Table 12--Disaggregation of demand parameters for fresh cassava in rural and urban areas, Colombia, 1981.

Parameters	Rural		Urban
		(percent)	
Population growth	-0.1		3.7
Per capita income growth	2.5		1.4
Demand growth	0.6		4.2
Income elasticity	0.28		0.38
Weighed average[a]	0.51 (0.6)	+ 0.49 (4.2)	= 2.4

[a]Weights are the distribution of total consumption between rural and urban areas in 1981.

The consumption of fresh cassava in Latin America is in transition. Because of rapid urbanization, the locus of consumption is shifting from rural areas where per capita consumption levels are high to urban areas where per capita consumption is relatively low. In most Latin American countries, cassava is thus shifting from being a starchy staple to being more of a vegetable crop, but one with a significant elasticity in demand. Thus, while aggregate trends are downward, markets for fresh cassava tend to be quite dynamic. This conclusion is seemingly contradicted, however, by the decline in urban per capita consumption levels that have apparently occurred in Colombia, in southeastern Brazil, and in coastal Peru. To evaluate this, the discussion turns to the last factor influencing cassava demand, the price of substitutes.

CASSAVA AND THE POLITICAL ECONOMY OF THE URBAN STAPLE

Urban food prices entered the Latin American political arena during the rapid urbanization and industrialization process of the postwar period. Urban poverty and malnutrition, the perceived need to control upward pressure on urban wages, and the politics of managing inflation, all induced most Latin American governments to implement controls on prices of major urban staples. These controls focused on grains, especially those where imports could be used as a means of either controlling prices or reducing subsidy costs, that is, where domestic production was also supported. Maize in Mexico and wheat and rice in other Latin American countries were the principal markets in which governments intervened. In general, mechanisms were developed to support domestic producers of these grains. Policies, however, were not implemented for domestic producers of carbohydrate substitutes, especially cassava.

Because of the significant cross-price elasticities between cassava and prices of major grains, the interventions in grain market can have a marked effect on cassava consumption. Retail price trends in Latin American countries bear out this scenario. In virtually all Latin American countries over the past decade and a half, the real price of fresh cassava at the retail level has risen (Table 13), a trend that at least partially supports the relatively dynamic nature of cassava markets, resulting in some upward pressure on cassava prices. On the other hand, prices of competing grains have fallen. In some cases for rice--in Colombia, for example--this has been due to the introduction of new technology. However, in the majority of cases, the principal cause has been price policy, aided in the case of wheat by a falling international price and a tendency to overvalue the exchange rate. Because governments intervene in wheat markets and because wheat subsidies are used in many countries, however, declining international prices have aided governments in effecting policies, but they were not the principal cause of declining domestic prices.

Table 13--Annual percentage change in retail prices of fresh cassava, wheat flour, and rice (in constant prices), selected countries.

Country/Period	Fresh Cassava	Wheat Flour	Rice
		(percent)	
Colombia (1960-84)	1.7	-3.0	-3.4
Venezuela (1965-84)	3.8	3.0	-0.5
Peru (1966-83)	0.2	-0.8	-1.5
Paraguay (1968-83)	1.4	-2.1	-1.2
Ecuador (1970-84)	2.5	-0.4	-0.2
Brazil (1969-85)	-0.2	-1.6	-0.1

Source: Data provided by Centro Internacional de Agricultura Tropical.

Prices of both cassava and substitutes have played a dominant role in cassava consumption trends. This is clearly shown in both the time-series and cross-sectional demand estimates. Moreover, the effect of prices is clearly portrayed when consumption estimates over time are matched with changes in relative prices. In the case of Cali, Colombia, per capita consumption has declined as a result of changing relative prices of cassava and rice (Table 14). The most dramatic case, however, is that of _farinha_ in Brazil (Table 15). Not surprisingly, _farinha_ consumption has declined as prices relative to wheat flour went from 0.6 to 3.0. While _farinha_ consumption halved, wheat consumption doubled, principally motivated by a massive subsidy on wheat consumption.

Table 14--Changes in real retail prices and average per capita consumption, Cali, Colombia, 1970-82

	Change in Price, 1970-82	Change in Consumption, 1970-82
	(percent)	
Chicken	-12	267
Wheat	-10	109
Potato	3	104
Beans	25	16
Rice	36	13
Beef	54	0
Pork	93	-51
Maize	162	-61
Cassava	191	-53

Source: Douglas Pachico, N. de Londoño, and M. Duque, "Economic Factors, Food Consumption Patterns, and Nutrition in Cali, 1982," Centro Internacional de Agricultura Tropical, Cali, Colombia, 1983 (mimeographed).

Table 15--Relationship between prices of _farinha de mandioca_ and wheat flour and consumption, Brazil, 1960-80

Commodity Consumption and Ratio	1960	1970	1980
Farinha consumption (kilograms/capita)	26.3	23.5	12.0
Wheat consumption (kilograms/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

Cassava is virtually invisible to policymakers; little data or market analyses exist for the crop. Cassava is outside the control of government marketing agencies, and cassava producers can muster no political voice to defend their interests. Either cassava must be brought into the political arena or the crop will slowly disappear from the food basket in tropical Latin America. This conclusion, however, is not a plea for subsidies or an admission that cassava cannot compete in rapidly expanding markets for carbohydrates. The irony is that the decline in cassava is being attributed to a lack of effective demand, whereas the fault lies with discriminatory policies rather than consumer preference. There is a need for consistency in the setting of price policies, which implies that cassava should be brought into the agricultural political economy of Latin America.

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6
The Meat of the Matter: Cassava's Potential as a Feed Source in Tropical Latin America

John K. Lynam

Latin American economies have gone through a period of profound 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. Virtually all of these adjustment problems have antecedents in, or implications for, the agricultural sector--a fact that has motivated heavy policy intervention in this sector. The focus of these interventions was the grain and livestock sector, as governments strived to balance policies designed for low urban food prices while maintaining incentives to domestic farmers (see Figure 1). The following discussion will review the interaction between changing demand conditions, policy interventions, and production response for meat and grains. This will then provide the context for an evaluation of the opportunities for cassava to play a more fundamental role in this sector.

A CHICKEN IN EVERY POT: THE POULTRY REVOLUTION IN LATIN AMERICA

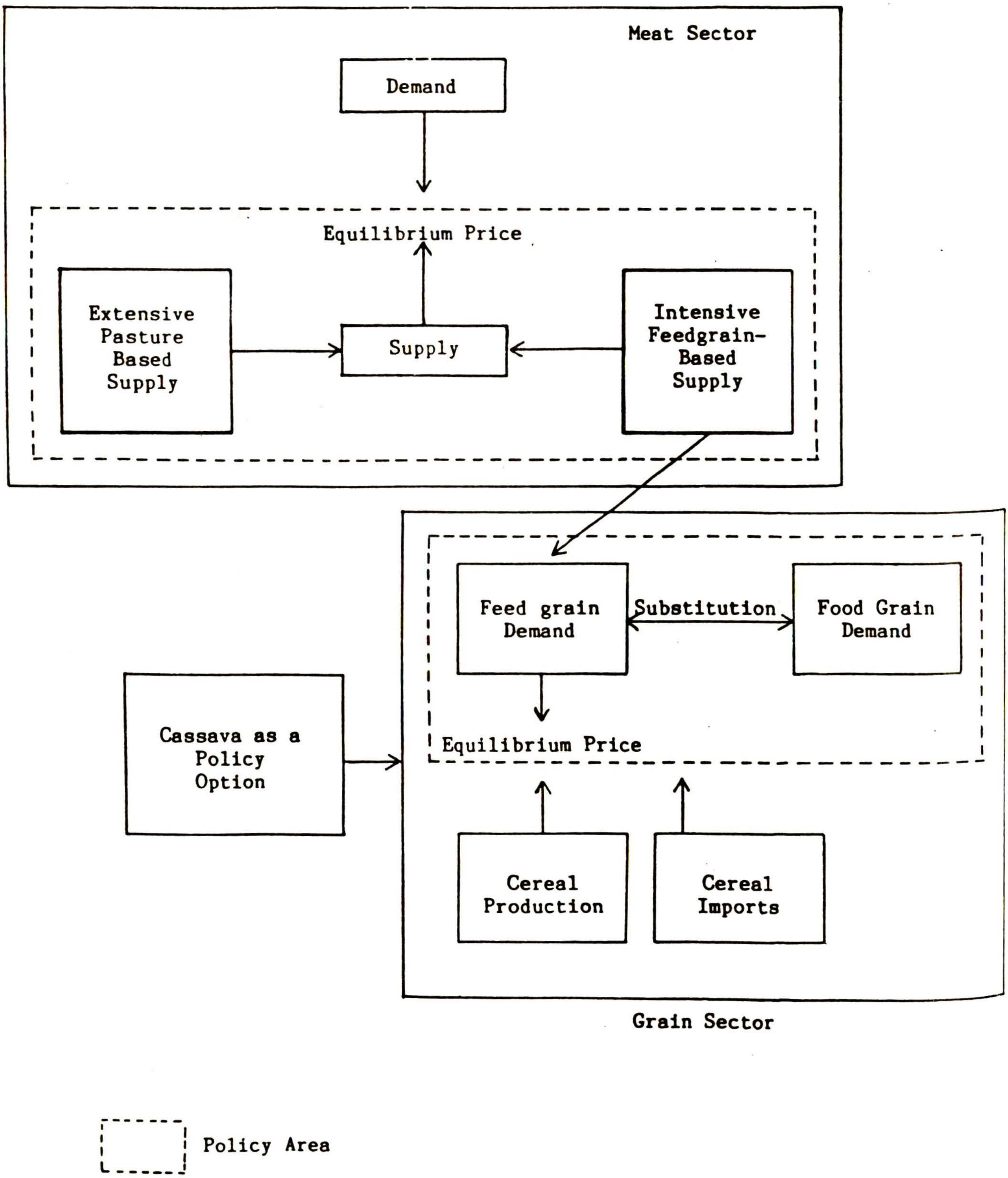
The structure of agricultural output in Latin America is heavily weighted toward livestock products, especially if compared with Africa or Asia (Table 1). Livestock production is larger in value than the combined production of cereals and other starchy staples. In the livestock sector, beef cattle form the largest component and in turn command significant land resources.

Table 1--Structure of agricultural output, by region, 1976-80

Region	Cereals	Other Staples	Livestock	Other Foods	Non-foods
			(percent)		
Latin America	17	9	33	31	11
South Asia	45	9	13	27	7
Southeast Asia	44	10	12	26	8
Africa	17	27	18	25	14

Source: World Bank, World Development Report, 1982 (New York: Oxford University Press, 1982).

Figure 1--Schematic of the analysis of cassava within the Latin American grain-livestock sector



Permanent pastures in Latin America cover three times more area than the land devoted to annual and permanent crops (FAO 1985). There are historical, structural, and economic reasons for the preeminent role that cattle play in the Latin American agricultural economy. Cattle's importance in the agricultural sector is translated into a dominant role for beef in food consumption patterns.

The importance of beef in tropical Latin American economies can be seen as a 20th-century phenomenon, the genesis of which lay in the economic history of the continent. Urbanization of Latin American economies provided the markets, and the skewed land distribution and historical accumulation of cattle stocks provided, in a sense, a latent capacity for livestock production that awaited only market development. Cheap beef found ready markets in urban Latin America and because of its relative price, it became a major item in the food budget.

The last quarter of a century, however, has witnessed major divergences in the demand for and actual consumption of beef (Table 2). Between 1960 and 1985, growth in beef production has

Table 2--Annual growth rates of potential domestic demand and production of beef and veal, by country, 1970-81 average

Region and Country	Annual Average Growth Rate Demand	Annual Average Growth Rate Production
	(percent)	
Tropical Latin America	5.3	2.2
Brazil	6.1	1.5
Mexico	4.4	3.3
Bolivia	4.9	4.9
Colombia	4.9	3.5
Ecuador	8.9	5.3
Paraguay	4.4	-1.1
Peru	3.0	-1.3
Venezuela	4.2	5.4
Cuba	4.5	-2.6
Dominican Republic	6.0	3.4
Central America and Panama	4.0	3.3
Costa Rica	4.8	6.3
El Salvador	3.9	3.4
Guatemala	5.2	3.9
Honduras	3.6	5.2
Nicaragua	1.6	-1.1
Panama	3.5	1.3
Caribbean	3.2	2.0
Guyana	1.5	-1.1
Haiti	4.5	2.7
Jamaica	-0.6	2.0
Trinidad and Tobago	5.1	2.3

Source: Centro Internacional de Agricultura Tropical (CIAT), "Trends in CIAT Commodities," Internal Document Economics 1 (No. 10), 1985.

Note: The grouping of countries into regions here is based on CIAT's classification.

slowed down, and per capita consumption levels have declined. Given the growth in per capita income levels, declining per capita availability has resulted in a widening divergence between growth in consumption and growth in demand, a situation that puts upward pressure on prices. Beef prices have in general increased, but not enough to explain the difference in demand growth (Table 3).

Table 3--Comparison between growth in excess demand and real price increases for beef, 1970-81, selected countries

Country	Production Growth	Demand Growth	Growth in Excess Demand	Growth in Real Prices
		(percent)		
Brazil	1.5	6.1	4.6	3.0
Colombia	3.5	4.9	1.4	-0.7
Dominican Republic	3.4	6.0	2.6	-1.1[a]
Ecuador	5.3	8.9	5.5	3.0
Panama	1.3	3.5	2.2	2.7
Paraguay	-1.1	4.4	5.5	-0.4
Peru	-1.3	3.0	4.3	3.1
Venezuela	5.4	4.2	-1.2	6.7

Sources: Centro Internacional de Agricultura Tropical (CIAT), "Trends in CIAT Commodities," Internal Document Economics 1 (No. 10), 1985; and price data files derived from national statistical sources.
Note: Real prices refer to retail prices.
[a]This figure is for 1974-84.

Price increases have occurred during a period when many governments have had a clear policy objective of controlling inflation. In most countries, real beef prices have increased but at a lower rate than suggested by demand growth. In some cases, governments have intervened in the beef market in order to control variability and increases in beef prices. This intervention is clearest in Brazil, where until 1982 the government bought and stored refrigerated beef. On average, 10 percent of annual beef production went into government-controlled freezer storage (Rivas et al. 1986), a program that was very costly to operate and that in the end was counterproductive within the context of beef cycles (Jarvis 1986).

A far more dominant influence on beef prices over the past 25 years has been the rapid rise in poultry production. Production of chicken meat has grown at a sustained annual rate of about 9 percent in tropical Latin America during the 1968-84 period. In Brazil, poultry production--or at least, commercial production--grew at an annual rate of 26 percent from 1960 through 1983. Such growth, even from a relatively low initial level, is rare and reflects the dynamism that can arise when technological change is linked to an expansive market. As a result, per capita consumption of chicken meat in tropical Latin America increased from 4.8 kilograms in the 1969-76 period to 8.2 kilograms in the 1978-85 period, a level that is well over half the present per capita consumption of beef (14.0 kilograms). The expansion in chicken meat led to an expansion in total meat consumption (beef, pork, and chicken) and the relative share of the former in cereal from 18 percent to 29 percent of total consumption of meat.

The increase in consumption at such rates was motivated by the declining real price of poultry meat, which in turn was possible because of reductions in costs due to technical change. Moreover, the price of chicken declined even more than the reference meat, beef (Table 4). In countries such as Brazil, Colombia, and Peru, chicken was more expensive than beef in the 1960s, but in the early 1970s chicken became cheaper, with the price difference widening through the 1970s and 1980s. In other countries, such as Mexico, Venezuela, Jamaica, and the Dominican Republic, beef and chicken were similarly priced in the early 1960s, and again the tendency was for chicken to become less expensive than beef. Declining prices and rising incomes certainly induced increased consumption of chicken. The question, however, is whether changing relative prices caused chicken to be substituted for beef.

Table 4--Growth rates of retail prices for meats, 1965-84, selected countries

Country	Beef	Chicken
	(percent)	
Brazil (1960-82)	2.4	-2.7
Colombia (1960-84)	-0.4	-3.6
Dominican Republic (1974-84)	-1.1	-2.9
Ecuador (1970-84)	2.7	-0.1
Panama (1960-84)	1.7	-2.1
Peru (1966-83)	2.3	-4.1
Venezuela (1965-84)	2.2	-2.4

Sources: Centro Internacional de Agricultura Tropical (CIAT), "Trends in CIAT Commodities," Internal Document Economics 1 (No. 10), 1985; and price data files derived from national statistical sources.

Income growth was not the dominant force influencing consumption trends in meats; prices played a much more significant role. Based on the study by Rivas et al. (1986), the own-price elasticity for beef varies between 0.05 and 0.78, with four of the seven countries examined having a price elasticity below 0.25 (Table 5). Beef consumption is moderately inelastic to price, a finding that reflects the relatively high consumption levels for the meat. For chicken, on the other hand, the own-price elasticity varies from 0.12 to 1.72; thus the elasticity is quite responsive to price changes, a fact that is reflected in the declining price trends and the high growth rates in per capita consumption. What is particularly salient, however, is that the cross-price elasticity, measuring the substitution of chicken for beef, is either similar to or, in the case of Brazil, significantly larger than the own-price elasticity for beef.[1] In general, a change in the chicken price will have as much influence on beef consumption as an equivalent change in the beef price itself. These cross-price elasticities vary between 0.4 and 0.74.

Table 5--Estimates of demand elasticities for beef and chicken meat, selected countries

	Beef			Chicken		
Country	Income	Own Price	Cross Price	Income	Own Price	Cross Price
Brazil	0.32	-0.23	0.50	1.69	-1.26	0.03*
Colombia	0.72	-0.69	0.42	0.88	-0.46	0.61
Dominican Republic	0.77	-0.14*	-1.12	0.00*	-0.12	0.19*
Jamaica	0.67	-0.12*	-0.20*	0.80	-1.72	1.27
Mexico	0.37	-0.78	0.74	0.74	-0.62	0.22
Peru	0.85	-0.42	0.40	0.75	-1.19	0.66
Venezuela	0.37	-0.05*	-0.33	1.09	-0.92	0.44

Source: Libardo Rivas et al., "La Situacion de la Oferta y Demanda de Carnes en America Latina," Proyecto Colaborativo FAO-RLAC/CIAT, Cali, Colombia, 1986 (mimeographed).
*These estimates are not significant at the 10 percent probability level.

[1] In Jamaica, Venezuela, and the Dominican Republic, the cross-price elasticity was either not significant from zero or negative, the latter indicating complementarity, which is nevertheless doubtful. The cross-price elasticity of chicken consumption with respect to beef prices was in all cases positive. Such nonsymmetry in sign is not possible. In all these countries, the own-price elasticity for beef is not significant from zero and, moreover, chicken is a large consumption item, with per capita consumption levels being higher than beef in Jamaica and the Dominican Republic. Under such circumstances, the structural model was not able to distinguish between the effect of the two prices on meat consumption.

Then considering the significant rates of decline in chicken prices, the substitution effect played a major role in holding down beef prices; this is clearest in Brazil (Table 6). During the 1970s, the major effect on demand came from price changes (both own-price and substitution effects). Given that relative prices have tended to stabilize in the 1980s, the importance of incomes as determinants of the demand for individual meats will increase in the coming years.

Table 6--Disaggregation of factors influencing the growth in beef demand, Brazil, 1960-82

Demand Component	1960-67	1968-75	1976-82	Average
		(percent)		
Actual per capita consumption	-1.2	1.3	-2.8	0.3
Income effect (= 0.32)	0.8	2.7	0.8	2.0
Growth in excess demand	2.0	1.4	3.6	1.7
Implied price change (= -0.23)	8.7	6.1	15.7	7.4
Actual change in beef price	2.9	8.2	3.3	2.4
Actual change in poultry price	-2.3	-0.6	-6.3	-2.7

Consumer budget surveys from Peru and especially Brazil give a more detailed look at changes in meat consumption. What is apparent in major metropolitan areas of Brazil between 1960 and 1975 is the declining consumption of beef and the rising consumption of poultry. Consumption of chicken meat increased across all income strata, while that of beef tended to decline. These trends again support the dominance of the price effect over the significant growth in income during the period.

The most significant substitution of chicken for beef was among the poor. Chicken was rarely eaten by the urban poor in the 1960s. By 1975, chicken was virtually on a par with beef as the principal meat eaten by the lower income strata. As sig- nificant, however, was the decline of the total consumption of meat by the poor over the same period in northeast Brazil. Vergolino (1980) presents data for Recife to show the consistency of this trend (Table 7). Rising beef prices were squeezing the meat consumption of the poor, even though there was a significant switch to chicken. Finally, the data for Peru (Table 8) suggest how rapidly substitution can take place when the change in relative prices is so marked.

The rapid increase in the proportion of chicken in total meat consumption in tropical Latin America was due not so much to an intensification of current production systems as to a complete restructuring of the sector. The impetus was the rising demand for meat, aided by rising beef prices and urbanization. Whereas traditional production was oriented to rural consumption, the rise of large-scale broiler operations, often vertically linked to feed-concentrate manufacturers, was oriented to the development of urban markets. Marketing of chicken followed the development of super-markets as a major form of food retailing and the rise of "fast food" chicken restaurants. The whole poultry sector was trans-formed, from retailing through production and provision of feed

Table 7--Trends in annual per capita consumption of beef and poultry in Recife, Brazil, selected years

Year of Consumer Survey	Average Consumption Beef	Average Consumption Poultry	Low-Income Strata[a] Beef	Low-Income Strata[a] Poultry
		(kilograms)		
1961-62	31.6	1.3	n.a.	n.a.
1967-69	28.4	5.2	14.5	0.5
1973	23.0	13.0	8.9	3.7
1975	17.9	10.5	4.4	2.5

Source: J. R. O. Vergolino, "O abastecimiento de Alimentos no Nordeste," Revista de Economica Rural 18 (1980):
[a]Families with income less than one minimum salary.

Table 8--Consumption changes for beef and poultry by income strata in Lima, Peru, 1972-79

Year	Consumption per Family: Low-Income Strata Beef	Low-Income Strata Poultry	Medium-Income Strata Beef	Medium-Income Strata Poultry	Real Prices (1973=100) Beef	Real Prices (1973=100) Poultry
		(grams/day)			(sols/kilogram)	
1972	136	126	241	177	44.9	75.7
1976	56	318	75	425	65.3	45.9
1979	29	210	90	290	50.5	47.6

Source: Peru, Ministerio de Agricultura, Oficina de Estadistica Agropecuaria, Boletin Estadistico del Sector Agrario, 1968-1985 (Lima, Peru: Ministerio de Agricultura, 1985).

sources. This restructuring allowed for significant gains through economies of scale at all levels.

Economies of scale were probably even more important in the decline of poultry prices than was technical change, which is not to diminish the role played by new technology. Balanced feed technology together with new breeds, often introduced from the United States, resulted in a significant decline in the amount of feed needed to produce a kilogram of meat. Mortality measures were reduced by antibiotics, the time-to-slaughter weight declined, and slaughtering technology allowed factory-scale operations. The effect was a significant reduction in per unit costs and, just as importantly, an ability to adjust production levels quickly to change in profitability, whether due to changes in output or feed prices. For those governments concerned about the inflationary effects of meat prices, the poultry industry allowed more control over market prices. As the weight of chicken meat increased in the consumers' budget, in some cases to a parity with beef, the supply responsiveness and weight in the consumer budget drew meat-sector policies toward the poultry industry.

Feed is the dominant cost in the production of poultry meat, making up as much as 80 percent of the total (Table 9). It is the switch from land devoted to pasture to land sown with feed crops that forms the basis of the development of the intensive frontier. The feed-concentrate industry has in most instances been the lead sector in the development of the poultry industry. It is the growth node, with forward linkages to poultry producers and backward linkages to feedgrain producers. The dynamism of the balanced feed industry establishes the limits on poultry expansion and the market growth for feed ingredients. This industry has been dynamic indeed, with annual growth rates in several countries of well over 10 percent (Table 10). The major portion of feeds are directed to poultry, but swine feeds are a significant component in some countries, particularly Mexico and Venezuela. There has been little difficulty in drawing investment resources into the industry at rates sufficient to maintain growth rates. To date, only government interventions have limited growth in the concentrate industry. Examples are the price controls on eggs and poultry meat in Mexico and Peru, often creating a cost-price squeeze, and the controls on imports of feed ingredients in Colombia and to a certain extent, Ecuador. On the other hand, feedgrain pricing policy has in some cases favored the poultry industry. Low feedgrain prices have been a consistent policy in Mexico and Venezuela, a topic taken up in the next section.

Table 9--Cost distribution, as a percent of total production costs, in the production of broilers, Peru and Brazil

Cost Component	Minas Gerais, Brazil, May 1978	Lima, Peru, May 1986
	(percent)	
Feed	65.6	77.6
Day-old chicks	19.5	15.6
Vaccine	0.5	1.5
Litter	0.2	0.7
Disinfectant	0.8	0.4
Water	0.9	2.2
Labor	3.8	0.9
Other	8.7	1.1
Total	100.0	100.0
Total cost per kilogram	Cr$ 12.07	Intis 12.94

Sources: Marilia Ferreira, "Custos de Produçao e Cotacoẽs da Bolsa de Frangos," Informe Agropecuario 4 (1978): 18-21; and Hector Malarin, "Sustitucion de Maiz Amarillo Duro Importado por Harina de Yuca en el Sistema de Produccion y Consumo Aviola: Analisis y Evaluacion" (thesis, Universidad de Pacifico, Lima, Peru, 1986).

Note: Costs for Brazil are based on a lot size of 5,000 birds; those for Peru are based on a lot size of 100,000 birds.

Table 10--Characterization of the mixed feed industry, selected countries

Country	1984 Feed Production	Poultry Feed as a Share of Total	1970-84 Growth Rate of Feed Production
	(1,000 metric tons)	(percent)	
Brazil	10,824	67	11.0
Colombia	1,536	76	18.6
Jamaica	227	62	n.a.
Mexico	8,500	53	5.8
Peru	595	73	4.6
Venezuela	2,244	66	9.9

Sources: Associations of feed manufacturers in the individual countries.
Note: n.a. means not available.

The expanding concentrate industry precipitated a rapid rise in the demand for feed components, especially carbohydrate sources. This results in significant demand-led growth in the feedgrain sector. In some countries, feedgrain demand was met by the expansion of an already existing maize production base; in other countries, sorghum expanded rapidly as a new crop. In no tropical Latin American country, except for Paraguay, was the expansion in production always able to meet the increases in demand. All these countries turned to imports of feedgrains, with import volumes growing rapidly in all but a few cases. At this point, the analysis turns to a closer evaluation of the determinants of the supply of carbohydrate components for animal feeds.

THE GRAIN DIVIDE: THE CHOICE OF CARBOHYDRATE SOURCE IN FEED DEMAND

A rapidly expanding feed-concentrate industry, led by the increasing demand for animal products, can create either a dynamic domestic grain sector, rising real prices of grains, or increases in grain imports. A dynamic grain sector has obvious positive benefits, but rising grain prices or imports can raise significant policy problems. Increasing demand for maize as a feed source, in particular, has important implications for countries in Latin America, where maize is a primary food source. Latin American governments often intervene in maize markets to keep consumer prices low for poorer segments of the population. Yotopopoulos (1983) argues that rising incomes of middle-income classes lead to increasing demand for income-elastic foods, particularly meat, which in turn bids grain prices up; the latter obviously can have a negative effect on the nutrition of the poor, who depend on such grains as a primary calorie source in their diet. However, in Latin America, governments have taken steps to minimize this competition, enhancing natural segmentation in grain markets based on price and quality factors.

Grains are virtually substitutable in balanced feed rations--factors such as carotene, tannins, and amino acid content do result in price differentials but do not hinder substitution--but not in the human diet. Substitution between rice, wheat, and maize does occur but to a more limited degree. Sorghum is not seen as a food in Latin America except in small, rural areas of Central America and Haiti. What is also clear in Latin America is that food uses will always draw grains away from feed uses, not vice versa. Rice is rarely used in animal feeds and wheat only slightly less often in Latin America, principally because the nutrient content is too expensive relative to alternatives. Moreover, in countries where hard (dent or flint) maize is a major food source, sorghum is normally the principal grain used in feed rations. This is certainly the case in Mexico, Nicaragua, Venezuela, and Colombia: in the latter country, maize is only of regional importance in human diets. There is a natural evolution to whichever grain does not compete in the food economy, essentially because too often food-grains become too expensive or too scarce to sustain the animal feed industry.

In countries such as Brazil, the Dominican Republic, Jamaica, Ecuador, Peru, and Panama, maize is the principal grain in feed rations. In all these countries, rice and/or wheat is the major food grain. In most of these countries, root crops and plantains are also important calorie sources. In Ecuador and Peru, soft or floury maize is a regionally important food source but this is a distinct commodity from the hard maize. In all these countries, hard maize is a minor food item when there are readily available supplies of more preferred grains. In such a food economy, changes in overall food demand for maize will have little effect on its price. Competition between the food and feed markets in these countries is thus minimized by the structure of grain preferences and relative prices.

Minimizing competition on the demand side does not necessarily translate to a minimum of competition for resources on the supply side. For relatively homogeneous production inputs like fertilizer and credit, there will be natural competition determined by relative profitability. Competition for land is probably the more relevant factor, and here differential adaptation to agroclimatic conditions provides a significant degree of segmentation in the competition for land. Certainly, wheat in tropical Latin America does not compete with feedgrains, except possibly for wheat and maize in Paraguay. Irrigated rice and feedgrains also do not compete for land. Upland rice and maize do compete for land in central and western Brazil, but land is really not the relevant constraint in these areas. Sorghum and maize for human consumption is the only real area where there is significant competition for land, but this occurs only in the irrigated areas of Mexico. Competition in Mexico, however, is a relative moot point because of the control over both consumer and producer prices exercised by the state trading company, Comisión Nacional de Subsistencias Populares (CONASUPO), and the heavy reliance on imports of both commodities.

The above would appear to be a workable solution to food-feed competition were it not that many governments heavily subsidize the consumption of key grains, for example, maize in Mexico or wheat in Brazil, Peru, and Ecuador. In such cases, foodgrains become competitive in price to feed rations, and governments try to maintain the independence of the two markets through elaborate administrative rules on imports, domestic sales, and subsidy payments. In all cases, a national grain marketing agency administers much of the domestic marketing of the subsidized grain. Nevertheless, in all these countries, there is evidence of some leakage of the subsidized foodgrain into use by feed compounders. The clearest case is wheat flour in Brazil where flour prices to the consumer are kept exceptionally low (Table 11).

Table 11--Difference between wheat flours sold by flour mills and actual human consumption, August 1974-July 1975, Brazil

Region	Sales by Mills	Flour Consumption	Absolute Difference
		(metric tons)	
Rio de Janeiro	447,244	292,113	155,131
São Paulo[a]	1,005,645	584,951	470,694
South	721,556	769,365	-47,809
Minas Gerais and Espirito Santo	310,646	279,665	30,981
Northeast	676,660	511,943	164,717
Federal District	23,297	18,970	4,327
North	168,924	145,645	23,279
Total	3,353,972	2,552,652	801,320

Source: Brazil, Comissão de Financiamento da Produçao (CFP), <u>Estudo do Consumo de Alimentos Basicos no Brasil: Trigo</u> (Brasilia: CFP, 1981).

[a]The major portion of the mixed feed industry is located in São Paulo. The consumption estimate is based on the national food budget survey.

Intervention in foodgrain markets in many cases precipitated later interventions in feedgrain and poultry markets. The policy objectives varied somewhat, but all major feedgrain-producing countries, apart from Caribbean countries, intervened to support farmer incomes and to provide sufficient incentive to increase production. How this was done varied depending on whether foodgrain consumption was subsidized. In countries such as Mexico, Venezuela, Peru, and Brazil, where foodgrains were subsidized, governments normally intervened with input subsidies, particularly on fertilizer and credit, and attempted to keep output prices close to import prices. (In many cases, this failed due to a progressive overvaluation of the exchange rate, and producer prices moved above import prices.) On the other hand, countries such as Colombia and Panama that did not subsidize foodgrain consumption maintained support prices for feedgrains well above import prices, through a government marketing agency and import controls. During the 1970s most countries intervened to some degree in feedgrain markets, almost always to the advantage of feedgrain producers, and they only rarely neglected the interest of the feed-concentrate industry.

Striking a balance between the interests of feedgrain producers and feed-concentrate manufacturers often required either subsidies or the strategic use of imports, which often entered on the basis of overvalued exchange rates. Each country managed incentives to the two groups through its state marketing agency. This agency maintained the producer support price by buying in the domestic market when necessary, controlling the price and supplies to the feed-compounding factories, and managing imports. In some cases, for example, Peru and Venezuela, the marketing agency sold to the factories at a lower price than the domestic price, in effect balancing the loss with imports that were even cheaper. Peru and Venezuela also eventually moved to a system of allocating import quotas at import prices to factories on the basis of purchases of domestic production at the higher support prices.

By far the most usual subsidy was on transport costs, where both support prices and sales prices to the factory were fixed at a single price for the whole country. This was not a problem for a country such as the Dominican Republic or Panama, but it had profound implications for large countries such as Mexico, Peru, and Brazil. In Brazil, the Companhia de Financiamento da Produçao (CFP) would sell at market prices in the region but often with a transport subsidy. In all these countries, surplus feedgrain production areas were often far removed from deficit demand areas. In Brazil and Peru, the transport subsidy was a direct subsidy to foster feedgrain production in frontier areas, which in Peru were in the Selvas (the Amazon Basin), and in Brazil, in the central western cerrado areas. Transport subsidies in these cases were large and shifted comparative advantage to those areas where transport costs would otherwise be prohibitive.

In Brazil, transport subsidies absorbed by CFP can shift comparative advantage away from local production. Table 12, showing the regional structure of maize production and demand, clearly indicates that maize must move from the south and central west to the deficit areas of the northeast and southeast. The comparison of relative costs (Table 13) shows the importance of transport costs in the supply of feedgrain markets in Brazil. Subsidies are often necessary to keep the central western areas competitive in maize production, often at the expense of the development of production in the northeast, a point to which the discussion will return when considering the potential for cassava in feed rations.

Table 12--Regional surpluses or deficits in the production of maize and animal feed, Brazil, 1983

Region	Maize	Animal Feed
	(1,000 metric tons)	
North	19.3	-28.7
Northeast	708.0	-199.3
Southeast	1,212.1	-139.9
South	600.1	346.6
Central West	1,559.1	30.8
	(percent of total consumption)	
North	7.4	-39.1
Northeast	44.0	-22.1
Southeast	16.6	-3.0
South	6.2	6.7
Central West	186.5	9.5

Sources: Data provided by the Comissão de Financiamento da Produção (CFP) and the Sindicato da Industria de Racoes Balanceadas.

Note: Minus sign indicates a deficit.

Table 13--Private and social costs of supplying maize and dried cassava to the northeast, Brazil, 1986

Item	Private Costs		Social Costs	
	Absolute	Cassava/ Maize	Absolute	Cassava/ Maize
	(Cr$/ metric ton)	(percent)	(Cr$/ metric ton)	(percent)
Locally produced maize	1,517	86	1,405	88
Maize from south	1,616	81	1,468	84
Maize from central west	2,494	52	2,130	58
Imported maize	1,705	77	1,675	73
Locally produced cassava	1,306		1,231	
Maize price	1,690	77	1,690	73

Sources: Survey prepared by Comissão de Financiamento da Produção (CFP, Centro Internacional de Agricultura Tropical/Empresa Brasileira de Asistencia Tecnica e Extensao Rural (CIAT/EMBRATER).

Feedgrain production has responded to the expanding markets and policy interventions, except in Panama and Peru (Table 14). In Peru, maize supply has depended on the relative support price of maize to rice, with rice having a clear advantage until 1985. Basic differences in technology between maize and sorghum bring into sharp focus how these production increases were achieved. In the case of sorghum, production increases were achieved by expanding the area planted with the use of an imported technology based on hybrid seed and mechanized production in all stages from planting to harvesting. This technology was appropriate for expansion only on large farms.

Table 14--Volume and growth of the feedgrain sector in selected countries, 1966-85

	Production			Net Imports		
Country	Volume 1983-85	Growth 1966-75	Growth 1975-85	Volume 1966-68	Volume 1976-78	Volume 1983-85
	(1,000 metric tons)	(percent)		(1,000 metric tons)		
Sorghum						
Mexico	5,557	10.0	4.0	-177	517	2,766
Colombia	574	19.8	4.6	1	60	127
Venezuela	475	10.7	15.3	1	513	546
Maize						
Brazil	20,638	3.6	3.0	-760	-529	-72
Dominican Republic	97	2.2	-0.3	0	93	185
Ecuador	257	4.3	1.3	-1	20	10
Paraguay	473	5.8	4.3	-4	-8	-12
Peru	689	1.2	0.2	22	212	255
Panama	72	-5.7	0.3	1	4	29
Jamaica	4	9.6	-12.5	47	166	177

Source: FAO (Food and Agriculture Organization of the United Nations), "Production Yearbook Tape, 1985," FAO, Rome, 1986.

In the case of maize, however, the production structure in most tropical Latin American countries has been skewed toward the small-scale producer. Moreover, the increase in production, especially in the last decade, has been due more to increasing yields than increasing area, except in Paraguay. The implication, however, that small farmers were able to capture the major portion of the benefits of this expanding market is not supported by the limited data on the subject. In Ecuador, the small-scale producer of floury maize in the Sierra remained isolated from the change in the market for yellow, dent maize. This was captured by large-scale, mechanized producers on the Pacific coast. In Brazil, both area and yield expanded on farms of more than 50 hectares, as both mechanical and yield-increasing technologies were adopted by large-scale farmers (Table 15). Those farmers with farms from 5 to 50 hectares in size, increased yields but with declining area planted to maize. Farms of 5 hectares or less were effectively marginalized as yields grew only slowly and area declined markedly. Large farmers have a clear advantage in being able to take advantage of both labor-saving and yield-increasing technologies, drawing on the technology developed in U.S. agriculture over the last two or three decades. In general, the small farmer has lost the comparative advantage he had in management--normally reflected in higher yields. Moreover, he often does not have the same access to the subsidized inputs and credit that have fueled this expansion in feedgrains.

Table 15--Changes in area planted and yield of maize by farm size, Brazil, 1970-80

Farm Size	1980 Area	1980 Yield	Increase 1970-80 Area	Increase 1970-80 Yield
(hectares)	(1,000 hectares)	(tons/ hectare)	(percent)	
Less than 5	979.6	0.93	-23.9	8.1
5 - 10	972.4	1.45	-18.9	21.8
10 - 20	1,638.8	1.63	-12.9	28.3
20 - 50	2,353.0	1.61	-9.5	27.8
50 - 100	1,275.0	1.52	5.9	27.7
100 - 200	1,026.0	1.54	19.3	28.3
200 - 500	1,005.1	1.62	19.4	29.6
500 - 1,000	504.9	1.67	31.6	21.9
More than 1,000	583.2	1.64	41.5	15.5
Total/average	10,338.6	1.52	-3.1	26.7

Source: Fundação Instituto Brasileiro de Geografia e Estadística (FIBGE), 1974 and 1984.

Nevertheless, even rapid rates of growth in feedgrain production were not sufficient to meet expanding domestic demand. Imports were necessary both to meet deficits and in many cases to support price policies for grain supplies to feed manufacturers. The rising trend in feedgrain imports in many countries, however, was affected in the 1980s by the external debt crisis in Latin America. The ratio of debt-servicing to exports rose significantly, precipitating major devaluations, fiscal stringency, and declines in domestic demand. Agricultural imports are a significant component of the import bill, and they have been increasing as a percentage of total imports (Table 16). The devaluations and the need to cut back government spending, especially on subsidies,

Table 16--Agricultural imports as a percent of total imports, selected countries, 1980-84

Country	1980	1981	1982	1983	1984
Brazil	9.9	9.1	8.5	8.7	11.0
Mexico	16.1	13.5	12.8	26.3	20.8
Colombia	11.5	9.5	10.3	10.9	8.3
Ecuador	8.1	7.8	9.1	14.9	12.1
Peru	20.4	20.4	18.0	17.5	15.7
Venezuela	16.2	17.0	15.2	11.6	20.7

Sources: Inter-American Development Bank, Economic and Social Progress in Latin America (Washington, D.C.: IDB, 1986; and FAO (Food and Agriculture Organization of the United Nations),"Production Yearbook Tape, 1985," FAO, Rome,1986.

forced many countries to expand efforts to increase self-sufficiency in basic commodities. With recent changes in domestic price policies and (because of devaluations) the domestic price of feedgrain imports, there is opportunity to develop a more diversified strategy in meeting carbohydrate demand in the feed sector. In particular, there is an incentive for governments to evaluate the potential of cassava to meet the expanding demand for feed sources.

THE CASSAVA OPTION IN MEETING FEED DEMAND

The rapid expansion in the demand for feed components changes the whole dynamic of demand for certain starchy staples as an economy urbanizes and incomes increase. In general, direct food demand for grains and starchy staples in general increases until an income level of about US$1,000 (in 1978 prices) is reached, and then it declines somewhat (Monke 1983). At about that point, however, derived demand for carbohydrate sources for animal feeds begins to grow. For commodities such as maize, sorghum, and cassava, and occasionally soft wheats, this market transition provides an opportunity to maintain a significant elasticity in total demand for the commodity. Few agricultural commodities face such continual increases in demand throughout the growth process, and only flexibility in end uses and relatively cheap production costs allow a commodity such as cassava to move from being primarily a food staple to becoming a commercial crop supplying a growing industrial demand. Adaptation to shifting end markets and changing market structure is the key to modernizing agriculture, where expanding marketable surpluses lead to increasing farmer incomes and thereby help to moderate rural-urban migration.

Cassava is basically a starch source and, because carbohydrate or energy sources are the principal component in balanced feeds, dried cassava has the potential for forming a significant percentage of the complete ration. Mixed feed technology allows the incorporation of high protein sources to compensate for cassava's lack of protein. Least-cost feed formulation models allow factories to produce a balanced ration with the lowest cost mix of ingredients. Experience with using cassava in Europe, especially in the Netherlands, has shown cassava to have few negative nutritional characteristics. Aflatoxin is usually nonexistent because of cassava's low protein content. If properly dried, hydrocyanic acid (HCN) toxicity is not a factor in animal nutrition. For poultry, there is some concern with the energy density of the diet if cassava assumes a high percentage, but this can be overcome by pelleting and the addition of a small percentage of animal tallow or vegetable oil. In general, cassava can fully replace grains in swine and dairy rations and can take up 20 to 30 percent of poultry rations.

The movement to use balanced feeds in animal nutrition is also associated with structural changes in animal production, with the locus of production shifting from integrated crop-livestock systems on individual farms to large-scale, specialized production units, normally close to major urban markets. This structural transformation is clearest in the case of broiler and egg production. In swine, on the other hand, farm production is often able to resist the movement to large integrated units, due essentially to lower cost feed sources and diminished scale economies in swine production. For the farm operation, however, the difficulty is to maintain balanced nutrition from on-farm sources, especially adequate protein levels. Technical change in swine production in Latin America, first phase, has taken the form of a shift to breeds with leaner carcasses and the purchase of protein concentrates to mix with energy sources produced on the farm. In the second phase, in a few countries, particularly Mexico and Venezuela, large-scale specialized swine production systems have also developed.

Cassava, as an animal feed in Latin America, develops first as an on-farm feed source. Throughout tropical Latin America, cassava is fed to animals raised on the farm. Normally this is not systematic. The cassava is often noncommercial; for example, the roots are small or left in the ground beyond the period of satisfactory quality, or it is the surplus after a periodic harvest. Moreover, the swine, and even poultry, tend to scavenge for a large component of their feed needs. Animal productivity in these systems is low but costs are also low. Generally, in such systems, only a minor percentage of the total cassava crop is fed to the animal stock. The opportunity cost of the cassava is too high compared with the low weight gains of the animal: lack of protein tends to limit the effectiveness of the energy source. Such systems are quickly disappearing as they are overtaken by more efficient production systems.

The key to more productive on-farm swine production systems has been the availability of protein concentrates. In areas such as southern Brazil, particularly Rio Grande do Sul and Santa Catarina, and parts of eastern Paraguay, cassava has developed as a major on-farm feed source in intensive swine production systems. In Rio Grande do Sul, it contributes to dairying systems. Particularly in Brazil, the development has been dramatic over the past couple of decades. A coincidence of factors gave rise to this dominant role of cassava in on-farm feeding systems. Predominant among these was the demise of the farinha market in southern Brazil as a result of the wheat subsidy. Shrinking demand made cassava relatively cheap at a time when swine production systems were changing with the introduction of breeds with less fat (the market for lard declined with the rise of the soybean oil industry) and the improved availability of protein concentrates. The key, however, was the low production costs for cassava compared with those of the principal competing energy source, maize (Table 17). At the farm level, cassava is competitive with grain sources as an energy source in the feeding of animals. The one restriction is that the cassava varieties used must be relatively low in HCN content, a factor that limits on-farm feeding to swine in the northeast.

Table 17--Production costs for maize and dried cassava in the south, Brazil, 1986

Cost item	Cassava	Maize
	(Cr$/metric ton)	
Variable costs	172.5	555.4
Factor costs		
Labor	131.2	330.0
Capital	17.6	32.2
Input cost	23.7	193.2
Fixed costs	139.3	331.6
Factor costs		
Land	58.3	220.0
Labor	27.9	27.5
Capital	13.3	27.5
Input cost	39.8	56.6
Total costs	311.8	888.7

Source: Field data provided by Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Developing a cassava production system that can supply a continuous supply of roots during the whole year and yet releases land at critical planting periods requires either an extensive land area or a storage system. In southern Mexico, with the rise of large-scale swine production systems in the ejidos, large silos have been developed for ensiling cassava roots. The ensiled roots can be kept for an indefinite period of time and the roots can be assembled near the swine production units. The costs of such systems have been competitive with sorghum prices (Table 18), which must be imported into the region. The ensiled cassava is mixed with a protein concentrate and minerals and provides a balanced feed source. Ensiled cassava systems can be adapted to almost any size of production system, but investment in a permanent silo and a chipper requires a certain minimal size of swine operation.

Table 18--Comparison of costs of production of ensiled cassava roots with sorghum price in Tabasco, Mexico, 1986

Cost Component	Cost
	(Mex$/kilogram)
Variable costs	
Root price	17.00
Loading and unloading	0.80
Transport	4.00
Chipping and tamping	0.85
Plastic cap	0.20
Working capital	2.29
Subtotal	25.14
Fixed costs	
Silo depreciation	0.96
Capital costs	1.60
Subtotal	2.56
Weight loss and deterioration	4.92
Total costs	32.62
Cassava cost on a dry weight basis	77.67
Sorghum cost on a dry weight basis	93.49

Source: Field data provided by Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Availability of protein concentrates, intensification and technical change in swine production systems, and organization of the cassava production system to provide continuity of supply are all necessary for the development of such integrated systems. They also require an obvious coincidence between cassava production areas and swine production, and the latter requires adequate access to urban markets. Besides southern Mexico, southern Brazil, and Paraguay, there is also potential to develop such systems in the Dominican Republic and possibly in the Selvas of Peru and the Santa Cruz area of Bolivia. However, to broaden the market for cassava as an animal feed source, especially for the poultry sector, requires the mixing of dried cassava in balanced feeds.

Cassava is just becoming a participant in the market for feed components for the rations industry. Spontaneous development of a feed market for dried cassava has developed in Asian countries, particularly Thailand and Malaysia, but in Latin America cassava has not easily made the transition away from on-farm uses and food markets. There are two questions to be asked with regard to cassava's emerging role in the feed market. First, can cassava prices compete with those of the principal feedgrains and can it potentially carve out a significant share of this expanding market? Second, if cassava is already profitable, why have dried cassava markets not spontaneously developed in Latin America? If cassava can compete, then an understanding of constraints on development of a cassava feed market will hopefully pinpoint mechanisms by which market linkages can be formed.

To generalize about the ability of cassava to compete with grains in animal feed rations is fraught with the problem of policy interventions in the marketing and pricing of feedgrains. A starting point is a comparison of costs of production and prices at the farm and factory level for dried cassava and the principal competing grain. As can be seen in Table 19, cassava competes favorably with feedgrains in terms of farm-level profitability. In all countries considered, dried cassava either now provides or could provide a reasonable return on farmer-owned resources. Moreover, these farm-level prices are translated into prices at the rations factory that enter the least-cost feed formulation for swine and, in most cases, for poultry. At issue then is why these obvious profit incentives have not been translated into a rising production of dried cassava. To understand this requires an evaluation of grain pricing policy, on the one hand, and an understanding of pricing of alternative cassava products, especially in food markets, on the other hand.

Table 19--Comparison of production costs for dried cassava and prices for cassava and the principal feedgrain, 1986, selected countries

Feedgrain/ Country	Production Cost[a] Cassava	Price[a] Cassava	Grain	Cassava/Grain Ratio
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[b]	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[c]	78

[a]Prices and costs are in local currency per ton.
[b]For Peru, it is assumed that cassava comes under the government purchasing system, Empresa Nacional de Comercialización Insumos (ENCI), in which case transport costs are not included.
[c]This is the maize import price.

Governments have intervened heavily in feedgrain markets in Latin America over the past two decades, although there has been no direct intervention in cassava markets. Obviously, this policy support for grains has directly affected the private profitability of cassava. Policy intervention has taken many forms. In Mexico, there were direct subsidies provided by CONASUPO, in which the sales prices to factories were usually less than either the purchase price paid to farmers or the import price (Table 20). Also, the sales price was fixed for any location in the country so that transport subsidies were also significant. In 1985, with the pressure to reduce the fiscal deficit, purchase and sales prices were brought into line; and, in 1986, sales prices started to reflect transport costs as different prices were now set for six different regions. Cassava produced in the south in 1986 began to compete with sorghum in regional markets.

Table 20--Sorghum prices managed by CONASUPO, Mexico, 1971-85

Year	Purchase Price	Import Price	Sales Price
		(Mex$/metric ton)	
1971	600	870	817
1972	729	760	810
1973	776	-	873
1974	1,113	1,849	1,225
1975	1,600	1,457	1,595
1976	1,638	-	1,739
1977	2,016	2,293	2,011
1978	2,030	2,473	2,127
1979	2,033	2,704	2,231
1980	2,891	3,352	2,672
1981	3,927	4,072	3,439
1982	5,093	8,264	4,746
1983	12,388	16,239	9,150
1984	20,478	22,631	18,861
1985	28,705	26,598	33,720

Source: Comisión Nacional de Subsistencias Populares (CONASUPO)

In Peru and Venezuela, cassava could compete with nationally produced grains on the basis of costs of production, but it could not compete under existing policy arrangements. In Peru, the state marketing agency, Empresa Nacional de Comercialización de Insumos (ENCI), buys and sells maize at one single price in the whole country. The whole marketing margin is absorbed by ENCI, the effect of which has been to shift comparative advantage from the high cost production on irrigated areas of the coast to the Selvas (jungle areas) in eastern Peru. As can be seen in Table 21, maize production in the Selvas is much more profitable than on the coast under such a subsidy system. However, cassava cannot compete in coastal markets with subsidized maize if it must pay the transport costs. In 1986, dried cassava was brought under ENCI price support and purchasing operations.

Table 21--Cost and price comparison for maize and dried cassava, Peru, 1986

Cost/price	Maize: Coast	Maize: Selvas	Cassava: Selvas
	(Intis/metric ton)		
Production costs	2,377	1,810	994
Transport costs	300	1,500	1,500
Total costs	2,677	3,310	2,494
Price[a]	3,300	3,300	2,475

Sources: Hector Malarin, "Sustitucion de Maiz Amarillo Duro Importado por Harina de Yuca el Sistema de Produccion y Consumo Aviola: Analisis y Evaluacion" (thesis: Universidad de Pacifico, Lima, Peru, 1986); and field data provided by Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Note: The selvas is the jungle area of the Amazon basin.

[a]ENCI purchase price.

In Venezuela, the policy has been to foster cheap feed but not at the expense of domestic grain producers. Domestic sorghum producers receive significant input subsidies, especially fertilizer and credit, and price supports ensure significant profit margins. Cassava is put under some disadvantage with the fertilizer subsidies but can still compete at sorghum support prices. There is a policy constraint, however, in that most sorghum is imported, and it comes in under a preferential exchange rate (Table 22).

Table 22--Comparison of prices for sorghum and dried cassava, Venezuela, 1985

Item	Price
	(Bs/ton)
Dried cassava	
Production costs	1,279
Price	1,870
Domestic sorghum	2,200
Imported sorghum	
Free exchange rate	2,640
Preferential exchange rate	990

Source: CIAT field date.

In order to obtain a license to import, the feed manufacturer must purchase a certain amount of nationally produced sorghum at the ruling support price, but there is no requirement that cassava be purchased in order to obtain an import license. This means that cassava must compete with this mix of domestic sorghum and imported sorghum at the preferential exchange rate. Under this policy, cassava is rendered less competitive by an administrative rule that excludes cassava.

However, apart from Venezuela, the 1982 debt crisis has forced a rationalization of both exchange rate and domestic pricing policies in tropical Latin America. This has created a price environment in which cassava now can begin to compete on a basis that more accurately reflects real production and marketing costs. In this environment, cassava is, in general, cost competitive with domestic grains. Nevertheless, for countries such as Panama and Colombia, there have never been grain policies that have adversely affected the ability of cassava to compete in the mixed feed market. In these countries, the second constraint on the development of the dried cassava market becomes apparent, that is, the nature of price formation in existing cassava markets and the effect this has on incentives to invest in processing capacity for cassava chips.

In Panama and Colombia, and in the rest of Latin America except for Brazil, price formation in cassava markets is based on the market for human consumption of cassava, which in turn is based on the marketing of fresh roots. The perishability and bulkiness of fresh roots creates several constraints on the development of a unified price structure for cassava. First, markets for fresh cassava are spatially fragmented. The perishability and high transport costs limit arbitrage between markets at any significant distance. Prices depend instead on local supply and demand conditions, resulting in significant differences in cassava prices in different markets.

Second, farm-level prices for cassava entering the fresh market are normally well above the costs of production of cassava that would be processed. Prices set in the fresh market, therefore, give the illusion of higher costs of production than really predominate. The reasons for this divergence between prices and costs are risk and quality factors. A certain percentage of roots is discarded due to insufficient size. Normally, a relatively high starch content is required, and factors such as insect attack or a rainfall after an extended dry period will reduce starch levels below commercial acceptance. Another risk is the rationing of market access that is found in fresh cassava markets. Farmers cannot normally sell when they want to but rather when they can. They will often sell early, sacrificing yield, in order to gain access to markets. Janssen (1986) estimated for the Atlantic coast of Colombia that farm prices for the fresh market could be discounted by 25 percent to reach a price at which selling to a processing market would be equally profitable.

Finally, spatially fragmented markets, where volumes entering the market are small compared with the production capacity, introduce significant year-to-year price variability. (Significant seasonal price variability is limited because of the seasonal storage possible by leaving cassava in the ground.) This interplay of supply and demand results in prices in years of relative scarcity being far above what is needed for cassava to enter the animal feed market. A unified price structure is required for development of multiple markets. However, a shift in either supply or demand conditions in the fresh market makes returns on capital invested in processing capacity very risky, due to the inability to operate in years of high prices.

This riskiness of capital returns on processing investment also affects Brazil, where farinha dominates in price formation in cassava markets. For Brazil, an inelastic price elasticity, declining demand induced by the wheat subsidy, and variability in production due to the marginal climatic conditions of the northeast, cause significant price variability. This creates an uncertain environment for both farmers and prospective investors in cassava chipping and drying. For farmers, any expansion in planted area, especially in a year of above-average rainfall, risks driving prices down to variable costs of production. On the other hand, investment in chipping and drying capacity runs the risk of coinciding with a year of poor rainfall, high prices, and inability to compete with maize in the animal feed market. Incentives on the side of the farmer and the processor run counter to each other, even though costs of production suggest acceptable profit levels for both farmers and processors.

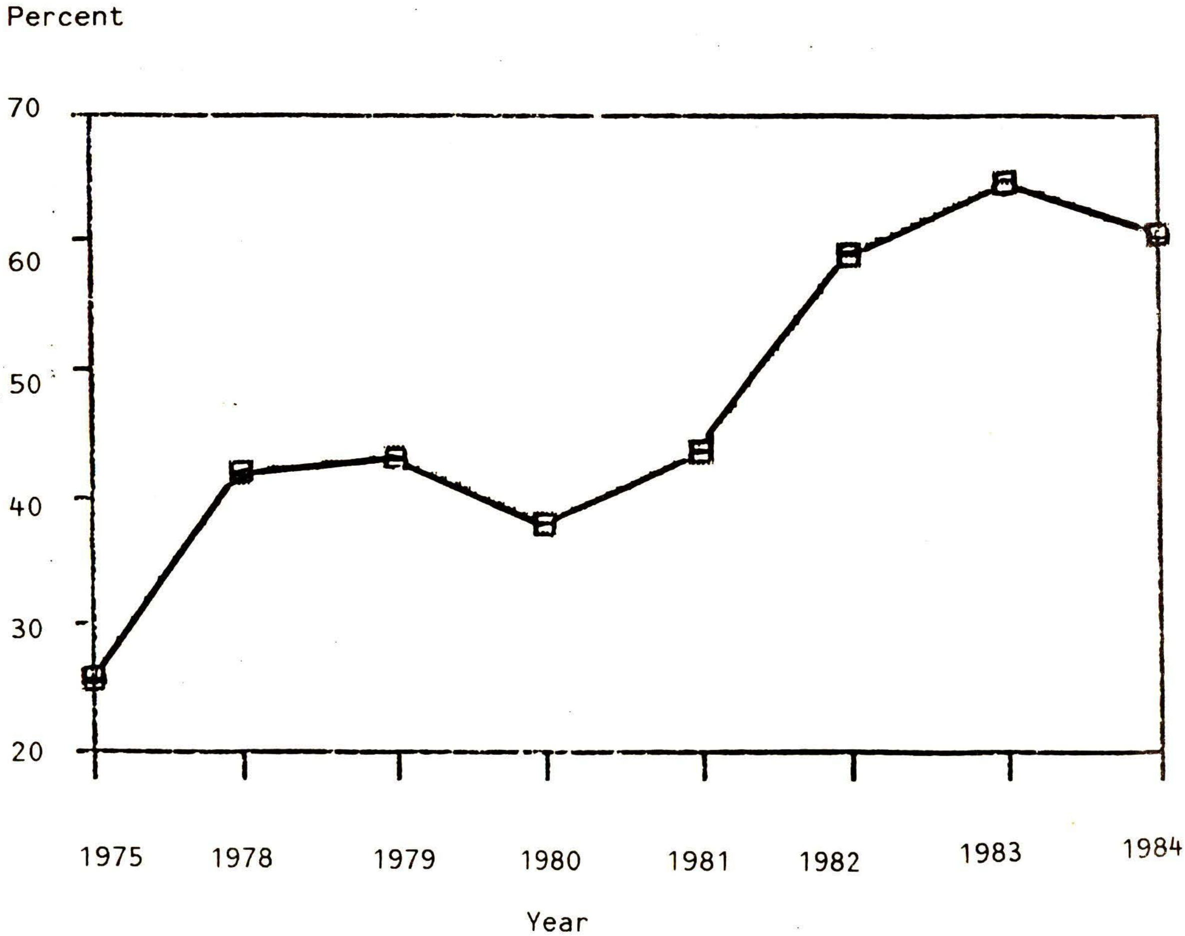
In the case of both the fresh urban market and the farinha market, price formation has inhibited the development of alternative markets for cassava. By comparison, grains are tradable internationally, year-to-year price variability is offset by storage, and markets are spatially integrated with relatively low transport costs. Grain prices are more stable and market integration ensures a more effective transmission of incentives. However, the fact that cassava could compete in the feed rations market suggests a market failure where intervention would lead to increased production and economic efficiency.

The basis for correcting that market failure is suggested in Figure 2. Development of an alternative market such as the animal feed market provides both growth prospects and a floor price for the food market. Reduced market risk provides the incentive for farmers to expand production. Janssen (1986) estimates the response of farmers to the development of such a floor price. On the other hand, expansion of the production base drives prices in the food market down to the floor price, thereby both stabilizing prices--with attendant benefits for cassava consumers--and unifying prices in both markets. The key, of course, to the whole process is investment in processing capacity that allows production to expand to that critical point where the cassava price has stabilized and is unified with the feedgrain price. There are several options for accomplishing such stabilization and the options should be evaluated according to policy objectives.

THE DEVELOPMENT POTENTIAL FOR CASSAVA IN LATIN AMERICA

Cassava's multiple uses allow the crop to adjust to changing market conditions as economies develop and in so doing to maintain a significant elasticity in demand. Most staple food crops at critical income levels actually face declining per capita consumption, but by

Figure 2--Debt service to export ratio, Latin America



developing alternative markets, such as that for animal feed rations, cassava is able to maintain a continued growth in market demand. Development of cassava as a component in the mixed feed industry thus opens an opportunity to use cassava to generate income in typical cassava production zones. These zones tend to be the marginal agricultural regions of Latin America and, as a large World Bank study for northeastern Brazil concluded (Kutcher and Scandizzo 1982), such agricultural economies tend to be demand-constrained in terms of their growth prospects. This seems somewhat paradoxical unless one realizes that the type and number of cropping and livestock alternatives available to farmers in such areas are limited, and most crops face inelastic demand. The potential for developing cassava as a major cash crop in such areas is real and to date has been overlooked in areas such as northeastern Brazil and the Atlantic coast of Colombia.

The other principal characteristic of cassava in Latin America is its production by small-scale farmers. Cassava fits well into small- farm systems. Its manipulability in intercropping systems; its flexibility in planting and harvesting; and its adaptability to principal cultural practices, often not mechanized, have contributed to its widespread use in small-farm systems. However, just as important to the dominance of small farmers in cassava production is the organization of marketing systems for fresh roots and the supply of roots to small-scale farinha plants. Harvesting small lots on a regular basis under significant marketing risk is not compatible with the management resources or (probably) risk preference of large-scale farmers. Thus, cassava offers that rare combination of a small-farmer crop, produced under marginal agricultural conditions, but with significant potential growth in overall demand. With these characteristics, policy should be oriented to maximizing cassava's development potential in Latin America, especially as a means to increase incomes of small farmers.

Realizing cassava's development potential, therefore, depends on linking the small-scale producer to growth markets, particularly the feed-component market. At issue, then, is how to motivate investment in processing capacity so as to maximize access of small-scale farmers to this market. Two design issues dominate: the scale of the processing plant and ownership and management of the plant. Scale will largely influence ownership options and both will influence the degree to which the cassava producer vertically integrates into processing and marketing of chips and pellets.

Small-scale agroindustry is rare in Latin America, especially compared with Asia. Much of the small-scale processing that is done in Latin America is done by the producer himself. Panela, cheese, farinha de mandioca, and chuno production are all cases where the farmer himself invests in processing capacity. The alternative in Latin America has been large-scale processing plants, for example, rice milling, sugar refining, milk and cheese processing, maize starch production, and oilseed crushing. Rarely have processing plants of intermediate size been a feature of the agricultural economy. Farinha production, in parts of northeastern Brazil, is one of the few examples of intermediate processing plants. Three factors contributed to the development of these plants. First, Brazilian manufacturers designed intermediate processing machinery, such as hydraulic presses and mechanized roasting equipment. Second, cassava production itself reached a sufficient density to support specialization and economies of scale in processing. Third, improvements in transport infrastructure aided the process. By contrast, in the North region of Brazil farinha is still produced at the farm level.

The farinha economy of the Brazilian Northeast provides the model for the prospective cassava chip industry of Latin America. This chip industry, however, must pass through various stages to arrive at such a model. The initiation must focus on stabilizing market conditions for the cassava farmer, thus motivating him to expand cassava production. The initial production base must be built on an integration of the farmer into processing. The technology of solar drying of cassava is well adapted to such an integration; it makes use of underemployed labor during the off-season. Moreover, the processing plant provides the mechanism for operation of the price floor. The farmer can expand production, and if prices in the food market rise, he will still be better off, because he will have the funds to cover the investment in the processing plant through sales to the fresh market. Independent processors do not have such flexibility in covering the capital costs of the plant. A certain critical density of production needs to be developed before there is any movement to specialization in processing, motivated by scale economies (Lynam 1987). The operative factor here is a sufficient density to minimize transport costs for roots, on the one hand, and the effective price linkage of the cassava root and feedgrain markets, on the other. Otherwise, spatially separated, small-scale plants operated by producers will have the advantage.

Developing the market for cassava chips and pellets in Latin America requires key institutional interventions in order to overcome the particular kind of market failure inherent in lack of diversification in cassava markets. These interventions to date have been organized around pilot projects in key target regions. The initial interventions must demonstrate the economic and technical feasibility of the processing plants, create market channels to mixed feed factories, and develop plans for the backup of production increases. This process obviously requires an integrated, institutional approach in the initial stages, with institutional costs declining as the demonstration effect starts to take over. Key services are a line of credit for small-scale agroindustry, technical assistance in plant construction and management, extension services for production technology, and contract development between cassava drying plants and feed factories. Proper organization of these pilot projects can ensure that small-scale farmers are the primary beneficiaries of development of the dried cassava market (Lynam et al. 1986).

CONCLUSIONS

Agricultural economies in tropical Latin America have undergone significant structural change during the postwar period. Changes on the production side, such as massive mechanization, increased fertilizer and agrochemical use, and the advent of improved varieties in some major crops, were matched by significant changes in food demand due principally to rising incomes, rapid urbanization, and major changes in the organization of food wholesaling and retailing. Changing consumption patterns and rapid demand growth in income-elastic food commodities created significant growth markets and income generation potential for domestic producers. In many commodities, however, production was not able to respond quickly enough to meet rising demand, resulting in either increases in imports or upward pressure on prices. This rapid structural change created a complex set of issues for policymakers, especially how to best use changing domestic demand to modernize agricultural production while ensuring that food prices were kept in line. Meeting the food needs of the burgeoning urban population and yet controlling inflation became a major policy concern.

Nowhere were these issues more pronounced than in the feed-livestock sector in tropical Latin America. Expenditure on meat formed a large component of the consumer's total budget. Moreover, the relatively high income elasticity resulted in a significant growth in demand. But growth in the supply of beef, the predominant meat in the diet of tropical Latin America, did not respond sufficiently to meet the growing demand. In part, this was due to biological limits on the rate of growth in beef production, and, in part, to the reliance on extensive systems. The area devoted to pasture expanded more or less in line with growth in cattle stock. Only in Brazil and Venezuela were there major increases in the stocking rate, and even in those countries these increases started from low levels.

This gap between the supply and demand for beef was met, not by beef imports, but by increases in the production of alternative meats, especially poultry. Poultry production expanded rapidly in the last two decades in tropical Latin America, as production systems became more intensive and marketing systems for poultry achieved significant scale economies. Real prices of poultry fell in most countries, while the price relative to beef fell even further. The poultry sector was the solution to overall price inflation in the meat sector. First, supply was responsive to profit incentives, and meat supplies in the short run were not constrained by biological or reproductive limits. Second, substitution between beef and poultry was significant, with the falling price of poultry putting a lid on rising beef prices. The poultry sector made the whole meat sector more manageable and more responsive to short-run shifts in demand.

The rapid increase in poultry production resulted in numerous backward linkages to other sectors in the agricultural economy. The derived demand for feed components, especially carbohydrate sources, increased dramatically. Not all countries have exploited the opportunity created by this market to develop feedgrain production (and income generation potential for feedgrain producers). Moreover, all tropical Latin American countries, except Paraguay, have become net importers of feedgrains, as production has been unable to keep up with demand. As with diversification in meat production, one of the means to increase supplies of carbohydrate sources for the feed industry is to diversify sources of supply. Some countries, such as Colombia and Mexico, have been particularly successful in developing sorghum production. Dried cassava offers another distinct, and yet unexploited, alternative for increasing supplies of feed components. Cassava will not completely replace maize or sorghum, but there is a potential niche in most agricultural sectors in tropical Latin America where cassava can be competitively produced to compete with feedgrains in mixed feed rations.

Latin America is at a stage in its development where diversification should be occurring in cassava markets. However, Latin America lags well behind Asia in this regard. There are many reasons for this lag, but the principal factor has been that prices in cassava food markets have not been an efficient indicator of the relative profitability of investing in cassava processing capacity. Price variability has increased the risks of entrepreneur investment in these new markets. Linking price formation in cassava markets to feedgrain markets would provide the basis for cassava to begin to take part in the development process in Latin America. However, in Latin America, this will require an initial institutional intervention to form these market linkages. Moreover, encouraging cassava can be a policy tool for equity by making the development process more equitable. Linking the small-scale, cassava-growing farms, which are characterized by underemployed labor and land resources, to a growth market, such as exists for dried cassava, can achieve increased income in a stratum that has been increasingly marginalized in the recent growth process in Latin America.

In recent times the economic climate in tropical Latin America has been appropriate for bringing cassava into the agricultural policy process. The 1982 debt crisis resulted in major realignments in foreign exchange rates, reductions or elimination of subsidies, and a renewed emphasis on increasing domestic production and reducing imports. Except for Venezuela, cassava has become competitive with feedgrains under existing grain pricing policies. Demonstrating that cassava can be a vehicle for raising labor and land productivity in marginal agricultural zones, for increasing small farmer incomes, and for reducing feedgrain imports will ensure that cassava will be a component in future overall agricultural planning. Cassava adds flexibility to the planning process, and it provides a cropping alternative especially adapted to tropical conditions. The niche is there; it only remains to exploit it.

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7
Trends and Prospects for Cassava in India*

P. S. George

India accounts for about 3 percent of the world's cassava area and 5 percent of the world's production of cassava. During 1983/84, the area under cassava was less that 0.2 percent of the total cropped area in India and the rice equivalent of cassava production equaled about 5 percent of the total production of rice in the country. Though the area under cassava and its production do not occupy an important position in the Indian agricultural economy, cassava is an important crop in the two states in which its production is concentrated, Kerala and Tamil Nadu. In 1960/61, Kerala accounted for about 88 percent of the cassava area in India, and Tamil Nadu accounted for another 9 percent. By 1983/84, Kerala's share of cassava area was still about 76 percent, and Tamil Nadu had increased its share to about 16 percent. About two-thirds of total production in 1983/84 came from Kerala; about a quarter came from Tamil Nadu.

Because Kerala has chronic rice deficits, cassava was popularized as a cereal substitute toward the end of the last century, and it continues to play that role even today. The area under cassava accounted for about 8 percent of the total cropped area in the state in 1983/84; converted to its rice equivalent, cassava production equaled about 145 percent of rice production. Most of cassava produced in Kerala is for home consumption and comes from rainfed land. More than half the cassava area in Kerala is concentrated in the three southern districts of Trivandrum, Quilon, and Kottayam.

Agriculture in Kerala is characterized by its emphasis on plantation crops, especially rubber and coconuts. Because of the permanent nature of these crops and the high returns they give, cassava does not compete with them. At the same time, with increasing returns for these crops, there has been a tendency to bring even somewhat marginal lands under rubber and coconut cultivation. So the area available for cassava might decline. A comparison of food and fodder crops made in a study of the economics of crossbred cattle indicates that in the plains and hilly areas of Kerala the net income from cassava was less than the incomes from paddy and fodder crops during the mid-1970s.

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*Summaries of the six country case studies are presented in these proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See P. S. George, Trends and Prospects for Cassava in India, Working Paper 1 on Cassava (Washington, D.C.: IFPRI, May 1988).

Most cultivators in Kerala grow some cassava as a pure crop or as an intercrop on garden patches or plots on the hillsides. Chemical fertilizers are rarely applied. In the major cassava-growing areas of the state, 70 to 80 percent of the growers have less than 0.4 hectares of land. In the midland and highland zones of the state, not less than a third of the cultivators depend on cassava as their principal crop.

In Tamil Nadu, the Kanyakumari district (which is geographically an extension of Kerala's Trivandrum district) produces cassava mainly as a supplement to the rice diet. As in Kerala, production occurs mostly on rainfed land. However, the introduction of cassava in the Salem district of Tamil Nadu, which did not develop until after the Second World War, was influenced by the industrial use of cassava for the manufacture of starch. This district now accounts for more than half the cassava area in Tamil Nadu. Much of this land is irrigated, and a large proportion of the cassava produced is used for industrial purposes. The use of chemical fertilizers is common. Yields are usually much higher than in Kerala (32 tons per hectare in Tamil Nadu against 16 tons per hectare in Kerala in 1983/84), which reflects the nature of the land under cassava cultivation and cultural practices.

Cassava is consumed mainly as baked tubers in India. Small quantities are used in the form of chips, flour, and sago, which is a wet starch that is roasted, dried, and finished. Cassava used to be the main staple in the diets of many low-income households, and continues to be an important item of consumption for many, though easy access to rice has reduced dependence on it. A consumer survey conducted in 1972 indicates that nearly all householders in Kerala used cassava as a supplement to their rice diet or as a side dish. During periods of scarcity, cassava is used as a substitute for rice by low-income people. The social stigma attached to cassava production was removed when the middle-class population with fixed incomes began to consume cassava during periods of high inflation. The growing demand for cassava from the middle-class, fixed-income group reached a peak in the early 1970s. The average daily consumption per capita in Kerala was estimated to be 0.2 kilograms in rural areas and 0.1 kilograms in urban areas.

The availability of most food items in Kerala is at a minimum during July and August, and these months are the worst period for the poor. Since cassava can be planted at different periods and since there is some flexibility in the harvesting period (even to the extent of harvesting the tuber before it is fully mature), many poor households survive on a cassava-dominated diet during these months. Though the harvesting of the principal crop at maturity is scheduled only in February, there is a minor crop season in which the harvesting period coincides with the July-August period of scarcity.

The industrial use of cassava began after the Second World War when starch and flour were manufactured to meet shortages of maize and potato starch from Western countries and cassava starch from Indonesia, which was used in textile mills. Limited quantities of cassava were used in products such as dextrines, manioc meal, and glucose. Starch is also used in the manufacture of sago, mostly in Tamil Nadu. Restrictions imposed during the 1960s on processing and exporting cassava and its products from Kerala induced the growth of cassava-based industries in Tamil Nadu. Attempts to expand the industrial use of cassava in Kerala have met with little success. But this is not true in Tamil Nadu, particularly in Salem.

TRENDS

Cassava area in India was 2.7 million hectares in 1960/61, and grew rapidly through the 1960s at an annual rate of about 4 percent (Table 1). The growth rate was still positive during the 1970s, 0.3 percent, but it fell during the late 1970s and early 1980s, making the growth rate for the whole 1970/71 to 1983/84 period negative--1.2 percent. Cassava area reached a peak of 3.9 million hectares in 1975/76, but then declined, falling to 3.0 million hectares by 1983/84.

These changes were heavily influenced by changes in the area under cassava in Kerala. The growth rate of cassava area in Kerala was highly positive during the 1960s, 3.12 percent, but it became negative, falling to -2.3 percent for the 1970/71-1983/84 period. Cassava area in this state was 2.4 million hectares in 1960/61, reached a peak of 3.3 million hectares in 1975/76, and fell below the 1960/61 level to 2.3 million hectares in 1983/84.

The growth rate of area in Tamil Nadu was steadier. It was about 9 percent through the 1960s, and remained positive through the 1970s and early 1980s at 1.3 percent. The rate of growth in recent years has not matched the rates of earlier years, however.

The all-India average yield of cassava increased from 7.2 tons per hectare in 1960/61 to about 19 tons per hectare in 1983/84, an annual growth rate of 3.4 percent. The growth rate for the 1960s was about 9 percent, fell to 0.2 percent in the 1970s, and was slightly higher, 0.5 percent, for the 1970/71-1983/84 period. There was a sudden increase in yields (which may be partly due to a change in estimating procedures) from 7.1 tons per hectare in 1962/63 to 11.6 tons per hectare in 1963/64. The increase was more or less gradual afterwards until it reached another peak, 17.5 tons per hectare, in 1972/73.

The all-India yields reflect two distinct phases in Kerala and Tamil Nadu. In the first phase, which lasted until 1974/75, yields in Tamil Nadu remained more or less stagnant at about 10 tons per hectare, but Kerala's were usually much higher. In the second phase, beginning in 1975/76, yields in Tamil Nadu increased substantially and maintained the tempo through the end of the decade. In 1983/84, the average yield in Kerala was 16.7 tons; it was 31.2 tons in Tamil Nadu. Between 1960/61 and 1983/84, yields of cassava increased at an annual rate of 2.9 percent in Kerala and 7.2 percent in Tamil Nadu.

These changes in area and yield resulted in an increase in cassava production from nearly 2.0 million tons in 1960/61 to 5.8 million tons in 1983/84. The increase was most rapid between 1960/61 and 1969/70--reaching as high as 12.7 percent--and somewhat more gradual until peak production of 6.6 million tons was achieved in 1975/76. But by 1983/84, production had declined to 5.8 million tons, as the growth rate for the 1970/71-1983/84 period fell and became negative. The growth rate for the entire 1960/61-1983/84 period was 4.7 percent.

Table 1--Trends and growth rates for area, yield, and production of cassava, selected years, 1960/61-1983/84

Year	Area			Yield			Production		
	Kerala	Tamil Nadu	All India	Kerala	Tamil Nadu	All India	Kerala	Tamil Nadu	All India
	(1,000 hectares)			(kilograms/ hectare)			(1,000 metric tons)		
1960/61	242.2	24.6	274.0	6,949	9,638	7,186	1,683.0	237.0	1,969.0
1970/71	293.6	38.6	345.2	15,726	12,088	14,860	4,617.2	466.6	5,129.6
1975/76	326.9	50.1	392.0	16,489	22,272	16,934	5,390.2	1,115.8	6,638.3
1983/84	233.0	48.1	304.7	16,752	31,193	19,035	3,903.2	1,500.4	5,800.2
Growth rates					(percent)				
1960/61-1969/70	3.12	9.38	4.08	10.50	2.17	8.61	13.62	11.55	12.69
1970/71-1979/80	-0.61	3.50	0.25	-2.31	11.79	0.15	-2.92	15.29	0.40
1970/71-1983/84	-2.27	1.30	-1.20	-1.01	8.64	0.47	-3.28	9.94	-0.73
1960/61-1983/84	0.68	2.93	1.32	2.88	7.20	3.36	3.56	10.13	4.68

Source: Compiled from various issues of <u>Agricultural Situation in India</u>. Calculation of growth rates was made by the author.

The growth of cassava production in the 1960s in India was closely linked with cassava production in Kerala. During the 1960s, the annual growth rate of production in Kerala was 13.6 percent, and production grew from 1.7 million tons in 1960/61 to a peak of 5.7 million tons in 1972/73. However, the growth rate became negative, -3.3 percent, during the 1970s and early 1980s, with production falling to 3.9 million tons in 1983/84. Over the entire 1960/61-1983/84 period, the growth rate of production in Kerala was 3.6 percent.

In Tamil Nadu, the growth rate of production during the 1960s was 11.6 percent, so that production increased from 237,100 metric tons in 1960/61 to 466,000 metric tons in 1970/71. The growth rate increased during the 1970s, but fell during the early 1980s so that the growth rate for the 1970/71-1983/84 period in Tamil Nadu was 9.9 percent. Production in 1983/84 was 1.5 million tons.

About 70 percent of the cassava produced in Kerala was used for human consumption in 1981. This came mainly from the Kanyakumari district. Nonavailability of rice was the major factor responsible for increased cassava consumption. Data available from consumer surveys indicate that the income elasticity for cassava is high among the poorest households and echelons with increased income, becoming negative for high-income groups.

Though estimates of starch production vary, it is estimated that about 30 percent of the cassava produced in India is used for the manufacture of starch. With another 55 percent going for human consumption, only about 15 percent of the production remains for other purposes, such as feeding cattle directly.

Cassava prices showed large annual fluctuations. Retail prices of cassava were about 25 percent higher than wholesale prices. With increased availability of rice, the ratio of retail prices of rice to cassava has fallen in recent years.

There has been an improvement in the production of livestock products, and this has generated increased demand for livestock feed. The supply of the raw materials available for cattle feed is likely to fall short of anticipated demand. Utilization of cassava in manufacturing cattle feed can be an effective means of bridging the gap in feed availability.

There is no systematic procedure for obtaining data on domestic utilization of cassava for different uses. Therefore it is not possible to obtain reliable time series data on cassava utilization in India. As data based on a constant proportionality between uses in deriving the domestic utilization pattern indicate only production changes, they were not used in the study. Instead, whatever fragmentary evidence is available from various sources has been brought together to give some idea of the domestic utilization pattern.

Data from the 17th and 28th rounds of the National Sample Survey (NSS), which relate to 1961/62 and 1973/74 respectively, indicate that during this period rice consumption in Kerala declined, but cassava consumption increased. The per capita daily consumption of rice was 1,136 calories in 1961/62 and 840 calories in 1973/74; per capita daily consumption of cassava was 182 calories in 1961/62 and 278 calories in 1973/74. These estimates were consistent with estimates from food balance sheets of rice consumption, but are underestimates for cassava consumption.

The per capita consumption of rice did not vary much between urban and rural areas, but per capita consumption of cassava did. For example, the 28th round of the NSS showed that per capita consumption of rice was 845 calories in rural areas and 190 calories in urban areas. In the two lower expenditure groups in rural areas, more calories came from cassava than rice.

A food habits survey conducted by the Operations Research Group (ORG) during the early 1970s indicated that the average daily consumption of tubers and roots (mostly cassava) by adults was 175.3 grams, by school children was 120.8 grams, and by preschool children was 30.9 grams. The ORG study also showed that the number of calories obtained from rice increased with income, but that the number of calories obtained from cassava decreased with income. A study by the International Food Policy Research Institute showed the same trend.

The estimates of the income elasticity of demand for cassava based on the NSS data show that lower income groups had positive values and higher income groups had negative ones. Furthermore, the aggregate income elasticity was positive for rural areas and negative for urban areas. Some cross-section surveys also indicate a negative relationship between cassava consumption and income.

Since data on all-India prices of cassava are not available, it is possible to analyze only the price trends in the major production areas, especially Kerala. The farm price of cassava in Kerala increased from Rs 7.85 per quintal in 1960/61 to Rs 70.02 per quintal in 1983/84. The increases during 1964/65 and during 1973/74 over the prices of the immediately preceding year were substantial. While the overall tendency for prices to increase was maintained throughout the period, there were nine years between 1960/61 and 1983/84 when farm prices fell from the previous year's prices. In fact, the tendency for a year of high prices to be followed by a year of falling prices was noticed even during the 1950s. The Tapioca Enquiry Committee attributed this to farmers' behavior. They tended to plant additional land with the crop the year after the price was high and to take additional land out of cassava cultivation when prices declined in the following year as a result of increased production.

MAJOR ISSUES

The High Level Committee on Land and Water Resources appointed by the Government of Kerala identified a number of constraints to increasing the output of cassava. These include the prevalence of low-yielding varieties; the slow adoption of modern production technology; the lack of awareness of improved practices; the use of uncertified, diseased planting material; the absence of plant protection practices; an uncertain market with fluctuations in prices; and poor avenues for alternative uses of cassava products to generate larger market demand.

Though research and extension on cassava have only been carried out on a limited scale, it has been possible to evolve some high-yielding varieties (HYVs). Most of the research has been carried out at the Central Tuber Crops Research Institute (CTCRI) and the agricultural universities of Kerala and Tamil Nadu. To accelerate the adoption of research findings by farmers, the CTCRI has launched the Lab-to-Land Programme. Information on the cultivation of HYVs and local varieties obtained from participating farmers indicated that during 1984/85, farmers realized an average yield of 26.28 tons per hectare from HYVs and 14.30 tons per hectare from local varieties, against 30 tons per hectare from HYVs on the CTCRI farm. Yields obtained from research stations reached as high as 60 tons per hectare. CTCRI trials of cassava-based multiple cropping systems showed that the maximum tuber yields, 47.8 tons per hectare, came from a system that mixed cassava and bananas.

The trends show that a turning point was reached in the 1970s for the area, yield, and production of cassava in Kerala. The role of cassava as a cereal substitute was highlighted before 1974/75, but this aspect was not given adequate emphasis after this year. This has bearing on the availability of rice from within the state and from imports from outside. Though cassava is not a major competitor with rice in terms of area allocation, the competition on the demand side is reflected in the allocation of other resources for cassava production. For example, about three-fourths of the gross irrigated area in Kerala was accounted for by rice, about 40 percent of the rice area was covered by HYVs, and a major portion of fertilizers used in Kerala was accounted for by rice. In contrast, less than 3 percent of the cassava area was irrigated, leaving 97 percent to be grown on rainfed area. Though HYVs of cassava have been introduced by the CTCRI since 1963, there has not been much effort to spread them. An evaluation study by the State Planning Board indicated that 64.5 percent of rice was treated with fertilizers, while the corresponding percentage for cassava was only 15.1

Data from a survey made by the CTCRI of farmers from villages where the Lab-to-Land Programme was in operation during 1984/85 show a net return of Rs 2,839 from 1 hectare sown with local varieties of cassava, but a net return of Rs 5,100 from shifting to HYVs. The net income from the HYVs cultivated at the CTCRI farm was Rs 6,085. The unit cost of production of HYVs was less than the cost per kilogram at the CTCRI farm.

The data on costs and returns suggest a number of conclusions. Cassava does not compete effectively with tree crops such as coconuts and rubber or with garden land crops such as bananas. Also, in most cases cassava is grown in areas where it has some comparative advantage because of its agroclimatic requirements. It does not normally compete for land with food or feed crops with which it competes on the demand side, except in some dry land areas in districts similar to Kanyakumari. The cost of production of cassava HYVs is such that they can effectively compete with other raw materials used in the manufacture of starch and cattle feed, and at the low competitive rates, these varieties offer enough incentives for farmers to adopt improved cultivation practices to get higher yields. Utilization of cassava in livestock feeds is an important area that has not been systematically explored. Even most feed composition studies in Kerala have only included cassava residues. In a linear programming study on optimum feeding practices involving 52 combinations of cow type, size, and milk yield, one author determined the composition of different feeds in a Tamil Nadu district. Cassava appeared to be a component of the optimum feedmix only for crossbred cows of 300 kilograms yielding 10 kilograms of milk. Farmers could realize savings of 9 percent over their current feeding practices if they feed their cows the optimum mix. It was not optimum for larger crossbred cows with higher yields or for buffalo.

In the absence of actual data on feed composition and cost of production, a survey was conducted among feed manufacturers to obtain some idea of the potential for the use of cassava in feed. Of the 13 manufacturers who responded, 6 used cassava in animal feeds and 1 used it in poultry feed. However, the maximum quantity of cassava used in animal feeds was 10 percent. It was only 1 percent in poultry feed. Four manufacturers used less than 2 percent cassava and 1 used 7 percent. All the feed manufacturers were willing to include cassava in animal and poultry feed, provided that good quality dried cassava was available throughout the year at an economic price. Cassava would replace maize, jowar, and broken rice in the feeds, up to a maximum of 20 percent, but in most cases only up to 10 percent of the feed mix.

The manufacturers were asked what price would induce them to switch from foodgrains to cassava. They replied that it would be between Rs 1,000 and Rs 1,400 per ton. Assuming an average price of Rs 1,250 per ton of dried cassava at the processing plant, and providing an allowance of Rs 250 per ton for processing charges, transportation charges, and margins to the dealers, this would imply a price of about Rs 1,000 per ton of dried cassava at the farm level. An average tuber-to-chips ratio of 2.75:1.00 would imply that the economic price at which feed manufacturers would substitute feedgrains with cassava would be at a farm-level price of about Rs 360 per ton of raw cassava, which is considerably below the price that prevailed in 1983/84. At a price of Rs 360 per ton and with costs and yields realized by farmers growing HYVs in the Lab-to-Land Programme, the net return would be Rs 3,228 per hectare. The net return to farmers at this price is much lower than the net return realized for HYVs in 1984/85, but higher than the net return from local varieties.

Studies based on the composition of animal feeds have indicated that dried cassava could replace at least 20 percent of the cereals now used for poultry feed and even more than that for cattle and pig feed. The use of cassava in compound feeds is very limited, however. At the same time, many farmers use cassava chips and cassava waste to feed cattle at home.

PROJECTIONS

The trend growth rates for area show a wide range, varying according to the number of years included in the estimation procedure. In view of the differences in trends, it can be assumed that the estimates based on the recent past (that is, a shorter period) represent a lower bound, and those based on the longer period, an upper bound. The projected area for 1990 has a lower bound of 288,100 hectares and an upper bound of 354,000 hectares (Table 2). For 2000, the lower bound is 257,600 hectares and the upper bound is 406,400 hectares. A different set of projections incorporates adjustments for possible changes in the area in

Table 2--Projections of area, yield, and production of cassava, 1990 and 2000

State/Year	Area	Yield	Production
	(1,000 hectares)	(kilograms/ hectare)	(1,000 metric tons)
Kerala			
Trend			
1990			
Lower bound	201.4	14,256	...
Upper bound	260.6	19,412	...
2000			
Lower bound	160.0	14,256	...
Upper bound	274.2	25,234	...
Adjusted			
1990	231.0	17,000	3,927
2000	231.0	19,700	4,551
Tamil Nadu			
Trend			
1990			
Lower bound	55.2	50,466	...
Upper bound	61.7	56.363	...
2000			
Lower bound	63.4	100,693	...
Upper bound	81.3	129,121	...
Adjusted			
1990	58.5	34,400	2,012
2000	72.3	43,600	3,152
All-India			
Trend			
1990			
Lower bound	288.1	17,741	...
Upper bound	354.0	22,131	...
2000			
Lower bound	257.6	18,578	...
Upper bound	406.4	30,549	...
Adjusted			
1990	329.5	19,900	6,557
2000	358.3	24,500	8,778

Sources: Calculations made by the author.

Notes: The adjusted estimates assume that the area in Kerala will stabilize at the level of 1990 and that the proportion of cassava area in other regions will increase. The adjusted estimates for yield were made with adjustments in the trend estimates to allow for progress in the adoption of improved varieties and greater use of irrigation and fertilizers.

different regions: it assumes that the area under cassava in Kerala will stabilize around the level projected for 1990 and that the area in other regions will increase. These projections for 2000 are close to the average for 1969/70 to 1971/72, namely, 350,000 hectares.

When trend growth rates are used, the projected all-India yields for 1990 range between 17.7 and 22.1 tons per hectare. For 2000 they range between 18.6 and 50.1 tons per hectare. Yields projected on the basis of past trends for Tamil Nadu reflect the high growth rate of the 1960/61 to 1983/84 period, and so appear to be beyond reach on the basis of currently available varieties and the rate of adoption of new varieties. Therefore, considering that progress in the adoption of HYVs has been slow and that cassava development has had little importance placed on it, one can speculate that all-India cassava yields may be 20 tons per hectare in 1990 and rise to 25 tons per hectare in 2000.

The projections for area and yields indicate that production of cassava in 1990 will be 6.6 million tons and that by 2000 it will go up to 8.8 million tons. Kerala's share in all-India production is projected to fall to 60 percent in 1990 and 52 percent in 2000. At the same time, the share of Tamil Nadu is projected to increase to 30 percent in 1990 and to 36 percent in 2000. States other than Kerala and Tamil Nadu, which between 1981/82 and 1983/84 produced an average of 5 percent of India's cassava, are projected to produce 10 percent of it in 1990 and 12 percent of it in 2000.

Changes in the demand for cassava for human consumption occur through changes in tastes and preferences, income, relative prices, and population. It is assumed that there will be no major change in the tastes and preferences of consumers in the important consuming centers over the period of the projections.

The income elasticities indicated by the NSS and cross-section surveys suggest that although low-income groups will increase their consumption of cassava, increases in the incomes of middle-income families and changes in the distribution of income will reduce overall cassava consumption. In view of these estimates, the income elasticity of cassava can be assumed to be close to zero, and therefore the effect of income changes on consumption can be excluded from the projection framework.

The availability of rice and other cereals has been satisfactory and can be expected to improve. This will keep their market price within certain limits and makes it unlikely that relative price will move in favor of cassava. Therefore, no increase in the demand for cassava for human consumption on account of changes in relative prices is envisaged.

Population change will thus be the major factor influencing cassava consumption. The annual growth rate of population in Kerala during the last few years has been slightly less than 2 percent. Considering that the annual growth rate of consumption between 1970/71 and 1981 was less than 1 percent, and that population increases would be the major factor contributing to the increase in the demand for cassava for human consumption, it is estimated that the demand for cassava for human consumption will increase at an annual rate of 1.5 percent, so that the quantity demanded in 1990 will be about 3.3 million tons and that in 2000 will be about 3.9 million tons (Table 3).

Table 3--Uses of cassava projected to 1990 and 2000

Use	1981/82 to 1983/84 Average	Projections 1990	2000
		(1,000 metric tons)	
Human consumption	2,956	3,330	3,865
Starch[a]	1,625	1,750	1,875
Cattle feed	820	1,850	3,850
Exports	...	100	500
Total	5,401	7,030	10,000

Source: Calculations made by the author.

[a]This includes 20 percent waste.

In view of the availability of maize and starch manufacturers' preference for maize starch, it is assumed that the demand for cassava by starch manufacturers will increase only marginally from the current demand of 1.6 million tons (which includes an allowance of 20 percent for wastage) to 1.8 million tons in 1990 and 1.9 million tons in 2000.

It is estimated that the shortfall in concentrate feeds of plant origin will be at least 5.8 million tons in 2000. Since about 25 percent of this deficit could be made up from cassava, there is a demand for about 1.4 million tons of dried cassava for this purpose. Assuming that the ratio of raw cassava and dried cassava is 2.75: 1.00, the demand for raw cassava as an ingredient in animal feed is projected to be 1.9 million tons in 1990 and 3.9 million tons in 2000.

If prices are favorable and some efforts to export cassava products are made, it may be possible to reach export targets of 100,000 tons of cassava in 1990 and 500,000 tons in 2000.

Given all these assumptions, the potential demand for cassava will be about 7.0 million tons in 1990 and 10.1 million tons in 2000. The major source of market expansion is likely to be the use of cassava for cattle feed. Thus by 2000 the likely demand will exceed the likely supply by about 1.3 million tons.

POLICY IMPLICATIONS

Some of the constraints on the output of cassava might be overcome through the research conducted at the CTCRI, especially through the development of high-yielding, disease-resistant varieties, as well as efficient cultural practices, research and extension activities, and proper monitoring devices for the control of pests and diseases.

Assured supply of good-quality cassava on a continuing basis at competitive prices is important for inducing feed manufacturers to switch to cassava. Therefore, in addition to the existence of improved technology, it is important to evolve suitable processing facilities and to integrate cultivators and feed manufacturers through appropriate organizational mechanisms. Such integration has already proved effective in starch production in Tamil Nadu. Most cassava producers are small farmers and many of them may also have some cattle. Farmers' organizations are gradually undertaking the organization of milk collection and the supply of cattle feed. In this chain it may also be possible to introduce cassava, at least in the major cassava-producing regions, so that effective links can be established between the supply of cassava for cattle feed production, the distribution of cattle feed, and the organization of milk collection.

The alternatives available for bridging the gap between supply and demand projected for 2000 are based on strategies that depend on area expansion and yield increases. Since the scope for increasing the area under cassava in Kerala and Tamil Nadu above projected levels is limited, filling the entire gap by area expansion will require additional area of about 60,000 hectares in other states. On the other hand, if yield increases are considered, yields will have to rise to 28 tons per hectare to fill the gap--an increase of 15 percent over projected yields. In view of the limitations on increases in area, it may be necessary to concentrate on strategies to raise yields.

Adoption of HYVs would not only contribute to increased production of cassava, but it would also make it possible to overcome, at least partially, some of the disadvantages cassava has in competing with tree crops like coconuts and rubber or with garden land crops like bananas, which have limited the area used to produce cassava.

The key factor in realizing projected demand is the expansion of the domestic market through cassava use in cattle feed. The major constraints on expanding this demand originate in uneconomic cassava prices for feed producers and inadequate linkage between farmers and feed producers. The latter was discussed above. In regard to the former, the economic price of Rs 360 per ton of cassava suggested by feed manufacturers offers a viable price for farmers if the cost of production can be kept down.

Development of export markets is also a possibility. Both will require favorable cassava prices, stable supplies, and linkage of producers and processors through appropriate marketing arrangements. Technology has a vital role to play in expanding yields and reducing unit costs to levels at which cassava can compete effectively with other alternatives as an ingredient in cattle feed production and on international markets. Using cassava to its full demand potential and bridging the demand supply gap will depend upon development and adoption of improved technology at the farm level, evolution of suitable processing technology, and integration of producers and processors with cattle feed manufacturers.

8
Trends and Prospects for Cassava in Indonesia*

Faisal Kasryno

Cassava is the third most important staple food in Indonesia, after rice and maize, and it is one of the most commonly cultivated secondary crops in rural areas throughout the country. Indonesia is already self-sufficient in the primary crop, rice, and has established policies in its current five-year development plan to attain self-sufficiency in cassava, maize, and the other secondary crops.

Cassava can be cultivated on any soil and climatological condition in Indonesia. In fact, it is more important where agroclimatological conditions are poor. It is widely grown on marginal land, particularly on steep slopes where other crops cannot be grown efficiently. This practice may lead to serious soil erosion, particularly as cassava is planted with wide spaces and this might expose the soil to rainfall and runoff during the early stages of cassava growth, or after harvest. Cassava competes with rice in production on upland irrigated land and in rainfed regions, so incentives given to rice production may reduce cassava production.

The center of cassava production in Indonesia is Java; about two-thirds of Indonesia's cassava was produced there in the early 1980s, and East Java is the province that produces the most. The province of Lampung, on Sumatera, produced more cassava than any other province outside Java; in 1986, 47 percent of Sumatera's cassava was produced there.

The cassava production systems on Java and on the outer islands are different. Most Javanese farmers grow cassava intercropped with other crops such as maize, upland rice, and legumes. This makes crop intensity high. But land productivity is still low. Monoculture plantings are most common near urban markets. In the outer islands most cassava is planted in pure stands. Farm holdings there are larger and less intensively cultivated.

Because cassava is essentially an upland crop in Indonesia, it is rarely grown on irrigated land, where rice or perhaps sugarcane are usually planted. Fertilizer use is also low, even though application levels on other crops, particularly rice, are high. Farmers compensate for this to a significant extent by applying manures. Whatever fertilizer is used is limited to nitrogen (principally urea) and phosphorus (concentrated superphosphate).

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*Summaries of the six country case studies are presented in this proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See Faisal Kasryno, <u>Trends and Prospects for Cassava in Indonesia</u>, Working Paper 3 on Cassava (Washington, D.C.: IFPRI, December 1988).

Cassava roots are consumed in many forms. They are boiled, steamed, or fried; they are also processed further into gaplek--dried cassava chips--and starch. Cassava is a major source of calories and a major staple for rural households, especially where the resource endowment and productivity are poor. Bitter varieties are processed into gaplek or starch.

Gaplek is produced in three steps. The cassava root is peeled immediately after harvest, sliced, and dried. It can be stored for several months and has a moisture content of 14-18 percent. Although gaplek contains only 2.84 percent protein on a dry matter basis (compared with 11.86 for soft red winter wheat and 47.33 for expeller soybean meal), it is an excellent energy source: it contains 4,000 kilocalories per kilogram (compared with 4,254 for soft red winter wheat and 3,870 for expeller soybean meal). This could make it important as an animal feed.

Other types of food that are made from gaplek include gatot and tiwul, which are made by moistening the gaplek flour slightly and steaming it. Another food, ojek, is prepared by grating the roots, steaming the mash, drying the product, and reconstituting it with steam.

Starch is used by food and manufacturing industries, such as those producing krupuk (chips), snacks, alcohol, plywood, and paper. Demand for starch by these industries was estimated to be 15,000 to 24,400 tons per month in 1985. Most units that make starch in Indonesia are basically household industries.

Alcohol made from fresh cassava has been produced since 1984 by a pilot project in Lampung. The two plants in the project have a joint capacity of 140 tons of cassava per day and are able to produce 23,000 kiloliters of alcohol. Although the performance of these plants is attractive, the project is not yet commercially viable.

In terms of nutritional value, cassava by-products are competitive with other feed sources. Cassava tops provide high quality roughage and have been widely used by smallholders to feed large and small ruminants. Cassava peelings have also been fed to livestock. But, because they are usually mixed with soil, their quality is low. Cassava starch waste is used as a concentrate. Because it is a by-product of the starch industry, its production as a source of feed is tied to the development of that industry. When it is a watery product it is bulky, but the dry form is economically attractive as a source of feed than can be stored or transported.

TRENDS

The rate of growth of cassava production in the 16 years between 1969 and 1985 was slow, an average of 1.6 percent per year. In 1969 cassava production was 10.9 million tons, and by 1985 it had risen to 14.1 million tons (Table 1). Most of this increase came from Sumatera and Nusa Tenggara; production on Java was nearly unchanged. The year-to-year fluctuations of cassava output are high.

Harvested area under cassava declined at an average rate of 0.8 percent annually in the 1969-85 period. On a regional basis, cassava harvested area declined on Java, but grew modestly on the outer islands. A number of factors contributed to the decrease in area.

Table 1--Supply utilization of cassava, 1969-85

Year	Production	Net Imports	Total Supply	Feed	Manufactured Food	Manufactured Industry	Waste	Food Consumption Direct	Food Consumption Tapioca
	(1,000 metric tons of fresh root equivalent)								
1969	10,917	-930	9,987	200	60	313	999	5,556	2,820
1970	10,478	-945	9,533	191	58	289	953	5,123	2,990
1971	10,690	-1,494	9,196	184	125	281	920	4,989	2,680
1972	10,385	-1,007	9,378	188	125	285	938	5,057	2,780
1973	11,186	-210	10,976	220	221	324	1098	5,761	3,350
1974	13,031	-1,160	11,927	239	221	346	1193	6,128	3,800
1975	12,546	-303	12,243	245	150	354	1224	6,356	3,910
1976	12,191	-174	12,256	240	422	363	1202	6,415	3,610
1977	12,488	-472	12,053	240	218	359	1202	5,881	4,150
1978	12,902	-856	12,046	241	244	359	1205	5,179	4,810
1979	13,751	-1,972	11,779	234	229	348	1524	4,584	4,860
1980	13,726	-1,073	12,653	253	311	375	1645	4,244	5,720
1981	13,301	-1,036	12,265	245	372	359	1594	4,341	5,350
1982	12,988	-616	12,372	247	293	369	1608	4,438	5,410
1983	12,103	-748	11,355	227	293	340	1476	4,537	4,480
1984	14,167	-1,125	13,024	261	292	332	1695	4,637	5,800
1985	14,057	-1,586	12,471	249	289	360	1621	4,738	5,210

Source: The figures for production, net imports, feed, waste, and food manufactured uses are from Indonesia, Biro Pusat Statistik, Neraca Bahan Makanan Indonesia, 1969 to 1985 (Jakarta: Biro Pusat Statistik, 1969 to 1985). The figures for industry and direct consumption use are from Indonesia, Directorate General for Food Crops, "Supply and Demand for Food Crops in Indonesia," DGFC, Jakarta, January 1988.

Note: Tapioca consumption is defined as the total available for consumption minus direct cassava consumption.

There was a fall in the rate of growth of domestic demand for cassava. Government programs increased the amount of land used for the intensive cultivation of food crops, for the cultivation of rice, and for forests, all at the expense of cassava. For example, the decline in cassava area on Java has been accompanied by an increase in the areas of rice and maize. The planting of perennial crops such as cloves in West Java (Garut) has also led to reduced cassava area. Lastly, a decline in the ratio of cassava prices to the prices of other crops led to reductions in harvested area under cassava and increases in the area sown with crops such as soybeans, peanuts, and maize.

The decreases in area were offset by increases in yields, which grew an average of 2.5 percent annually. Average yields are, however, less than 10 tons per hectare. They are higher elsewhere in Asia: 15.7 tons in Thailand, 22.0 tons in Malaysia, and 19.0 tons in India (all 1982 figures). A part of the increase in yields was due to intensification programs for cassava begun in 1975, but these were limited mostly to Java. The area planted with cassava covered by these programs increased dramatically from 5,000 hectares in 1975 to 67,000 hectares in 1984.

Food balance sheets and food consumption surveys were used to make estimates of cassava use. But different data sets have different definitions; therefore they will not result in the same estimates. As it turns out, per capita consumption based on food consumption surveys was only a third of the consumption estimated in food balance sheets. The difference may be caused by underreporting of cassava consumption in the survey data and to a lack of reporting of consumption outside the home.

Domestic utilization of cassava in Indonesia can be classified into three groups: food, feed, and industrial uses. Most cassava was used as food. This use accounted for half of production in the first half of the 1970s and 73.0 percent in the early 1980s. Feed accounted for only 2.5 percent of production in both periods. Nonfood industrial use of cassava was estimated to account for about 3 percent of net production availability in the 1980s. The remainder of the amount of cassava produced is accounted for by waste and exports. About 35 percent of cassava is consumed on farms, 30 percent is marketed as food, 25 percent is sold to starch factories, and 10 percent is exported.

On a per capita basis, average annual consumption of all cassava products reached 19.14 kilograms in 1984. This was less than that in 1976 or 1980. Consumption of cassava was higher in rural areas than in urban areas. It changed little in the latter between 1976 and 1984, but fell in the former, accounting for the overall decline. Cassava consumption also fell as incomes rose, and the decline was particularly fast in rural areas.

More than three times as much fresh cassava was consumed in rural areas than in the urban areas. In 1980, urban people consumed small amounts of dried cassava and cassava flour--0.10 kilograms per capita of the former and 0.57 kilograms per capita of the latter--but rural people consumed more--4.0 kilograms per capita of dried cassava, 0.10 per capita of cassava flour.

Much of the cassava processed in Indonesia is *gaplek*. Most *gaplek* is consumed as food--between 50 and 90 percent of the *gaplek* produced on Java and 20 to 40 percent of the *gaplek* produced in Lampung (on Sumatera).

For Indonesia as a whole it has been estimated that as much as 29 percent of the cassava produced was processed into starch in 1974, and that this amount increased to 35 percent in 1979 and 37 percent by 1985. Almost all cassava starch produced in the 1970s was consumed domestically. The large-scale starch industry grew dramatically in Lampung during the 1970s, so that the share of the province's cassava processed into starch increased from 20 percent in 1974 to 70 percent in 1979. It is estimated that 25 percent of the cassava produced on Java went into starch production. The proportions were 60 percent in West Java, 23 percent in Central Java, and 7 percent in East Java. Domestic demand for starch has been increasing.

Because cassava is highly perishable once harvested, waste was high, 9 percent of production in the early 1970s and 12 percent in the first half of the 1980s. Data on losses or waste should be treated carefully. Roots left in the soil, losses in the field after harvests, and cassava peels are included in waste data. The last are often used to feed livestock in rural areas; therefore actual waste may be less than what the food balance sheet data indicate. A similar problem for industrial uses of cassava is also likely to result in underestimation in the food balance sheet data. Other sources of data on losses are from surveys of cassava starch factories. In Indonesia, these factories are of two types, traditional and modern. In the near future, the number and capacity of the latter will increase, as the government has attempted to integrate opening new land for transmigration with the development of infrastructure and facilities for agricultural processing. Improvement of these infrastructures will reduce losses, improve the quality of cassava products, and increase cassava utilization for manufacture and feed.

Before independence, Indonesia was the largest exporter of cassava. The largest volume of gaplek exports was 341,000 tons in 1928, and that of starch was 223,000 tons in 1937. During the 1950s and 1960s exports of gaplek fluctuated greatly and exports of starch became negligible.

Exports of gaplek have ranged between 149,000 and 710,000 tons since 1970, although gaplek exports were banned in 1973 and so fell to 75,000 tons. Subsequently exports rose and fell again in the early 1980s, reaching a low of 156,000 tons in 1981. The Indonesian government has been encouraging exports since 1983. Consequently, they have crept back up to 385,000 tons in 1984 and to 535,000 tons in 1985 (but they went back down to 425,000 tons in 1986). The annual rate of growth of gaplek exports between 1978 and 1986 was 7.2 percent. Most gaplek exports--97 percent in 1982-84--went to the Federal Republic of Germany. During 1982-84, 62 percent of the gaplek exports came from Java, and 34 percent from Lampung province.

Only small amounts of cassava starch were exported in the 1970s; the largest volume was about 7,500 tons in 1974. Because of a shortfall in domestic production, Indonesia imported 64,000 tons of cassava starch in 1976; increases in domestic demand led to further imports in the 1980s--54,000 tons in 1982 and 64,000 tons in 1984.

For the 17 years ending in 1983, real prices of cassava were nearly constant, but the trend of real prices declined after 1984. Rice prices were also nearly constant and began to fall in 1984-85.

The seasonal price changes of cassava, however, were small compared with those of rice and even those of maize. In Java, the price of fresh cassava increased relative to the price of rice between 1959 and 1977, giving farmers an incentive to produce it.

Past trends showed a large increase in per capita income between 1976 and 1983; average income increased 40 percent in that period, a rate of slightly less than 5 percent per year. The increase in per capita income was much higher among the bottom 40 percent than among the middle 40 percent, while per capita income among the top 20 percent decreased slightly. These changes indicate better income distribution in 1983 than in 1976.

More than half the households in the bottom 40 percent increased their per capita income by more than 100 percent, but only 22 percent in the middle 40 percent and 18 percent in the top 20 percent did. Indeed, 44 percent of the households in the top 20 percent suffered a decline in their per capita incomes of more than 20 percent, compared with only 7 percent in the bottom 40 percent and 23 percent in the middle 40 percent.

As a food, cassava has been shown to have income elasticities that range between 0.10 and 0.40. These elasticities are higher for low- and middle-income groups than for high-income groups. Cassava appears to be favored by low-income households, reflecting the crop's inferior status. Processed cassava as a food has a higher income elasticity than does cassava consumed directly. The elasticities are higher off Java than on Java.

MAJOR ISSUES

There are two main sets of problems in increasing cassava production. The first is the problem of improving production technology. The second is in postharvest and processing techniques. Other issues include the substitutability of cassava in feed use.

Technological progress led to annual production growth rates of 3.9 percent for rice and 4.1 percent for maize in the 1969-85 period. Therefore it can be said that the substitution of production of other food crops for cassava in the past was due to government policies that favored maize and rice. With current technology and the existing economic environment, it is difficult for cassava to compete with other food crops in production.

But potential yields are far higher than those now achieved by farmers. Yields from recently developed high-yielding varieties are 50-60 percent higher than those from local, traditional cultivars. These have been included in breeding programs but have yet to be released.

There is ample potential for increasing yields through fertilizer use, especially in areas with optimum soil and climatic conditions. A comparison of fertilizer tests performed by the Bogor Research Institute for Food Crops (BORIF) shows that the differences in yields achieved using fertilizers are quite significant. Yields without fertilizer on farmers' fields with inferior soils averaged 7.1 tons per hectare. With fertilizer they averaged 12.0 tons per hectare. Yields on inferior soils without fertilizer were 10.6 tons per hectare in on-farm trials and 15.4 tons per hectare at research stations. With fertilizer, these yields were 40-50 percent higher, 20.1 and 23.5 tons per hectare. On optimum soils and under optimum climatic conditions the yields were higher yet.

Cassava yields vary widely between producing regions. These variations have been due mainly to variations in cropping practices, the use of inputs, marketing and trade, and accessibility to processing centers. Differences in local varieties contribute as well. Varieties in East Java have yields of 19.0 tons per hectare at research stations, close to the yields of improved varieties; in farmers' fields the yields vary between 6.4 and 11.9 tons per hectare. In Lampung a local variety has yields that vary between 12.0 and 23.5 tons per hectare.

The big gap between yields on farms and at research and experimental stations is the result of differences in the technological packages adopted and in the production environments. Compared with other food crops, the relative prices of cassava at the farm level are low, which makes it less profitable for farmers to adopt improved technology. Besides, most cassava farmers lack the capital needed to purchase farm inputs, and institutional credit is not available. Since the growing period for cassava is more than eight months, the cost of other forms of credit put them beyond the reach of farmers.

If yields in farmers' fields now vary from 7-15 tons per hectare, in on-farm tests from 10-20 tons per hectare, and at research stations from 15-40 tons per hectare, then it is possible that with a favorable environment and government intervention, yields from farmers' fields could reach 20-25 tons per hectare in 1990 and 25-30 tons per hectare in 2000.

A comparison of the expected returns from actual and improved agronomic practices in East Java and Lampung shows that a substantial increase in yields and profitability could be achieved in both areas. Cassava production costs could be reduced by almost 50 percent, which indicates that a large increase in cassava supply is likely to occur if new cultivation practices were adopted.

Variable costs increased in both areas, but net income per hectare with the improved technology is nearly six times the income with traditional technology. The cost of production per kilogram is nearly half the cost with traditional practices.

The high cost of improved technology might be a cause of the slow rate of growth of cassava yields. Many farmers have no credit or operating capital to buy fertilizer with. And because it takes up to 12 months to harvest cassava, the costs of noninstitutional credit are high compared with those of rice, maize, or soybeans.

Research on cassava intercropping was conducted by the Central Research Institute for Food Crops in Sumatera and in collaboration with the International Rice Research Institute in Kalimantan. New technology was applied. This included crop varieties suitable to local conditions, an early-maturing variety of upland rice that allows early planting of legumes during the latter part of the wet season, spacing crops to reduce competition for sunlight, greater use of fertilizers and pesticides, and mulches to retard weed growth and conserve soil moisture during the dry season. The project showed substantial improvements in productivity and farm income and indicated that there is a large potential for increasing productivity. The size of the potential returns varies, and would be highest where present practices are least intensive.

The low prices of cassava do more than affect the ability of farmers to adopt new technology. The high priority the government gives to developing food crops through market and trade interventions is widely understood. Price supports given to rice are an example of this. But there is no guaranteed or floor price for cassava and its products. Prices sometimes fall so low that farmers might not bother to harvest their cassava. Moreover, price differences between regions are larger than for other crops as a result of differences in infrastructure and processing facilities.

Given this, it is easy to see why cassava is less developed than rice production. From an economic point of view, farmers prefer to grow rice and soybeans because the prices and markets for them are secure. In addition, cassava is an inferior good, nutritionally.

Improvements in processing and storage techniques are needed to make it possible for farmers to obtain higher prices in the future. Processing and conserving cassava products make the commodities easier to handle and increase their nutritional and market values. In addition, these processes create jobs and encourage exports.

But Indonesian farmers are often negligent about handling and processing. The products are usually unclean because they are dried without mats and stored in farmers' houses using rattan baskets or plastic bags. With these practices, crops cannot meet quality standards (especially those needed for exports).

The example of one starch factory, at Temanggung in Central Java, illustrates some of the problems with the storage and processing of cassava in Indonesia. This factory had a problem getting clean water to wash the fresh cassava with. The polluted water it used reduced the quality of the product significantly: the biological oxygen demand (BOD) was three times the level that could be tolerated. Also, the factory was unable to reach its potential processing capacity because there was a shortage of fresh cassava roots. Fresh cassava should be processed as quickly as possible, so the factory will be unable to reach its capacity until adequate storage is available.

With respect to the livestock feed situation, in the last 10 years, the annual rate of growth of demand for livestock feed mix has been about 7 percent. About 65 percent of the feed mix produced was for poultry. The feed components of the typical poultry feed mix have included about 35-40 percent maize, as much as 45 percent rice bran, and a variety of other components, including soybean meal, fish meal, bone meal, coconut meal, and gaplek.

If cassava is to be a substitute for other crops in feeds, it must be complemented by more protein supplements than, say, maize-based feeds. A linear programming model applied to find the least-cost feed formulae for layers, broilers, and swine shows that those formulae would include 15 percent gaplek for layers, 6 percent gaplek for broilers, and 46 percent gaplek for swine. But no gaplek appears in the formulae currently used by the feed industry. Cassava, in fact, comprises only 0.007 percent of the total feed use. And while the potential use of gaplek in swine feed is promising, the demand for swine in Indonesia is limited.

The main protein supplements of cassava are soybean meal and fish meal, both of which are highly protected as imports, which drives up their prices and makes it unprofitable to use them in feed rations. In fact, the substitutability of cassava for other crops in feed is influenced by the price of cassava relative to maize, rice bran, and the two main protein supplements. For example, a mix of 4 kilograms of gaplek with 1 kilogram of soybean meal is similar to 5 kilograms of maize in nutritional value. So if the cost of the gaplek/soybean mix is lower than the cost of 5 kilograms of maize, the mix will be substituted for the maize. The real price of maize has tended to fall, and domestic prices have been similar to world market prices. Indonesia is a net importer of maize, but, like the real price of maize, imports of maize have tended to fall.

PROJECTIONS

The rapid growth of rice yields over the 1969-85 period has been the result of special efforts and market interventions by the Indonesian government. With special efforts directed at increasing cassava yields, they could increase at the rate of 3.0 percent per year. At this rate, cassava yields can be expected to reach 12.6 tons of fresh cassava roots per hectare in 1990 and 16.9 in 2000 (see Table 2). It is expected that in Java, yields will increase at an annual rate of 3.6 percent while in the outer islands yields will continue to increase at an annual rate of 1.8 percent.

Area planted with cassava will continue to decline at a rate of nearly 1 percent per year. The simple trend analysis used in this study puts the area under cassava at 1.23 million hectares in 1990 and 1.11 million hectares in 2000. Other studies put it at 1.12 million hectares in 1990 and at either 1.07 or 1.09 million hectares in 2000.

Using the projections of this study for area and yield, total production can be projected to be 15.5 million tons of fresh cassava roots in 1990, 17.1 million tons in 1995, and 18.8 million tons in 2000.

Projections of consumption must be based on the estimated size of the future population. The Central Statistical Organization, Biro Pusat Statistik, estimates that the population of Indonesia was 164 million in 1985, and it was growing at an annual rate of 2.11 percent. That growth rate had fallen from 2.34 percent in 1980. Therefore, it can be projected that the annual growth rate of the total population will be 2.05 percent in 1990, falling to 1.85 percent in 2000. This will make the population 182 million in 1990 and 219 million in 2000.

Income elasticities should be negative for middle- and high-income groups and positive for the low-income group in rural areas. Therefore, cassava will continue to be important in the diet, especially as a way of increasing food security.

Increases in income, mobility, and urbanization will reduce the direct consumption of cassava as food. Since cassava in general is considered to be a less preferred food than rice or maize, increases in the production of these latter commodities and a declining trend in their real prices will further reduce consumption of cassava as food. In fact, per capita direct consumption of cassava as food is projected to decline about 1.0 percent annually, to 45 percent of total cassava consumption as food in 1990 and to 43 percent in 2000 (down from about 55 percent in 1984 and 65 percent in 1976).

Table 2--Projections of supply and utilization of cassava to 1990, 1995, and 2000

Year	Area[a]	Yield[b]	Production	Net Imports[c]	Total Supply	Domestic Use: Feed[d]	Domestic Use: Manufacture[e]	Domestic Use: Waste	Food Consumption[f]: Direct	Food Consumption[f]: Tapioca
	(1,000 hectares	(metric tons/ hectare)	(1,000 metric tons of fresh roots)							
1985	1,292	10.9	14,057	-1,586	12,471	249	649	1,621	4,738	5,214
1990	1,229	12.6	15,485	-1,839	13,646	318	790	1,549	4,944	6,045
1995	1,168	14.6	17,053	-2,132	14,921	512	960	1,535	4,907	7,007
2000	1,110	16.9	18,759	-2,472	16,287	825	1,168	1,680	4,491	8,123

Source: These are the author's estimates based on past trends and future prospects.
Notes: Net imports expressed in terms of gaplek would be in 1985, -535,000 metric tons; in 2000, 890,000 metric tons.

[a]Area harvested with cassava is projected to decrease 1.0 percent annually, based on a 10-year trend.
[b]Yield is estimated to grow 3.0 percent per year with the addition of new varieties and greater use of fertilizer.
[c]Exports are projected to grow 3.0 percent annually.
[d]Demand for feed is estimated to grow at annual rates of 3.0 percent to 1990 and nearly 10 percent to 2000 as cassava becomes more competitive with maize and as swine production increases.
[e]The estimated use in manufacturing in 1985 is estimated to have been 20 percent of total production. Demand for cassava by industry is estimated to grow 10.0 percent annually. The biggest component would be starch as an import substitution policy is implemented.
[f]The per capita demand for direct human consumption is estimated to decline as income rises. The number of households eating cassava is also expected to decrease.

Demand for starch-based cassava will increase at a rate higher than the rate of population growth, to reach 55 percent in 1990 and 64 percent in 2000.

If the rural population increases at an annual rate of approximately 1.6 percent, total consumption of cassava as food will continue to increase. As urban consumption of cassava as food, though low, has been and will probably continue to be nearly constant, the demand for cassava as food--consumed directly and processed--will increase slowly, about 1.0 percent per year. This indicates that in 2000, 40-60 percent of cassava production will be used as food.

The use of cassava in feed mills will increase with the demand for livestock and poultry products. The prospects for growth of production of these products are good. The use of cassava in industry and as a feed is projected to increase but remain small in 2000, less than 10 percent of total production. It is projected that the demand for cassava by the feed industry will increase at a rate of about 5 percent through 1990 and that this rate will increase to about 10 percent by 2000. Yet only about 4 percent of cassava production will be used as feed in 2000. This amounts to a total potential use of cassava for feed of about 0.8 million tons of fresh cassava roots. Of this amount, which assumes the adoption of the least-cost combination of feed mix, 80 percent would be for poultry and 20 percent would be for swine. (This would also mean that the demand for soybeans for poultry feed would be increased correspondingly.)

It is estimated that if gaplek exports increase at a rate of 3 percent annually (they grew 7.2 percent annually between 1978 and 1986), they could reach 890,000 tons by 2000, the equivalent of 2.5 million tons of fresh cassava roots.

POLICY IMPLICATIONS

If the growth rate of cassava yields is to increase to at least 3.0 percent, a number of government efforts are needed. These should include research on cassava commodity systems that would include technological packages and farming system innovations, postharvest and processing technology, marketing and trade, and alternative uses for cassava. The extension service should be used intensively to promote use of the package of improved cassava technology. The farming system should be improved to enable it to increase its efficiency in marketing and to capture the economies of scale in processing centers. Credit should be provided for both farmers and agribusinesses. Perhaps a credit facility could be established that would induce farmers to adopt an improved package of technology and reduce the cost of producing cassava. Finally, the infrastructure of cassava production centers needs to be improved.

It will be difficult to encourage crop diversification--including increased production of cassava--if the incentives given to cassava production are less than those given to other crops, such as rice, or if adequate measures are not taken to encourage technical improvements. Such measures could include price supports--already given to rice--and input subsidies.

If the price of cassava is competitive with other feed sources with the same nutritional value, the use of cassava by the feed industry can be expected to increase. To achieve this objective, a number of policies should be considered. The first would be adoption of the measures outlined above to increase yields. Also, new cassava-processing technology would improve the quality of the product. Second, improvements in cropping patterns that lead to the development of cassava-producing regions together with the development of the agroindustries that process cassava could increase marketing efficiency, reduce price variability, and improve farmgate prices. A third set of policies would be those that would improve the access of farmers to credit. Among the effects this could have would be an increase in farmers' incomes. Finally, improvements in the technological package for soybeans would ultimately lower soybean prices. As soybean meal is a protein supplement for gaplek, this would make a mix of the two products more attractive, and make gaplek competitive with maize as feed. The use of maize as feed will also be helpful if swine exports increase--almost half of the least-cost feed mix for swine is gaplek, so if more swine are raised, more gaplek will probably be used.

In order to maintain Indonesia's comparative advantage in exporting cassava products, efforts to increase cassava production--with improved technology--in the major production centers for the crop should be intensified. The government might consider developing an efficient commodity system to integrate the food crop production program with processing facilities, feed mills, and poultry and livestock development programs. Such an integrated development program could generate employment and increased incomes.

The opportunities for exporting cassava will be improved if the quality of cassava products is increased. But so far, postharvest processing has been neglected, even though yields have increased. Farmers may not have the skills needed to use the appropriate technology, or may not know about it. Or the price differences between qualities may not be attractive enough to encourage farmers to be concerned about quality. Improvements in processing, particularly with regard to cleaning, drying, storage, and packing, should be carefully considered in attempting to improve farm income. Farmers should be made aware of the importance of proper techniques for postharvest processing and trained in them. In addition, the difference in prices between cassava products of different qualities should be made attractive enough to encourage farmers to improve the quality of what they produce. Improvements in water quality, such as those needed by the Tamanggung factory, should also be made. This would be to the advantage of both farmers and factories.

9
Trends and Prospects for Cassava in the Philippines*

Liborio S. Cabanilla

Cassava makes a smaller contribution to the Philippine agricultural sector than other food crop. It occupies 2 percent of the total food crop area--38 percent of the total root crop area--and has contributed an average of 10 percent to the value of food crop production. In terms of value, cassava output was only 4 percent of total agricultural output in 1983. The number of farmers producing cassava is likewise smaller than the number producing other crops. Cassava's contribution is small because it is mostly planted in marginal areas where other food crops do not thrive.

In terms of its contribution to family income, studies show that cassava contributes less than other root crops to gross family income. Cereal crops, such as rice, maize, and sorghum, contribute the most.

The relatively low profitability of cassava production has relegated it to being a subsistence crop grown on a small scale, instead of a major source of cash income for the family. Except in a few cases where cassava is grown under contract to starch manufacturers, cassava is a backyard crop. Most cassava is produced in regions where few crops compete for the available arable land. The management techniques employed have been traditional in nature, with little or no fertilizer or chemicals applied. Nor is cassava grown on irrigated land. The result has been low average yields--only 6.8 tons per hectare in 1983 (a drought year) and about 9.4 tons during the period 1980-82, for example.

Cassava is consumed mainly as human food in rural areas. Despite the high calorie content of cassava, surveys show that in the Philippines, average per capita consumption of cassava--5.5 kilograms per year--is low compared with other, traditional sources of calories. Filipinos consume only two-fifths as much cassava as maize and only one-twentieth as much cassava as rice.

Urban dwellers consume only one-fifth as much cassava as rural consumers do (1.5 kilograms compared with 7.3 kilograms per capita per year) because their per capita incomes are higher. In Luzon, where per capita income is three times as high as in Visayas and seven times as high as in Mindanao, per capita consumption is 2.0 kilograms per year, compared with 8.0 kilograms in Visayas and 15.0

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*Summaries of the six country case studies are presented in this proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See Liborio S. Cabanilla, Trends and Prospects for Cassava in the Philippines, Working Paper 2 on Cassava (Washington, D.C.: IFPRI, July 1988).

kilograms in Mindanao. This means that Mindanao residents consume about seven times more and the Visayas consumers about four times more cassava than people in Luzon. Furthermore, cassava in the Philippines has a negative income elasticity of demand, which further supports this observation.

Processed cassava products come in the form of starch, flour, and glucose. Cassava is also semiprocessed into dry chips used as raw material for further processing into starch or mixed feed.

Production of dried cassava chips did not become popular until the 1980s because drying was an added cost in cassava processing. The rate of increase in the production of cassava starch was particularly high during the mid-1970s and into the 1980s because of government incentives granted to entities engaged in cassava starch manufacturing. Under a presidential decree issued in 1981, cassava starch manufacturing was considered a preferred enterprise.

The 11 starch manufacturers in the Philippines at present have a total rated capacity of 520 tons per day. Under the contract, the starch companies extend a loan to farmers in the form of physical inputs like fertilizer and chemicals and agree to buy the fresh roots at a preset price. Since the loan is extended not in monetary form but in the form of physical inputs, contract farmers are forced to apply fertilizer, which means that their productivity is higher than the national average. Because most ordinary farmers do not apply fertilizer, varieties with high potential yields of 40-50 tons per hectare yield only about one-sixth of that potential.

Historically, cassava is used mostly for human food and for the manufacture of starch and livestock feed. The sweet type of cassava, including varieties such as Lakan 1, is planted for home consumption, whereas the bitter type, represented by varieties such as Datu 1 and Sultan 1, are planted for industrial use. Generally, the bitter varieties give higher yields than the sweet varieties do.

Unlike the cassava industries of other Asian countries, such as Thailand and Indonesia, the cassava industry in the Philippines is geared largely toward satisfying the limited domestic market. The rural infrastructure and other handling facilities that would encourage expansion of cassava production for export to the world market have not been developed. There is also a serious lack of other support services such as credit facilities. More importantly, because land frontiers have been closed since the early 1970s, expansion of production means that cassava will have to compete with other crops for available arable land. Lack of appropriate incentives and failure to make drastic improvements in farm productivity may prove to be the main constraints to the future potential of cassava in the Philippines. Extension workers also lament a shortage of planting materials of high-yielding varieties (HYVs).

Despite the establishment of the Root Crops Research Center at the Visayas State College of Agriculture in the province of Leyte in 1975, the amount of research funds that have been devoted to root crops has been small. From 1974 to 1985 the annual research fund allocation to cassava was equivalent to 0.33 percent of the value of the cassava produced. This is also quite small in absolute terms. It is glaringly small when compared with the amount allocated to other crops.

Problems with the data used in the study should be noted. For example, the wide variations in area and yield in the data published by the Bureau of Agricultural Economics are hard to explain. Data on cassava utilization in the food balance sheets of the National Economic Development Authority are likewise inconsistent with the food consumption surveys conducted by the Food and Nutrition Research Institute. Adjustments were made to smooth out the abnormal yearly variations in area and yield. In addition, domestic utilization data, particularly on the use of cassava as food, were adjusted in an attempt to make the estimates in this study close to those suggested in the food consumption surveys.

TRENDS

Cassava output more than doubled between 1961 and 1983 (Table 1). During the 1960s, however, production was stagnant, increasing sharply during the 1970s and 1980s. These increases were due primarily to area expansion; yield per hectare remained practically the same until the late 1970s, when increases reflected the adoption of HYVs.

Production dropped in 1983 because of a severe drought, but recent data indicate that it is picking up again and approaching the high growth rate of the mid-1970s.

The share of area planted with all crops increased during the 1961-83 period. There is not enough evidence to show that in general increases in area devoted to cassava came at the expense of area devoted to other crops. It is worth noting, however, that in some major cassava-producing areas of the country, increases in area planted with cassava relative to other crops have been observed.

Between 1961 and 1983, 55 percent of total cassava production was used for human food, 28 percent was used in manufacturing, and 17 percent was used as feed. As might be expected, the amount consumed as food has generally fallen over the years, except when rice shortages have occurred, and the share going to feed and manufacturers has increased.

The annual per capita consumption of cassava as food was 13.12 kilograms in 1961-63 and 7.15 kilograms in 1981-83. Human consumption of cassava as food declined in both aggregate and per capita terms from 1961 to 1971. Per capita consumption declined at an average rate of 2.33 percent per year from 1961-63 to 1981-83. This is due primarily to the Philippines becoming a net rice exporter in the 1980s and to the modest growth in per capita income during the same period.

The average per capita consumption for the whole 1961-83 period was 9.66 kilograms. This figure lies between the food consumption survey estimates of the Food and Nutrition Research Institute and those reported in the food balance sheets of the National Economic and Development Authority.

Cassava utilization by the manufacturing sector showed a distinct rising trend. From 1961 to 1971 an average of 21 percent of total production was used to manufacture starch and flour. This increased to an average of 36 percent between 1972 and 1983, coinciding with a decline in starch imports. In 1983, when the manufacturing sector of the country began to falter, starch production dropped significantly. It is worth noting, however, that cassava starch and flour manufacturing registered an average growth rate of 12.8 percent per year from 1961-63 to 1981-83.

Table 1--Area harvested, production, and yield of cassava, Philippines, 1961-83

Year	Area	Production	Yield
	(hectares)	(metric tons)	(metric tons/ hectare)
1961	88,885	494,512	5.50
1962	96,645	520,708	5.39
1963	86,630	476,287	5.50
1964	86,910	526,963	6.06
1965	93,410	620,938	6.65
1966	91,490	630,053	6.89
1967	88,110	571,557	6.49
1968	85,200	505,328	5.93
1969	84,785	484,628	5.72
1970	84,155	464,775	5.52
1971	82,200	434,639	5.29
1972	82,250	435,077	5.29
1973	85,050	448,074	5.27
1974	92,065	471,508	5.12
1975	101,272	559,021	5.52
1976	116,463	770,985	6.62
1977	133,932	1,058,063	7.90
1978	147,325	1,244,896	8.45
1979	153,218	1,424,927	9.30
1980	160,879	1,568,570	9.75
1981	168,923	1,589,565	9.41
1982	175,680	1,581,120	9.00
1983	173,923	1,182,676	6.80

Source: Philippine Bureau of Agricultural Economics, unpublished data.

Note: The data for 1961-74 are given as shown by the Bureau of Agricultural Economics. The data for succeeding years have been adjusted on the basis of the observed trend because of erratic movements shown in the original data.

Cassava use as animal feed grew at an annual rate of almost 10 percent between 1961 and 1983. This rate seems to be consistent with the trend in the cassava-maize price ratio and with the inventory of nonruminant animals, the heavy consumers of concentrate feeds. It must be pointed out, however, that demand is still stronger for yellow maize than for cassava because the yellow pigment in the former gives color to poultry eggs and meat.

Unlike in other countries, Thailand for instance, the cassava industry in the Philippines is not tied to the world market. Exports have been negligible, and imports, consisting mostly of starch, were only 0.08 percent of the total supply from 1961 to

1983. From 1964 to the mid-1970s, cassava starch imports--no matter how small in absolute terms, registered a rapid rate of growth. At that time, the growing demand for starch by the food and other manufacturing sectors was met through increases in imports. In 1976, however, starch plants in Visayas and Mindanao began operations. This resulted in an expansion of cassava production. Imports of starch dropped virtually to zero. The high tariff wall on cassava products--the tariff reached 70 percent--provided sufficient protection to allow domestic producers to expand output. The high price of maize starch relative to cassava starch in the domestic market likewise encouraged the increased use of cassava starch by the manufacturing sector.

The price of cassava tubers increased at an average rate of 12 percent per year between 1969 and 1984. Cassava prices rose abruptly when rice supplies were short because cassava is a food substitute for cereals. Such increases occurred in the crop year 1972/73, when a typhoon occurred. The price of cassava rose 26 percent over the previous year. They also occurred in the crop year after 1983, a drought year during which the rice harvest was bad.

In general, the price of fresh cassava followed the same trend as the price of rice through 1987. Furthermore, the monthly variation in the price of cassava was relatively large--an indication that the supply of cassava was irregular. The data on processed cassava show that the price of cassava starch declined relative to the price of maize starch between 1976 and 1981. As a result, the share of cassava starch in the total supply and consumption of starch increased.

MAJOR ISSUES

Given current productivity and practices, there appears to be a strong potential for yields of cassava to improve. Farm trials conducted by the Philippine Rootcrop Research and Training Center of the Visayas College of Agriculture show that on ordinary soil there is a substantial difference between yields on farms that apply fertilizer and those on farms that do not apply it. In three villages with ordinary soils, the yield differences ranged between 6.8 and 10.0 tons per hectare. In a fourth village with alluvial (riverbank) soil, the yield difference was 3.4 tons per hectare. The numbers from these trials, and discussions with scientists at the Philippine Rootcrop Research and Training Center, indicate that fertilizer use is the crucial factor in explaining cassava yield. Through fertilizer use, farmers working on ordinary soil will realize a net increase of at least 7.0 tons. In some previous studies, farmers were found to be not too keen to apply fertilizers for fear of their cost. But recent government moves to liberalize trade in fertilizer have resulted in a decrease in fertilizer prices, in contrast to the increasing trend to the mid-1980s.

Estimates were made of costs and returns in the farm trials in the village of Cantagnos, one of the three villages with ordinary soils in the trials referred to above. They showed a substantial reduction in costs per unit of output if farmers fertilize the crop--from ₱1,026 to ₱433 per ton. Net income also increased by more than ₱500.

The highly irregular supply of cassava and the additional costs of processing it for feed serve as constraints to its further expansion in feed manufacturing. The domestic price of imported soybean meal, which has been on the average 60 percent higher than the border price, has also affected the use of cassava for feed.

Since cassava is a good substitute for other energy foods such as maize, it can be expected to compete with those crops for available land as demand for energy increases. The critical factor in this competition is profitability. Where a crop can be expected to contribute an insignificant marginal increase to total family income, the farmer will not expand production of that crop beyond family subsistence needs. Data used in the analysis of the costs and returns of cassava, maize, and sorghum came from published reports and discussion with cassava experts and researchers. Except for hybrid maize, farmers planting these crops received a net negative income, although returns above cash costs (the prime consideration in farmers' decisions) were all positive.

A close scrutiny of on-farm trials and other farm-level data show, however, that there is room for improving the profitability of cassava farming. All that farmers need to do is to fertilize their crops. On-farm trials conducted by the Visayas College of Agriculture show that the marginal contribution of fertilizer applications on yields at the farm level is encouraging. Data from a contract-growing system in Bohol likewise indicate that fertilizer use doubles yield per hectare, and as a result, production costs per ton decline significantly. In a survey conducted by Gonzales, a comparison of farmers' practices with these farm trials showed the same result. Costs fall and income increases by about ₱6,000. The decline in the cost of cassava production improves its substitutability for maize in feeds. The increase in profitability through proper cultural practices (such as fertilizer use), on the other hand, makes it more attractive to farmers relative to other crops.

Studies have shown that the substitutability of cassava for maize ranges from 30 percent in hog feeds and 15 percent in poultry feeds to as much as 100 percent in broiler mash. In fact, a least-cost formulation shows that the costs of cassava-based feeds and maize-based feeds are similar. However, feed millers have not used cassava extensively in their feed-mixing operations. They complain of highly irregular supplies of cassava and high prices of the soybean meal that must be used to supplement the protein of cassava. Increases in the productivity of cassava-sown land and the concomitant decline in the cost of producing cassava, however, can be expected to change this in the future.

The price of cassava relative to maize is an important determinant in the substitutability of these feed ingredients. In the absence of least-cost feed formulations, a rule of thumb that is commonly used is that when the price of 4 kilograms of cassava with 1 kilogram of soybean meal is less than the price of 4 kilograms of maize, then cassava is competitive with maize. Given the implicit tariff on soybean meal, the trend in the wholesale prices of the commodities in these ratios was not favorable to the use of cassava in livestock feeds. For all years between 1961 and 1984, except 1981, the price of the cassava/soybean mix was higher than the price of yellow maize.

When the border price of soybean meal is assumed, however, the competitiveness of cassava over maize improves tremendously.

Between 1978 and 1985, the price ratios were less than one only in 1979 and 1982. This implies that liberalizing trade in soybean meal improves the competitiveness of cassava in feed formulations. Surprisingly, the same result is obtained when it is assumed that maize is subjected to nontariff trade restrictions such as the recent maize import ban. Price comparisons made while the ban was in effect showed that the implicit tariff on maize ranged from 30 to 50 percent. Using an average implicit tariff of 40 percent to derive the domestic wholesale price under the maize import ban, it is apparent that the effect of the ban on the competitiveness of cassava in feed use is the same as the liberalization of soybean imports. This strongly suggests that the prospects for cassava for feed use depend strongly on the pricing policies of the government.

For political reasons, it is likely that in the face of recent international developments (for example, discrimination against the country's coconut oil exports) the high tariff on soybean oil will remain. On the other hand, because protection for the domestic maize producers is increasing, the implicit tariff on maize is expected to increase. Nonetheless, it will be important to note that the net effect of this is a favorable price trend for the use of cassava in feed mixes.

PROJECTIONS

Because of the new, downward trend in fertilizer prices, it can be predicted that cassava farmers will be more encouraged to apply fertilizer. Also, some farmers are now planting new varieties. These improvements in agricultural practices will raise the average yield per hectare. The entry of agribusiness firms into contract-growing makes this prospect even more likely. This together with more widespread planting of HYVs can be expected to increase yield to about 10 tons per hectare by 1990 (Table 2). Expected increases in fertilizer applications make it not farfetched to expect to achieve a further increase in yield to about 15 tons per hectare by 2000. However, because of the long production cycle, which hampers the introduction and multiplication of improved varieties, an average yield of 12 tons per hectare is assumed for 2000.

On the basis of past trends, it can be expected that the total area sown with cassava will reach 209,000 hectares in 1990 and 270,000 hectares in 2000. Given the corresponding expected yields, total production will be 2.09 million tons in 1990 and 3.25 million tons in 2000.

Population growth in the Philippines is at present 2.7 percent per year--0.4 percent lower than in the last decade. With the active family planning program of the government, official estimates show that the population growth rate may fall to about 1.5 percent per year by 2000. This translates into a population of 62 million in 1990 and 75 million in 2000, from a base population of 53 million in 1984. Barring any drastic change in rural-urban migration, 70 percent of the population will remain in rural areas.

Given these figures and past trends, it can be expected that total consumption of cassava as human food will increase to 478,000 tons in 1990 and 545,000 tons in 2000.

Table 2--Projections of the area, yield, production, and utilization of cassava, Philippines, 1990 and 2000

Item	1990	2000
Area (hectares)	208,655	270,417
Yield (metric tons/hectare)	10.0	12.0
Production (metric tons of fresh root equivalent)	2,086,550	3,245,004
Utilization (metric tons of fresh root equivalent)		
Food	478,314	544,622
Manufacturing[a]	731,352	841,055
Feed:		
High substitution ratio[b]	1,705,307	2,885,462
Low substitutions ratio[c]	1,136,871	1,923,642
Total utilization		
High substitution ratio[b]	2,914,973	4,271,973
Low substitution ratio[c]	2,346,537	3,309,319
Balance		
High substitution ratio[d]	-828,423	-1,026,135
Low substitution ratio[e]	-259,987	-64,315

[a] In projecting demand for cassava in manufacturing, an average annual growth rate of 1.5 percent was used. This excludes abnormal growth rates exhibited during 1965 and 1976.
[b] The maize-cassava substitution rates assumed were 30 percent for pork and 15 percent for poultry meat and eggs.
[c] The maize-cassava substitution rates assumed were 20 percent for pork and 10 percent for poultry meat and eggs.
[d] These projections include feed use with maize-cassava substitution rates of 30 percent for pork and 15 percent for poultry meat and eggs assumed.
[e] These projections include feed use with maize-cassava substitution rates of 20 percent for pork and 10 percent for poultry meat and eggs assumed.

There are two ways to look at the prospects for the use of cassava as feed. The first and more direct way is to note that the Philippines has traditionally been an importer of maize. These imports shared the rapid increase in feed imports that occurred between 1965 and 1984, which was especially dramatic during the late 1970s. Maize imports increased geometrically between 1965-69 and 1980-84, and in the 1980-84 period they averaged about 311,000 tons per year. In the context of present government policy, which is to ban maize imports, this represents an additional ready market of about 1.7 million tons of cassava (in fresh root equivalent).

The second approach is to look at the future livestock output and then to estimate total demand for cassava feed based on alternative rates of maize-cassava substitution. The projections of pork, chicken meat, and egg production to 1990 are 939,000 tons, 514,000 tons, and 298,000 tons, respectively. The projections to 200 are 1.52 million tons for pork, 1.15 million tons for chicken meat, and 430,000 tons for eggs. Since pigs and poultry are highly dependent on maize, they can be expected to be heavy eaters of cassava feed in the future. The projections of the demand for cassava feed made in the study, using existing feed conversion efficiency rates, are based on the projected output of these two groups of monogastric animals.

It is assumed that relative prices will be favorable for the higher use of cassava as feed. This assumption is made for two reasons. First, the improvement in cassava yields will result in lower prices. Second, the recent decision of the government to ban imports--this was announced toward the end of 1986--will raise the price of maize relative to cassava.

It is also assumed that 60 percent of the total output from the animals will be maize-fed. This is because of the predominance of backyard producers who use indigenous feeds such as rice bran.

Although studies suggest that cassava-maize substitutability can be as high as 100 percent, a more conservative estimate is assumed. This is because of the high preference for maize that feed mixers seem to show. For this reason, two sets of estimates are given. One uses high maize-cassava substitution ratios of 30 percent for pork and 15 percent for poultry. The other uses lower substitution ratios to 20 percent for pork and 10 percent for poultry.

Given these assumptions, total demand for cassava as feed is projected to be 1.7 million tons in 1990 and 2.9 million tons in 2000 with the high maize-cassava substitution ratio. Under the lower maize-cassava substitution ratio, the projections were 1.1 million tons to 1990 and 1.9 million tons in 2000. As the demand for cassava as feed begins from a base of an average of 371,000 tons in 1981-83, feed manufacturing can be considered to be the major source of growth in demand for cassava in 1990 and 2000.

Consequently, total demand for cassava will increase from an average of 1.4 million tons in 1981-83 to between 2.3 million and 2.7 million tons in 1990 and to between 3.3 and 4.3 million tons in 2000. Deficits are likely to occur, mainly because of the phenomenal increase in feed demand. Although the numbers are purely indicative, they nonetheless show favorable prospects for cassava, especially as feed.

POLICY IMPLICATIONS

As the projections show, the prospects for cassava within the domestic economy are favorable. To realize these prospects, however, the government needs to strengthen support services such as market information, extension, and credit. It should build the necessary infrastructure, such as roads, to improve the efficiency of moving output from the production centers to the feedmill sites in Manila. This will add to the efficiency of assembling and marketing the cassava produced by small-farm operators, thereby decreasing their per unit costs of production.

In the context of the present difficulty in producing enough foodstuffs, particularly maize, renewed efforts to exploit the potential of cassava as feed must be strengthened. Scientists interviewed attest that HYVs of cassava that produce as much as 50 tons per hectare are now available, but that there is at present a shortage of planting materials. A government move to multiply these materials and disseminate them to farmers will go a long way toward increasing productivity. In addition to this, the present policy of liberalizing fertilizer trade should continue in order to maintain the present favorable price of fertilizers. Together, these policies will help in the successful exploitation of cassava's potential for food manufacture and feed.

The amount of funds allocated to cassava research is small both in absolute terms and when compared with the amounts allocated to other crops. There are high marginal returns to research on cassava, and there is a need to increase research support both in the agronomic and in socioeconomic aspects of production and utilization.

10
Trends and Prospects for Cassava in Thailand*

Chaiwat Konjing

Cassava is the most important economic crop among the roots and tuber crops cultivated in Thailand, occupying an area of 1.3 million hectares during 1983-85. Its harvested area accounted for 3.8 percent of total agricultural land or 8.3 percent of the total area under food and feed crops. Annual production of cassava reached 21.2 million tons during the same period. This amounted to 98 percent of total root and tuber crop production or 6.1 percent of total agricultural production.

Cassava is grown by small and poor farmers who cannot afford highly capital-intensive farming. It has become popular among small farmers because it has a high tolerance for drought and its yields are stable. With its flexibility in planting and harvesting times, cassava has been a promising cash crop that can provide farmers living in remote and less productive areas with both cash and food security. In particular, in rice-deficit areas or in areas that are vulnerable to drought and crop failure, cassava provides cash income for farmers that enables them to buy enough food for their families. In rice-surplus areas, cassava provides additional cash income but plays a minimum role in adding directly to the family's food consumption.

Cassava cultivation in Thailand usually begins in April, with the harvest taking place the following March. Another crop, usually a small one, is planted in December, at the end of the rainy season and is harvested the following November. About 48 percent of the harvested output is marketed in March, 12 percent in April, and 17 percent in November. The rest of the marketing is divided equally between February, May, October, and December.

Production of cassava in Thailand is labor intensive; only land preparation is mechanized. The crop is usually grown on marginal lands or sandy soils. In fact, most land under cassava cultivation is less productive or not suitable for other field crops. Little or no fertilizer is used. It is inexpensive to produce because it requires few purchased inputs, yet it gives high and stable yields.

The expansion of cassava area between 1975 and 1984 took place simultaneously with the expansion of area under maize and rice, which suggests that cassava does not compete with them for land use.

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*Summaries of the six country case studies are presented in this proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See Chaiwat Konjing, Trends and Prospects for Cassava in Thailand, Working Paper 6 on Cassava (Washington, D.C.: IFPRI, June 1989).

Surveys of the crop production patterns in such major cassava-producing regions as Nakorn Ratchasima and Udorn Thani in the Northeast region and Rayong-Chonburi in the East region confirm that cassava does not compete for land with other crops. The area planted with kenaf, a fiber plant, on the other hand, fluctuated widely and showed a strong trend to decrease. This suggests that cassava may be a substitute for kenaf, an argument that is directly applicable to the Northeast, where almost all kenaf is produced. Substitution between the two is location-specific, however, not all locations can be planted with both.

Cassava does not compete with rice for labor, because small cassava farmers do not face labor constraints in the production of rice and cassava. For example, a survey in Nakor Ratchasima showed that the use of family labor accounted for only 15 percent of the total family labor available for full-time farm work, suggesting that farmers used hired labor for full-time farm work while family labor mainly worked on off-farm jobs. In Rayong Province a similar phenomenon was found--family labor working on the farm accounted for only 17 percent of the total labor force available to the family. In short, farmers underemploy their own farm labor force or prefer to use hired labor rather than family labor in their own farming. Therefore, expanded cassava production does not face labor constraints. It could, instead, reduce underemployment and contribute to more efficient use of farm family labor.

During 1979-83 cassava yields fluctuated slightly around 14-15 tons per hectare. They averaged 15.7 tons between 1981 and 1983, compared with a world average of 8.5 tons per hectare. The comparable figures are 11.8 tons for Asia and 11.4 tons for Latin America.

Cultivation of cassava is concentrated in the Northeast region, where most of the land planted with cassava is not suitable for other crops and is vulnerable to drought. Of the total area planted with cassava between 1981 and 1984, 59.0 percent was in the Northeast, 37.1 percent was in the Central region, and 3.9 percent was in the North. Of total cassava output, 56.8 percent was in the Northeast, 39.0 percent was in the Central region, and 4.2 percent was in the North over the same period.

The utilization of cassava can be put into three categories. Human consumption is mainly of cassava flour and tapioca granulates (sago). Cassava used for animal feed consists of cassava chips and pellets and is mainly exported. Industrial uses include its utilization in the manufacture of paper, textiles, plywood, and monosodium glutamate.

Cassava is not a direct staple food in Thailand, but provides cash income for purchase of additional staple foods for small, poor farmers. During the 1981-83 period, the domestic utilization of cassava flour for human consumption averaged 114,000 tons. This was only 1.7 percent of the total output of processed cassava--6,859,900 tons.

Domestically, industrial uses account for a small proportion of total processed output, only 3.5 percent. The most promising products are modified starch and alcohol. Modified starch is a product that can be made from cassava or other cereal flour through an enzymatic process for specific industrial uses such as manufacturing paper, textiles, adhesives, cosmetics, drugs, and food.

There are at present six firms manufacturing modified starch. They can produce in all up to 107,000 tons per year, but actual production reached only 89,100 tons in 1987. The potential demand for modified starch has been increasing in recent years in both domestic and export markets. It was 204,600 tons in the domestic market in 1987 and 480,000 tons for exports. Major export markets include Japan, the Republic of Korea, Taiwan, the United States, and the Soviet Union.

The use of cassava as a raw material in producing alcohol for fuel and industrial uses is at the experimental stage in Thailand. Commercial production of alcohol is likely to be feasible in the light of the increased price of petroleum products that is envisaged for the next decade.

Most cassava products produced each year are exported in the form of dried chips or pellets for use as animal feed abroad. During the period 1981-83 only 3.5 percent of total cassava output was used domestically. The rest was exported, mostly to the European Community. Thailand, in fact, exports more cassava products than any other country. This was not always so. Cassava was grown mainly for domestic consumption, but more favorable foreign demand from the European Community in recent decades has made cassava an important export crop that earned an average of 16.3 percent of Thailand's total agricultural export value and 10.7 percent of all Thailand's export earnings between 1982 and 1984.

Because cassava is an export crop, statistical data on cassava in Thailand are more readily available than data on rice or sugar. Data on exports and production can be counterchecked by the Office of Agricultural Economics of the Ministry of Agriculture and Cooperatives and by the Customs Department of the Ministry of Finance. Statistical data collected by the Thai Cassava Trade Association also provide a base for crosschecking such data. The data on domestic utilization in this report are based on estimations made using input-output coefficients and a crop balance sheet approach. There has not yet been a direct survey or data collection network for the domestic utilization of cassava, particularly for the direct consumption of cassava roots and cassava products. This is a major gap in Thai cassava statistics.

TRENDS

The increase in cassava output in Thailand between 1961 and 1985, can be attributed mainly to expansion of the area planted with cassava. This area averaged 120,700 hectares during 1961-63 (Table 1). It increased rapidly to 328,000 hectares during 1971-73 and reached 1,291,600 hectares during 1983-85. The average annual growth rate of cassava area over the entire 1961-85 period was 11.4 percent. Between the early 1960s and the early 1970s it reached 10.5 percent per year. It increased further to 12.1 percent during 1971-85. Cassava area expanded most rapidly in the Northeast region, at a rate of 15.5 percent per year. It expanded somewhat more slowly in the North, at a rate of 12.6 percent per year, and still more slowly in the Central region, at a rate of 6.3 percent per year.

Table 1--Trends in area, production, and yields of cassava, Thailand, 1960-85

Period	Area	Production	Yield
	(1,000 hectares)	(1,000 metric tons	(tons/ hectare)
1960	71.5	1,222	17.09
1965	101.9	1,475	14.46
1970	224.5	3,431	15.28
1975	594.4	8,100	13.62
1980	1,160.0	17,110	14.75
1985	1,476.8	20,660	13.99
1961-63 average	120.7	1,987	16.46
1971-73 average	328.0	4,592	14.00
1983-85 average	1,291.6	21,221	16.43
Annual growth rate (percent)			
1961-63 to 1971-73	10.51	8.74	-1.60
1971-73 to 1983-85	12.10	13.60	1.34
1961-63 TO 1983-85	11.38	1.37	0.00
1973-85			
North	12.60	12.89	0.71
Northeast	15.52	16.06	1.59
Central	6.32	6.91	2.04
South	...	...	...

The pattern that the growth of yields followed was quite different. Average annual cassava yields fluctuated around 15 tons per hectare between 1961 and 1973, and may even have a declining trend. They increased slightly between 1971 and 1985, but there was no long-term growth for the 1961-63 to 1983-85 period.

Production reflected the growth of the area planted with cassava. It increased rapidly between 1961-63 and 1971-73, from 2.0 million tons per year to 4.6 million tons per year. The average growth rate for the period was 8.7 percent. By 1983-85, cassava production had reached 21.2 million tons, following in the path of the rapid increase in planted area. The average growth rate for the 1971-73 to 1983-85 period was 13.6 percent.

The contribution of the Northeast to the overall growth of cassava production in Thailand was significant. But the share of the Central region in the country's total production of cassava increased somewhat even though its share of total planted area fell, because productivity improved in the region. From a long-term perspective, growth of output that depends on expansion of area is not promising for all regions. Improvements in yields are feasible.

Total domestic utilization of cassava products during 1961-63 averaged 92,000 tons per year. Of this, 33,000 tons, 35.9 percent, was consumed as human food, and 60,000 tons, 64.1 percent, was used as raw materials for industry (Table 2). The annual consumption of cassava products as food increased to 114,000 tons during 1981-83. This was 47.4 percent of total domestic utilization in the period, down from 55 percent in 1971-73. The utilization of cassava chips or pellets as animal feed was less than 1 percent of total domestic utilization.

The highest average annual growth rate of consumption of cassava as food--8.5 percent--occurred during the 1961-63 to 1971-73 period. This fell to 4.0 percent during the 1971-73 to 1981-83 period. On a per capita basis, annual cassava consumption increased rapidly, from an average of 1.23 kilograms per capita during 1961-63 to 1.98 kilograms per capita during 1971-73 to 2.36 kilograms during 1981-83. This was, however, low compared with rice consumption, which averaged 130 kilograms per capita. The annual growth rate of per capita consumption of cassava as food was estimated to be 4.9 percent between 1961-63 and 1971-73, falling to 1.8 percent during 1971-73 to 1981-83. Human consumption of sago grew rapidly, 19.5 percent per year between 1961-63 and 1981-83, but the absolute amount consumed was still low, only an average of 354 tons between 1981 and 1983.

The industrial use of cassava grew more slowly in the earlier period, at a rate of 0.4 percent between 1961-63 and 1971-73, but more rapidly during the later period, at a rate of 7.3 percent between 1971-73 and 1981-83. The amount used more than doubled between 1961 and 1983, reaching 126,000 tons.

Between 1961-63 and 1981-83 the production of cassava pellets increased substantially from almost negligible amounts to 5.7 million tons. Output of cassava flour grew more slowly, at an average annual rate of 0.24 percent, or from 731,090 tons during the early 1960s to 767,610 tons per year during the early 1980s. Production of cassava chips and sago was insignificant, though each grew at a rapid rate.

In 1961-63, Thailand's exports of cassava consisted of 305,000 tons of flour, 330 tons of tapioca granulates and starch (sago), 38,000 tons of dried cassava chips, and 17,000 tons of meal. No cassava pellets were produced or exported during the early 1960s, but they have been gaining in importance in cassava exports since the early 1970s. During 1971-73, exports of cassava pellets

Table 2--Trends in the domestic utilization of cassava products, Thailand, 1961-83

Period	Cassava Flour		Sago	Cassava Chips and Pellets
	Food	Industrial Use		
		(metric tons)		
1961	32,472	59,528	8	1
1965	37,708	62,292	18	62
1970	62,743	59,257	18	58
1975	91,061	78,939	17	78
1980	109,627	120,373	29	14
1983	116,820	128,180	1,052	2
1961-63 average	33,784	60,216	10	90
1971-73 average	76,577	62,756	30	143
1981-83 average	113,673	126,328	354	81
Annual growth rate (percent)				
1961-63 to 1971-73	8.53	0.41	11.61	4.74
1971-73 to 1981-83	4.02	7.25	28.00	-5.53
1961-63 to 1981-83	6.25	3.77	19.52	-0.53

Source: Computed using crop balance sheet approach, based on Thailand's national data sources.

Notes: The figures given above are in terms of products.
Conversion factor: Roots to flour 4.5:1
Roots to chips 2.5:1
Roots to pellets 2.55:1
Chips to pellets 1:0.98

averaged 1.26 million tons per year. They increased to 5.69 million tons per year during 1981-83, an increase of more than fourfold within a 10-year period, which has been made possible through development of pelleting technology.

Exports of cassava flour and cassava chips, on the other hand, fell substantially during 1971-73 but recovered rapidly after. Exports of cassava flour reached 355,000 tons and exports of cassava chips reached 379,000 tons during 1981-83. While exports of these cassava products fell, exports of cassava pellets grew rapidly to a total of 1.26 million tons during 1971-73. They grew more slowly between 1971-73 and 1981-83, at an average annual rate of 16.3 percent. Exports of cassava meal fell throughout the 1961-63 to 1981-83 period, at a rate of 17.9 percent through 1971-73, and at a rate of 15.3 percent thereafter. In absolute terms, these exports became negligible, falling from 25,000 tons in 1960 to an average of 450 tons 1981-83.

There is no record of the farmgate prices of agricultural commodities in Thailand before 1967, because there was no agency responsible for collecting the data. Similarly, price data for cassava pellets are only available for the years after they were introduced in 1970. The prices of cassava showed a rapidly rising trend between 1971 and 1983. The prices of cassava flour and cassava pellets in particular increased in parallel in the wholesale and export markets. That is, the average wholesale price of cassava flour in Bangkok increased from Ƀ2,363 per ton during the 1971-73 period to Ƀ5,087 per ton during the 1981-83 period, with an average annual growth rate of 8.0 percent. Similarly, the export price of cassava flour increased from Ƀ1,920 per ton to Ƀ5,167 per ton in the same period, with an average annual growth rate of about 10.4 percent per year. In the same period the price of cassava pellets increased at an average rate of 8.4 percent in the wholesale market and 8.5 percent in the export market. The farmgate price of cassava roots, on the other hand, increased at an average annual rate of only 3.1 percent in the 1971-73 to 1981-83 period. There was also a large margin between the farm prices and wholesale prices of cassava, though each price had the same direction of change.

MAJOR ISSUES

Despite high yields, the most serious problem of cultivating cassava in Thailand is the deterioration of soil fertility. Repeated cultivation of the same land year after year without soil fertilization has caused average yields to decline, which has been a constraint on increases in output. But the application of chemical fertilizers on cassava has been found to be profitable on both inferior and ordinary soils. In particular, the application of fertilizer on inferior soils badly in need of soil-quality management has been found to raise cassava yields to a maximum of 31.2 tons per hectare in on-farm tests. National tests show that the use of fertilizers raised yields from 10.6 to 15.6 tons per hectare, although production costs also increased, from Ƀ5,626 per hectare to Ƀ6,165 per hectare. But the cost was reduced by 26 percent on a tonnage basis, and profits increased. On-farm trials showed less impressive profits because the costs incurred by more comprehensive crop cultivation were higher, as were wages and administrative costs.

The benefits of using fertilizer were even more pronounced on optimum or ordinary soils. The time-series and cross-section data available from both farmers' fields and on-farm trials showed that considerable increase in yields was associated with the application of fertilizers. The incremental yield per hectare ranged from 3.5 tons in farmers' fields to 12 tons in on-farm trials.

General formula livestock feeds are made up of 75-80 percent starch and fats, 15-20 percent protein, 4-5 percent minerals, and 1-2 percent vitamins. The starch and fats are usually obtained from cereals (maize and broken rice), or cassava starch. Protein and minerals can be obtained from concentrate feeds from a protein-base ingredient such as oilmeal or fish meal, or from chemical additives. The protein component is the most important one in formula feeds, since it has to meet the physical requirements and proper growth rate of the animals.

In the study, a number of farm-mixed feeds recommended to small livestock farmers for pigs and poultry are compared, half with cassava mixed in. The recommended rations indicate that cassava can be mixed into the feeds, and can sometimes substitute entirely for cereals, although cassava requires protein supplements (cassava-based diets may also be deficient in essential fatty acids). Recommended poultry diets containing more than half cassava should be supplemented by between 2.5 and 5.0 percent fats. Technical experiments in Thailand indicate that for three kinds of pig rations, the inclusion of cassava as a substitute for rice products together with high quality protein yielded satisfactory results. The optimum mixture depends on the availability and price of the ingredients. It should be noted that the performance of cassava-based diets has not been evaluated or tested comprehensively at the farm level; only limited information is available for citation.

But cassava was found to substitute for maize in animal rations only when cereal prices were high and the price ratios between cassava and maize or broken rice were at or below 77 percent. In computerized least-cost rations, cassava entered the rations when the ratio of cassava prices to maize prices was less than 55 percent. This suggests that, to minimize costs, cassava must be cheaper than maize by at least 45 percent.

In general, cassava can be a good substitute for maize or broken rice provided that the price of cassava is at least 23 percent lower than the price of maize or 31 percent lower than the price of broken rice. Technically, animal feeds can consist of up to 70 percent cassava by weight, depending on the type of animal. However, when the prices of feedgrains are low, as they were in mid-1986, the use of cassava as animal feed is not attractive to feed compounders.

In addition, animals fed with diets high in cassava are believed to produce some undesirable characteristics in livestock products such as hard pork belly and tainted lard. For broilers, high cassava-based feeds with too little synthetic xanthophyll will cause the chicken's skins to become whiter. These results have not been confirmed by scientific experiments.

Despite the optimistic view given in the projections below, which is tenable under the assumptions made, the export potential of compound feeds is low because imported protein supplements, such as soybean meal, are expensive. In addition, because the prices of feedgrains in major importing countries are low, the price ratio between cassava and maize is not attractive enough to facilitate substitution of a cassava-based diet for cereal-based diets. For example, the imported prices of cassava and maize in Japan were ฿4.03 and ฿4.154 per kilogram respectively, which indicates the cost disadvantage of using cassava against maize in livestock feed. If this price differential is less than 23 percent, the possibility of producing and exporting high cassava-based rations is unlikely, at least within the next decade. Instead, it will be feasible and profitable to produce and export cassava pellets for feed compounding in foreign countries that have a great import demand for feedgrains.

Another constraint has been the limits on and decline in export volumes to the European Community following an agreement between the Community and Thailand. The implementation of a government policy to limit cassava area in response to the decrease in exports to the Community has not been greatly effective, but it has had its effect in limiting output.

PROJECTIONS

The area under cassava is expected to increase as long as the price of cassava continues to increase or stays about the same as in 1986. The estimated annual growth rate of cassava area along the trend line of 1971-84 is 6.40 percent, which is quite high. The area projected for 1990 is 1.66 million hectares, which is about 28 percent higher than the 1980-84 average. By 2000, the area under cassava is projected to increase to 1.72 million hectares, which is 3.7 percent higher than the 1990 projection and 33.4 percent higher than the average area in 1980-84.

These projections of area, however, were made with the assumption that the current government policy to reduce or limit cassava area is not effective and does not lead to a nationwide reduction in cassava area. The projections also take into account the limitation of exports of cassava pellets into the EC countries. Such exports are now subject to an import quota of 5.5 million tons of pellets each year through 1992. However, with the present market and structure of demand for cassava products, it is projected that the price of cassava roots will not change much from the current price, about ฿600 per ton, which is still high enough to induce further expansion of cassava production.

By 1990 cassava yields in farmers' fields are expected to decline from the average yields of 1983-85, 16.43 tons per hectare, if farmers still use existing varieties and apply no fertilizer. This is because cassava depletes the soil. The yield projected for 1990 is 13.10 tons per hectare. However, new varieties, if used, are projected to increase the yields slightly, to 13.70 tons per still, which is still lower than the 1983-85 average. If fertilizer is used, on the other hand, the projected yield for 1990 rises to 19.35 tons per hectare with existing varieties or 22.5 tons with new varieties.

Yield is projected to reach 13.70 tons per hectare in 2000 with current varieties and without fertilizer. If fertilizer is used with existing varieties, the yield projection to 2000 rises to 20.25 tons per hectare. If new varieties are used, the projections are for yield to rise to 17.45 tons per hectare with no fertilizer use, or to 24.65 tons per hectare with fertilizers.

The projections of output differ with the assumptions for yield outlined above. Total cassava output in 1990 would range between an extreme low of 21.76 million tons with current varieties and no fertilizer use and an extreme high of 37.38 million tons with new varieties and with fertilizer applied. Output in 2000 with current varieties is projected to be 23.61 million tons with no fertilizer and 30.59 million tons with fertilizer applied. With new varieties, it is projected to rise to 34.90 million tons without fertilizer and to 42.49 million tons with it.

Ignoring the effects of prices, changes in the demand for cassava, particularly cassava flour, as food will depend largely on changes in population size, while a negative income effect will tend to offset any effect of population. This income effect stems from the inelastic and negative income elasticity of cassava, which means that as income changes, the quantity of cassava demanded as food changes in the opposite direction by less than a proportionate change of income. With population growth rates projected to be 1.78 percent by 1990 and 1.60 percent by 2000, the population of Thailand is projected to increase to 56 million in the earlier and 66 million in the later year.

With the income elasticity of demand for cassava as food assumed to be -0.22 for 1990 and -0.24 for 2000, total consumption of cassava as food is projected to reach the equivalent of 127,800 tons of cassava flour in 1990 and 133,600 tons in 2000. Annual per capita consumption, on the other hand, is projected to decline from 2.36 kilograms in 1981-83 to 2.26 kilograms in 1990 and 2.02 kilograms in 2000. The prospects for cassava as food are not impressive because of the inferior nutritional characteristics of cassava in Thai diets.

The requirement for feed cassava for Thailand's livestock is projected to be low--100 tons per year. This is because cassava is an export crop, and because cheap cassava faces strong competition from cereals.

The potential for cassava to substitute for cereals in feed compounding is great if the price of cassava falls because of the projected increases in yield and output stemming from the adoption of new varieties and the use of fertilizers and if the prices of feed cereals rise because the export markets for maize and sorghum are favorable. In the extreme case, if the price of cassava pellets falls from the current ฿2.56 per kilogram to a possible minimum of ฿1.45 per kilogram while the price of maize remains as high as ฿2.80 to ฿3.50 per kilogram, then the use of cassava in livestock feed can be expected to increase to between 0.13 million and 1.50 million tons.

In particular, if the average price of cassava chips were ฿2.05 per kilogram, the demand for cassava chips as animal feed could be projected to be 1.0 million tons for the entire animal feed sector in Thailand. Of this, 477,600 tons would be absorbed by the commercial feed industry.

The prospects for the industrial use of cassava are good. The demand for modified starch is expected to increase substantially. A simple trend projection indicates that the industrial use of cassava will be 210,000 tons in 1990 and 280,000 tons in 2000.

Exports of cassava flour and modified starch are projected to double by 2000. The prospects for exports of cassava pellets, however, will be limited by restrictions on imports into the European Community. These exports are expected to reach a ceiling of 7.0 to 7.5 million tons by the end of the next decade. In addition, the prospects for exports of cassava-based rations are also low because the needed imported protein supplements are expensive and because of strong price competition from competing feedgrains.

The projected supply-demand balances for cassava were made using the realistic assumption that the possibility that new varieties of cassava will be widely adopted is still low because the supply of planting materials is limited. The possibility that farmers will apply more fertilizer to existing crop varieties, on the other hand, is a real one, as cassava now gives higher profits to farmers than other cash crops.

Therefore, it is projected that cassava production in Thailand will reach the equivalent of 32 million tons of fresh roots in 1990 (Table 3). Of this, 576,000 tons will be used as food and 1 million tons will be used in industry. Domestic feed use is expected to be small. This makes total domestic utilization 1.6 million tons, leaving a surplus of 31 million tons available for export.

Table 3--Projected supply-demand balances of cassava, Thailand, 1990 and 2000

Item	1990	2000
	(1,000 metric tons)	
Production	32,140	34,900
Domestic utilization	1,584	2,003
Food use	576	603
Feed use	a	a
Industrial use	1,008	1,400
Surplus	30,556	32,897

Source: Computed based on national data shown in previous tables.
[a]Less than 500 tons.

The projections for 2000 increase production to 35 million tons. Domestic utilization in 2000 is projected to be 2 million tons. Of this, 603,000 tons will be for food and 1.4 million tons will be for industrial use. Domestic feed use will continue to be small. The surplus available for export will increase to 33 million tons, which is about 85 percent higher than average exports in 1981-83.

With higher yields per hectare assumed, the unit costs of cassava can be expected to fall, between 10 and 32 percent based on results of experiments in farmers' fields. The price of cassava can be expected to fall in the same proportion. With a price elasticity of demand for exports of cassava pellets of -2.36 and free trade in cassava exports assumed, a 20 percent fall in the price of cassava pellets would be associated with an increase of pellet exports of 47 percent. Import restrictions in the markets where cassava pellets are sold would change this, of course.

POLICY IMPLICATIONS

Thailand is faced with a number of options with regard to cassava. One would be to reduce costs through appropriate use of cost-reducing technologies with the aim of making cassava more competitive in both the domestic and world markets. Another option would be to reduce the production of cassava.

Should Thailand opt to reduce cassava costs, there are several measures that could be taken. The production and extension programs for hybrid or improved varieties and improved cultivation practices could be strengthened. Commercial and investment policy could be designed to encourage the expansion of the manufacturing of cassava products through grants of investment privileges, business tax cuts, and preferential loan programs.

With regard to production, research in cassava currently under way includes breeding and varietal trials aimed at raising yield per hectare and increasing the starch content of cassava. This research could reduce production costs. The introduction of new products, such as cassava fries and gari following the successful improvement of breeding reflects a new move in Thai cassava research. Research on postharvest technology, including tests of flour quality and flour enrichment technologies is still done on only a limited scale. Moreover, research on cassava consumption and nutrition seems to have been neglected because of the insignificant role of cassava in Thai diets.

Since the scope for increased utilization of cassava as feed is limited by a narrow margin between cassava and cereal prices, efforts to use cost-reducing technologies in feed manufacturing are important in increasing the economic viability of cassava-based feeds. As indicated above, a difference in prices of at least 23 percent would make substitution between cassava and maize in feed compounding possible.

Market policies to widen the price gap between cassava and maize and sorghum are required. Cost-reducing technologies in both farming and manufacturing are important and should be made available. In addition, the public media and extension programs need to be strengthened to support the adoption of new technologies.

In order to make the substitution of cassava together with protein supplements more effective, improvement of the manufacturing technology for both cassava pelletization and feed compounding is necessary. With improved breeding technology in pigs and poultry, fast-growing swine and broilers need more energy than older types of animals. Thus there exists a great demand for higher-density nutrients. The installation of additional compounding equipment such as sprayers to allow greater use of fat to increase the energy content of pig and poultry rations has been widely accepted by feed compounders. This equipment also allows greater use of cassava in animal feed. So does the pelletizing process of dried cassava chips. Improvement of modern pelletizing plants has contributed significantly to higher density, durability, and quality of pellets, while reducing transportation and handling costs. The addition of moisture or heat has increased the effectiveness of the pelleting machines and the nutritional value of cassava products by making it possible to add more fats and protein to cassava pellets. This kind of technological improvement has created more demand for cost-saving cassava-based diets in the European Community, the largest market for Thailand's feed cassava.

There is a need to set priorities in cassava research. It is important that top priority should be given to research to develop cost-reducing technologies in cassava production. Research on the nutritional content of cassava flour and on product innovation is also a critical need. Finally, the need for research on the effects on nutrition and consumption of cassava in both livestock and human diets is of equal importance.

11
Trends and Prospects for Cassava in Nigeria*

S. O. Adamu

Cassava is one of the major crops of Nigeria, ranking fourth in terms of output in wheat equivalent, behind sorghum, millet, and yams. According to the Food and Agriculture Organization of the United Nations (FAO), Nigeria produces about 9 percent of world cassava production on 8.5 percent of the world's area.

In Nigeria, cassava is called by different names by different ethnic groups, which is an indication that it is grown almost all over the country, from the rain forest zone in the south to the savannah in the north. It is boiled, cooked, and processed into a variety of foods. Traditionally, more than 65 percent of the cassava consumed in Nigeria is in the form of gari, a fermented and dehydrated flour with high starch content that resembles tapioca.

Cassava is easily propagated and can be stored in the ground long after it reaches maturity (that is, beyond the normal period for an annual crop). Not all of it has to be harvested at the same time. This ensures that farmers have a constant food supply for most of the year without storage problems. It can withstand dry weather and recover from damage caused by severe diseases, bush fires, and extreme infestation by insects and other pests. For all these reasons, cassava can play a vital role in alleviating famine.

Cassava is not planted to compete with other crops like yams and maize that use more fertile soils. This is because it can thrive on marginal soils, yet still cater to the needs of farmers. And the amount of cassava produced is not strictly inversely related to the prices of inputs such as fertilizers. Intercropping it with crops like maize makes it more efficient to produce than planting it as a sole crop.

Traditional cropping systems in Nigeria are characterized by intercropping, in fact. Cassava is rarely grown alone, except on a few large-scale mechanized farms. It is commonly intercropped with vegetables, maize, and legumes. The intercropping pattern adopted depends on the environmental conditions and food preferences of the area. Cassava seems to be ideally intercropped with short-duration crops. These crops mature when cassava is just attaining its maximum leaf area and is beginning to produce tubers. In addition, production of cassava by itself is not as economical as combining it

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*Summaries of the six country case studies are presented in this proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See S. O. Adamu, Trends and Prospects for Cassava in Nigeria, Working Paper 5 on Cassava (Washington, D.C.: IFPRI, April 1989).

with other crops such as maize, melons, and sweet potatoes, which farmers can harvest early, before the cassava is ready, to sustain themselves.

Until recently, cassava in Nigeria was produced essentially by small farmers. They farmed small holdings with the sole aim of providing for themselves rather than producing for markets. Hence they used traditional farming equipment such as hoes. But with the government's program to improve farming and subsequently to raise the income of farmers, interest is shifting to increasing the area farmed and to using credit to obtain inputs for farming. Small farmers who farm less than 10 hectares account for more than 90 percent of all farmers. Large-scale cassava-growing is a more recent phenomenon and still makes up just a small proportion of total production.

The interest of multinational companies in cassava is of two types. Some companies, provide support in the form of improved seedlings to farmers in their areas of operation. Others, grow and process cassava into food products like gari.

Although cassava has an important role to play in food security, information on its production and consumption is not adequate. At present, there are conflicting historical production series from local and international agencies interested in Nigerian agriculture. The Federal Office of Statistics (FOS) has the exclusive responsibility to provide statistics and is the main official agency conducting field surveys to estimate crop production. But the FOS clearly has problems of inadequate coverage and a lack of proper use of auxiliary information relating to cassava characteristics and farming systems in the sample design. For example, FOS production statistics do not include crops that are ready for harvesting but are not harvested, a procedure that clearly leads to underestimation in the case of cassava.

Examples of these differences can be shown with the growth rates for production, area, and yield. According to FAO, production of cassava in Nigeria between 1961 and 1983 grew at an average annual rate of 3.7 percent. This was essentially because of an increase in the area harvested, which had a growth rate of 3.9 percent, while yield fell at an average rate of 0.3 percent. Adjusted FOS data show an annual decline in production of -2.0 percent. The area harvested, according to FOS data, fell at an average rate of -2.2 percent, while yield rose at an average annual rate of 0.3 percent. The two sets of growth rates had cassava area, yield, and production moving in opposite directions. But the FOS results are probably closer to reality, because the evidence available on the decline of agriculture in the 1961-83 period suggests that it was due to the withdrawal of people from the land, which implies a fall in area of crops planted.

The major cassava-producing areas in Nigeria are the southern states and the middle belt of the country. The main reason for this regional specialization is the physical features of the country. The cassava-growing areas are in the forest zone, with average annual rainfall greater than 1,000 millimeters. There is a high preference for sweet cassava in the north, while in the east the bitter variety is preferred. Both varieties are preferred equally in the southwest. In the major growing areas, cassava competes with crops such as yams, cocoa, rubber, and maize. It has an edge over them because it can be produced on less fertile land with or without fertilizer.

Yields and technology vary widely in the country, because of a number of factors. These include variations in the fertility of the soil available for root crops, competing crops, and differences in the exposure of farmers to improved varieties and other results of research on cassava production and farm management techniques.

Improved varieties have been developed for resistance against pests and diseases, their high yields, their quality for consumers, and their low cyanide content. Improved varieties now being cultivated in Nigeria have been developed by the International Institute of Tropical Agriculture at Ibadan and the National Root Crop Research Institute at Umudike. These varieties and other results of research are being passed to farmers through the National Accelerated Food Production Program (NAFPP), established in 1975. It is not easy to evaluate the cost-effectiveness of expenditures on research relating to cassava because information on government allocations of research expenditures is not available in detail.

The variations in yields range from 8.2 and 17.7 tons per hectare in southwestern states and Benue, 7.4 and 8.9 tons per hectare in the eastern states, and 3.5 and 8.4 tons per hectare in the northern states. In none of these cases is cassava normally produced in the best available soil. Marginal soil is often used, while rich soils and the use of fertilizers are preferred for crops like yams and maize. If fertilizer is used on cassava at all, it must be because the cassava is intercropped or mixed with other crops that require fertilizer. The use of fertilizer is not of high priority in the improvement of yields, and even on-farm trials are carried out without fertilizer.

Improvements in yields have come about more as a result of improvements in varieties than through the use of fertilizer or irrigation. The yields in on-farm trials range between 9.9 and 17.3 tons per hectare for those conducted on farmers' farms and 19.0 and 37.9 tons per hectare for those conducted by the Nigerian Tobacco Company. Yields on research stations range from 13 to 35 tons per hectare. From the information available, there is no doubt that yield rates can be as high as 50 tons per hectare, but there are many limitations that must be removed or reduced before these can be achieved.

Most of the cassava used in Nigeria is consumed as food. The importance of cassava as food varies between states and between urban and rural areas within a state. For 1980/81, total consumption of cassava in gari equivalent was estimated to be about 1.1 million metric tons. Over 80 percent of this was consumed in rural areas. Processed cassava accounted for more than 80 percent of the total, and gari alone accounted for 65 percent of the total. Given a population of 86 million, cassava consumption per year in gari equivalent was calculated to have been 12.34 kilograms in 1981. Stated in terms of fresh cassava, consumption in 1981 was 60.2 kilograms per year or 0.165 kilograms per capita per day.

Less cassava is consumed in the northern states than in the southern. In the south, cassava consumption is higher in rural areas than in urban, but the reverse is true in the north. The major consuming areas included 12 states (out of 19 in existence since 1976), mostly in the Western, Mid-Western, and Eastern regions. One of these states, Benue, is in the north. Except for Lagos and Bendel states, the population of all, both urban and rural, depend on cassava for more than 10 percent of their daily dietary energy. These major cassava-consuming states accounted for more than half of the 1980/81 population and consumed 93.1 percent of all cassava consumed (in gari equivalent). Between them, they also produced more than 93.1 percent of total cassava production.

Data on cassava consumption show that a surprisingly large amount is accounted for by imports for Cross River, Imo, and Anambra states. If the production data are correct, there must be a lot of trade between these states and the adjoining states of Rivers, Bendel, and Benue, which have large amounts of cassava available for export. Otherwise, there may be serious errors in estimating production, consumption, or both for the three importing states. The total amount of cassava products going to interstate trade was 1.3 million tons in terms of fresh cassava (or 325,000 tons of gari) and excluding statistical discrepancies.

Cassava in its raw form is traditionally used as feed for livestock, particularly pigs. In most of the major cassava-growing areas, pigs are kept as domestic animals and cassava is the major source of feed for them. But because there is a lack of adequate data, the amount fed to pigs in this form cannot be estimated.

There are a number of other potential uses for cassava as well. Work on the use of cassava for bread has been spearheaded by research institutes. Pure cassava flour cannot be used for baking bread because it lacks protein with wheat-gluten properties. Adding an improver such as pentosan is necessary to produce loaves with good baking qualities.

Thorpe-Hentel has highlighted the implications for growing cassava for industrial use. He saw a need to establish species of cassava especially for industrial use. These species would have to have roots with an average starch content of 18-20 percent; the local cassava grown for food have roots with an average starch content of only 4-5 percent.

Women have major roles in all stages of agricultural development in Nigeria and have nearly total control in processing and storage. Traditional processing of cassava is wholly in the hands of women, whether at the household level for family consumption or at a central location such as the village or town marketplace, where commercial processing is done. Even nowadays, when processing is done in factories, peeling is still done manually and wholly by women. Women's participation varies between urban and rural areas and between the north and the south. The regional difference is accounted for mainly by religious differences.

Most of the commercial processing of cassava comprises turning fresh cassava into gari. There are a number of operational units involved, ranging from housewives using traditional methods to highly mechanized processes in factories with various scales of production. Most of the mechanized processing is done by cooperatives and private companies.

The development of mechanized processing was spearheaded by the Federal Institute for Industrial Research at Oashodi (FIIRO) and the Project Development Institute. But to make mechanized processing profitable, there has to be an adequate and cheap supply of cassava tubers. For this reason, the Agro-Industrial Development Scheme for village production of _gari_ was developed. This program involves small-scale hand-processing that uses mechanical power grating. Apart from mechanical processing of _gari_, research and development have been directed to products like industrial starch, glues and adhesives, and composite bread.

TRENDS

Cassava area harvested generally decreased between 1961 and 1983 (Table 1). Only the Eastern region recorded a positive growth rate from 1965-69 to 1979-83. Between 1969-73 and 1979-83, Rivers, Benue-Plateau, and North Central (Kaduna) states recorded positive average growth rates for the areas harvested. In general, the period between 1970 and 1976 saw a serious decline in area cultivated because a large number of peasant farmers left the land for urban areas, partly as a result of the oil boom of the time.

Table 1--Average annual growth rates of production, area harvested, and yield, 1961-83

Dates	Production	Area Harvested	Yield
1961-65 to 1979-83	-2.0	-2.2	0.3
1965-69 to 1979-83	-1.5	-1.6	0.1
1969-73 to 1979-83	-3.3	-3.2	-0.1

Regarding yields, the story is different. Average growth rates were positive for most regions between 1965-69 and 1979-83, reaching as high as 2.3 percent. They were negative for two regions in that period, Mid-West and East, but only slightly so. The average growth rate of yield for Nigeria as a whole has been positive since 1961-65, but has increased for the more recent 1976-78 to 1979-83 period to 8.3 percent per year. But that was because of a fall in yield between 1969-73, when the average yield was 10.0 tons per hectare and 1976-78, when it was 7.4 tons per hectare. It reached 10.3 tons per hectare in 1979-83.

Over the years, agricultural production in Nigeria has declined (Table 1). There were a number of reasons for this, such as the civil disturbances of 1966-70, the growth in the importance of oil and urban drift of population. Like other crops, cassava was affected by these events, but in recent years, production of cassava has picked up faster than that of other crops because of its characteristics. Another factor was research, which began to influence the output of cassava after 1978, because of the IITA and the national research institutes, acting through the NAFPP.

As a share of the output of the major crops of Nigeria, cassava production fell by 16.8 percent between 1969-73 and 1979-83. Output fluctuated widely between 1961 and 1983. Most states in the 12-state political structure had negative growth rates of production between 1969-73 and 1979-83. Three had positive growth rates for the period as a whole. When this entire period is divided into two subperiods, 1969-73 to 1974-78 and 1974-78 to 1979-83, the picture becomes more complicated, as some states had positive growth rates in one of the two periods and negative growth rates in the other or negative rates in both. The decline in output was greatest in the states with large urban populations that were also major cassava-producing areas.

Owing to lack of data, the trends in the utilization of cassava are difficult to discern, particularly food consumption. Ideally, a national consumption survey would be a major source of consumption data on specific items. But whereas many consumption surveys have been conducted in Nigeria, detailed results on expenditures or consumption have not been published, except for the 1980/81 national survey.

The report does show that increases in the utilization of cassava were sustained by the mechanical processing of cassava products, especially gari. Processed gari began to get to the market in the late 1970s with the pioneering efforts of some commercial organizations.

The data on prices are inadequate. Partly because the consumption of cassava is mostly in the form of gari, the only cassava prices collected nationally are for gari. A common feature of all price trends seems to have been high growth rates, especially in some major producing states like Bendel and East Central. The highest growth rates were recorded for the period between 1974 and 1983. The prices series show that there have been some seasonal effects.

April to June, the "hunger period" before the harvesting of any crop planted at the beginning of the early rain, is when prices reach their peak. They reach that peak after rising from a trough in October-December, and they fall from it in July-September.

MAJOR PROBLEMS

The most important limitation on yields is poor farm management. Food production technology transfer stations were created and designed specifically to deal with this problem by developing agricultural manpower. These stations form the technical and institutional arm, of the NAFPP. Three of them are involved with cassava. They link agricultural research and farmers in the dissemination of research findings as they relate to foodcrop production. The training given at the stations includes farm management, handling of farm machinery and equipment, and pest and disease management. It is too early to evaluate their success.

Much can be achieved with the introduction of improved methods of cassava production. The profitability of producing fresh cassava roots using improved technology was established in 1984. The IITA has shown that a traditional farm system has low productivity with negative returns to land and returns of no more than the current rural wage rate to family labor and management. But with access to modern technology improvements, the returns to farm labor double the rural wage rate and returns to capital increase more than fourfold. Improved technology should stabilize the farming sector and reduce rural-urban migration.

A comparison of the adoption of technology for maize, yams, and cassava, the three most important crops in the major areas producing cassava shows that cassava ranks highest among the three crops and it has the lowest cost per unit of output in relation to its value.

Efforts to improve the storage of cassava and cassava products have progressed well. The Nigerian Stored Products Research Institute produced an advisory bulletin that showed that under good management, cassava roots can be stored in fresh condition for six to eight weeks. Gari and dried cassava chips, if dried so that their moisture content is less than 12 percent, can be stored in simple, small containers using tin, bottles, drums, or polyethene bags. But fresh cassava normally cannot be stored for more than three days. The procedures cited in the leaflet that would make it possible to store it for much longer are only feasible on a small scale, as large scale storage would entail too many technical and organizational problems.

Mechanization of different stages of processing traditional foods has gone far, but certain problems still require solutions. One of these is the specification and standardization of equipment for manufacturing cassava-based foods to ensure consistency and quality control.

Attempts to fortify cassava-based foods such as gari, with vegetable protein from groundnut grits and other legumes have not been successful because the end products have not been generally accepted. There is, however, a lot of scope for such fortification of livestock feed.

Owing to the increasing demand for bread in Nigeria, and the fact that wheat usually has to be imported, there has been much interest in the use of local materials, including cassava, to manufacture composite flours to reduce wheat imports. Work done at the Tropical Products Institute indicates that reasonably satisfactory volumes of loaves of bread can be produced using cassava flour up to 20 percent of the total.

Cassava starch produced locally, according to Thorpe-Hentel, requires more energy to bring it to the point of application. Its physical stability during application on textiles requires intensive supervision. It is unstable in the presence of the most commonly used chemicals. Lastly, its shelf life is short. Despite these shortcomings, Thorpe-Hentel argues that the local starch can be modified through esterification, for example, and such modified starches can find extensive use in "sizing." Sizing is the application of an adhesive to a single yarn before weaving, so that some specific properties are imparted to the single yarn to facilitate weaving. With cooperation among research institutes, starch can be produced locally and satisfy both farmers and the textile industry.

FIIRO has been actively engaged in research on the mechanization of gari and on the production of gari and other cassava products. But there are problems that delay the commercialization of these research results. These include the inadequacy of raw materials to meet the capacities of production plants, the importation of start-off machines and equipment, relatively low profitability, and relatively high capital outlays. FIIRO hopes that all its projects will be commercialized in the near future.

PROJECTIONS

Trend estimates were used to project area harvested and yield to 1990 and 2000. It was assumed that area under cassava in the major producing states would grow at a maximum rate of 5 percent (except for Benue-Plateau, where area would grow at the trend rate of 4.8 percent) This 5 percent rate is double the assumed growth rate of population for the period. It was assumed that area in the minor producing states would grow at the maximum rate of 2.5 percent. It was also assumed that the maximum growth rate of yields would be 1.5 percent per year, that is, no growth rate higher than that was used to make the projections.

These estimates were then used to make three sets of projections of production, based on the national series for 1965-83, a series for 1965-83 based on the regional political structure of the period up to 1967, and a series for 1969-83 based on the 12-state political structure of the 1967-76 period. The larger the number of administrative units, the greater the variation and the better the estimates. No assumption was made about the varieties used or about the use of fertilizer, except for the activity of the NAFPP.

The output projections for 1990 were 5.5 million tons for the national series, 7.0 million tons for the regional series, and 7.1 million tons for the 12-state series. For 2000, they were 6.1 million tons for the national series, 11.9 million tons for the regional series, and 12.6 million tons for the 12-state series, all in terms of fresh root cassava.

Another group of production projections were made based on expert opinion on potential output per hectare and trend projections of area harvested, classified by soil fertility and climatic conditions. According to these projections, in 1990, production of existing varieties and new varieties already developed will be 8.5 million tons without fertilizer and 9.9 million tons with fertilizer. The corresponding figures for 2000 are 20.0 million tons without fertilizer and 25.8 million tons with it.

This second set of projections must be seen as ideal in some respects. In any case, it will be some time before farmers use fertilizer in producing cassava as they now use it on yams and maize. But as an optimum intercropping approach becomes accepted and adopted, some use of fertilizer on cassava will become normal practice. In general, the output projected with the different alternatives is consistent.

Projections of consumption of cassava as food were made using official projections of population for 1990 and 2000, separated into urban and rural areas. But good population data in Nigeria is not to be had. There has been no acceptable population census since 1963, and the only data on population available today are projections of the census data to 1983 based on some assumptions. Earlier projections assumed a growth rate of 2.5 percent. A new series of projections has just been published, also based on the 1963 data and assuming exponential growth rates of 2.5 percent from 1963 to 1975, 3.2 percent from 1976 to 2000 (based on Nigerian fertility rates), and 4.7 percent for Lagos (a result of high migration there). As a result of this, annual growth rates of population of 2.5 percent and 3.3 percent were assumed for the projections in the report.

The best series for GDP in constant prices has 1977/78 as its base, and shows a trend growth rate of 3.1 percent. Per capita GDP has been declining. If this is a short-run phenomenon, two alternative annual growth rates are proposed. These were 3 percent and 5 percent per capita.

The results of these projections indicate a food demand between 6.1 and 6.3 million tons for 1990 and between 6.8 and 7.2 million tons for 2000 (Table 2). The minimum alternative (1) estimate was obtained when the population growth rate was 2.5 percent, the GDP per capita growth rate was 5 percent, and the elasticity coefficient was -0.2 for both urban and rural areas. Alternative (2) was reached with the GDP per capita growth rate at 3 percent, other assumptions remaining the same.

Table 2--Supply and demand for cassava projected to 1990 and 2000

Use	1990	2000
	(1,000 metric tons)	
Alternative (1)		
Supply	5,506.4	6,052.5
Demand	7,165.7	8,134.1
Food	6,087.4	6,757.4
Feed	137.7	302.6
Other uses	27.5	60.5
Waste	913.1	1,013.6
Alternative (2)		
Supply	8,457.9	19,981.2
Demand	7,454.5	9,521.3
Food	6,261.6	7,236.9
Feed	211.4	999.1
Other uses	42.3	199.8
Waste	939.3	1,085.6

Note: Assumptions are as follows:

Supply
- Alternative (1): Based on National Series
- Alternative (2): Based on potential yields without use of fertilizer

Demand
- Alternative (1): Population growth: 2.5 percent; GDP growth: 5 percent per capita; income elasticity, -0.2.
- Alternative (2): Population growth: 2.5 percent; GDP growth: 3 percent per capita; income elasticity, -0.2.

Tentative estimates of income elasticity of demand for cassava based on the data of the 1980/81 National Consumer Survey indicate coefficients of 0.124 for urban areas and 0.743 for rural areas. Using these figures the aggregate food demand varied from 10.9 to 15.6 million metric tons in 2000 under the alternative population and per capita income assumptions. The lowest estimate was obtained when the population growth rate equaled 2.5 percent and GDP per capita growth equaled 3.0 percent. The highest projected demand was attained when both population and per capita GDP rates were high at 3.3 percent and 5.0 percent respectively.

Given the current situation regarding the raw materials for livestock production, it can be assumed that animal feed will account for 2.5 percent of Nigerian cassava production in 1990 and 5.0 percent by 2000. This should be possible considering the recent increase in production, which has been projected to continue.

Other uses of cassava that might become significant in 1990 and 2000 include its use in industry (in particular, as a base chemical in the textile industry), and for export. These other uses are projected to account for 0.5 percent of cassava production in 1990 and 1.0 percent in 2000.

A comparison of the projected aggregate demand for cassava with the projected supply shows that under the first alternative, the demand will exceed supply, but if the high yields projected for 2000 are achieved, the supply will be considerably in excess of demand and efforts will be needed to generate additional demand (Table 3). These gaps are based on the assumption of the income elasticity of demand for cassava being negative. However, if the coefficients are positive (0.124 for urban areas and 0.743 in rural areas) the total demand for cassava for food would be higher and it would be necessary to achieve the yields assumed under the second alternative to meet the additional demand.

Table 3--Projected surpluses or deficit of cassava in 1990 and 2000

Period/Alternative Projections of Demand	Alternative Projections of Supply	
	Alternative (1)	Alternative (2)
1990		
Alternative (1)	-1,659.3	+1,292.2
Alternative (2)	-1,948.1	+1,003.4
2000		
Alternative (1)	-2,081.6	+11,847.1
Alternative (2)	-3,468.8	+10,459.9

Note: For assumptions underlying alternatives (1) and (2), see footnote to Table 2.

POLICY IMPLICATIONS

Cassava requires no price incentives for its production. What it does require are incentives to vary allocations among users or to promote alternative uses such as feed, raw materials, and exports. Some of these policies would be by-products of the Structural Adjustment Programme of the government, more specific policies may be required.

Efforts should be made to improve the processing and storage of cassava. The solution to the problem created by difficulties of large-scale storage of fresh cassava is to design a crop rotation program that will ensure continuous harvesting of cassava roots to feed a manufacturing plant.

Efforts should also be made to develop standard products or the use of cassava in different forms. Packaging materials should be developed that will provide effective barriers between the packaged product and the external environment so that the shelf life of the product can be extended. Improvements that standardize products and stabilize consumption will enable the realization of the projected demand and help stabilize the incomes of producers at the farm level.

The need for proper utilization of cassava has been recognized since the work of Oyenuga and his students in the 1950s. Much of the work done since then has never been used. A change in the utilization of cassava is necessary, not only to replace imported feed inputs, but to increase animal protein for Nigerians as well. Prospects for other uses, such as in bread making, as a source of base chemicals for textiles, as a source of other industrial raw materials, and in processing for exports, have never been as bright. Research should be directed toward discovering varieties of cassava that will be suitable for these alternative uses. Development of appropriate processing techniques must be encouraged. And there is a need to promote exports of cassava products.

The trends and prospects of cassava must be seen in the context of the overall development of Nigeria. To this end, the main conclusions and policy implications of the study must be related to the overall policy goals of the country. The potential role of cassava must be seen in both the short- and longer-term contexts and in relation to other crops in production and utilization.

The goals of Nigerian economic development are essentially dictated by the present philosophy, which is set forth in the Structural Adjustment Programme. This program is designed to remove the constraints that have caused the economic system to malfunction. In particular, this means examining the roles of cassava in generating income and employment; as a raw material for manufacturing; as an export, making foreign exchange earnings directly or indirectly; and as an aid in increasing food production. The major goal of Nigeria is self-reliance.

Ideally, in analyzing the role of cassava in overall Nigerian economic development, all relationships with other crops in production and utilization need to be properly estimated in order to provide such benchmark data as income and the direct and cross-price elasticities of demand and supply of cassava. As the report shows, this kind of analysis has been hampered by lack of an adequate data base.

In this light, strategies to enable cassava to play a role in the overall policy goals of Nigeria must be geared toward further research on production and utilization, food production development, and the development of a comprehensive data base to aid policy analysis, planning, and the implementation of plans.

Appropriate policy measures that facilitate proper food production development in line with the objectives of the Structural Adjustment Programme need to be developed and implemented. There is a need to make research results ready for adoption by farmers for the development of food production. Research institutes and manufacturing firms need to be brought together, not only to see that the food products are manufactured, but to ensure that appropriate technologies are developed to ensure wholesomeness of finished products, hygienic and appealing packaging, and maintenance of quality control.

There is a need to collect comprehensive data for monitoring the implementation of food production programs. This requires proper planning and allocation of adequate resources to achieve reasonable results. The exercise must be integrated in order to cover production and utilization data from both primary and secondary sources. The fieldwork must be developed to cover at least one farming year, and it must be complete enough to make estimates possible for various items of interest, taking into consideration not only a national estimate but also estimates that reflect cropping patterns and other variations of interest in achieving policy goals.

The problem with production statistics for cassava in Nigeria is partly due to the nature of the crop itself and partly to the approach of FOS to data collection. Standard estimating techniques in collecting data on cassava must take into consideration its special features even when compared with other root crops in the forest zone of the tropics. To be able to obtain a proper historical series for cassava production, a special study must be mounted to examine available data state-by-state in order to come up with estimates close to reality. The production statistics must be monitored continuously.

12
Trends and Prospects for Cassava in Zaire*

Tshikala Tshibaka and Kamanda Lumpungu

Cassava was first introduced into Zaire in the 16th century. It was handicapped at first by a lack of communications facilities in the central basin of the Zaire river. After 1876, however, the cultivation of cassava spread rapidly across the country. This expansion can be attributed to qualities such as its tolerance to dry weather, its propagation by cuttings, its adaptability to many types of soil in different climatic conditions, and its flexible harvest time. Some of the spread of cassava can also be attributed to the colonial power, which imposed it on farmers as a way of avoiding famine.

Cassava is now the most important and widely grown food crop in Zaire. It is grown on 30 percent of the cultivated area, more than any other crop. Maize is second with 12 percent of cultivated area; groundnuts are third with 7 percent. One study found that among 132 farm households in the Zairean Basin during 1982/83, 97 percent included cassava in their crop mix. Only 62 percent included maize, 61 percent included rice, and 39 percent included plantains. Cassava was grown on 44.7 percent of the cultivated area of the Zairean Basin; rice, on 28.6 percent; maize, on 21.4 percent; and plantains, on only 5.3 percent.

Cassava grows well in the regions of Zaire where the mean annual precipitation varies between 1,200 and 1,500 millimeters, the mean temperature is 23°C-24°C, and the dry season lasts two or three months. In these conditions, all soils are suitable to cassava except for asphyxiation soils. Farmers prefer soil that has recently been forested because of its richness in natural nutrients and its ability to hold cassava roots for many years. But cassava yields are also good in dry, sandy soils where other crops cannot be grown.

In the equatorial region of Zaire, cassava is often grown with food crops such as maize, rice, and plantains. In tropical regions such as Bas-Zaire, it is cultivated with beans. The advantages of mixed cropping are considerable: it increases farmers' incomes and reduces infestation by weeds.

Cassava in Zaire is mostly a woman's crop. In the forested area, the land is prepared for cultivation by adult male members of

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*Summaries of the six country case studies are presented in these proceedings. IFPRI has published the complete text of this paper as part of a series of working papers on cassava. See Tshikala Tshibaka and Kamanda Lumpungu, Trends and Prospects for Cassava in Zaire, Working Paper 4 on Cassava (Washington, D.C.: IFPRI, February 1989).

the household, but in the savannah, it is prepared by both male and female adults. Like other food crops, however, female members of the household do most of the weeding and planting. Because the contribution of female labor to cassava production is large, policies that affect cassava also have a strong effect on the income and employment of peasant women.

In Zaire, as in many other countries of Sub-Saharan Africa, cassava is important not only as a root, but also as a vegetable. Therefore, an adequate appraisal of cassava's potential has to include the production of both roots and leaves; otherwise the picture of the contribution that cassava can make to food output and income of smallholder farmers will be incomplete. Research conducted in the Zairean Basin and elsewhere in the country indicates that 5 metric tons of edible cassava leaves per hectare can be produced under a peasant farming system without adversely affecting the output of roots. It also estimates that harvesting this quantity of cassava leaves will require an average of 229 man-hours of work per hectare and little or no capital.

These findings, as well as farm survey data, show that the production of cassava, both roots and leaves, is a labor-intensive activity, second only to rice. Survey data show that it takes about 1,388 man-hours to cultivate a hectare of cassava. This is about 2.6 times the labor that plantains require per hectare, 2.9 times that of rice, and 1.8 times that of maize.

But cassava and maize require about the same amount of capital: cassava roots and leaves require an average of Ƶ117.14 per hectare, while maize requires Ƶ119.21--about Ƶ100.00 less than the capital requirement for rice, but 3.4 times greater than that for plantains.

Although cassava may be second to rice in its use of labor and capital, it is first in productivity of those resources. The average product of labor is 6.19 kilograms per man-hour for cassava (both roots and leaves), but only 0.58 kilograms per man-hour for rice, 1.22 kilograms for maize, and 3.17 kilograms for plantains. The average product of capital is 73.36 kilograms per zaire for cassava, but only 4.18 kilograms per zaire for rice, 9.41 kilograms per zaire for maize, and 48.61 kilograms per zaire for plantains.

The returns to labor and capital and the benefit/cost ratio show that cassava and plantains are, at least potentially, the most profitable crops in Zaire. The returns to labor were Ƶ19.40 per man-hour for cassava, Ƶ18.52 for plantains, but only Ƶ3.45 per man-hour for rice and Ƶ12.75 for maize. The returns to capital were higher for plantains (Ƶ247.67 per zaire invested) than for cassava (-Z200.99 per zaire invested), but the returns from both crops were several times higher than the returns from rice (Ƶ19.89 per zaire invested) or maize (Ƶ85.50 per zaire invested). The benefit/cost ratio was highest for cassava (Ƶ31.80 of benefit per zaire of cost), with the ratio for plantains only slightly smaller (Ƶ31.45 zaire of benefit per zaire of cost). Again, the figures for cassava and plantains were several times larger than those for rice and maize.

Two major concerns about the contribution of cassava roots to the household diet are their cyanide content and their low nutrient content. The processing methods used in Zaire reduce the cyanide content. The nutritional contribution of cassava is improved significantly when the nutrients of the leaves are added to those of the roots. Cassava is, in fact, a major source of calcium, iron, phosphorus, and some vitamins, including vitamin A, riboflavin, niacin, and folic acid.

When measured by nutrient output per unit of input, cassava is the cheapest source of food crop nutrients in Zaire, taking both roots and leaves into account. A hectare of cassava produces 12 times the number of calories produced by a hectare of rice, 9 times the number produced by a hectare of maize, and 7 times the number produced by a hectare of plantains. Cassava's superiority in this respect is still overwhelming for minerals and vitamins. One might not expect a hectare of cassava to produce more protein than other crops, but it has three times the protein produced by a hectare of rice, more than two times the protein produced by a hectare of maize, and more than seven times the protein produced by a hectare of plantains.

Although cassava is produced throughout Zaire, its importance varies widely among regions. There are nine regions, including Kinshasa, the capital city. Three regions are completely within the tropical climate zone: Bas-Zaire, Kinshasa, and Shaba. Five are in both the tropical and equatorial climate zones: Bandundu, Kasai Occidental, Kasai Oriental, Equateur, and Haut-Zaire. The last, Kivu, is in all three climatic zones of Zaire, equatorial, tropical, and altitude temperate. Equateur, Haut-Zaire, and Kivu are forested. The rest are mostly savannah.

More land was allocated to cassava in Kivu between 1981 and 1983 than in the other regions, with Bandundu, Shaba, and Kasai Occidental following in order. These regions also had higher output of cassava than the others. But Kinshasa had the highest percentage of its geographical area devoted to cassava production, largely because cassava provides most of the vegetables consumed in Kinshasa. It should also be noted that the Kinshasa region depends on imports from other regions and the world food markets for most of its food. Bas-Zaire, Kasai Occidental, Kasai Oriental, and Kivu follow Kinshasa in the percentage of their geographical area devoted to cassava production.

Kasai Occidental, Kasai Oriental, and Bandundu regions all produced more than 200 kilograms of cassava roots per capita (expressed in cereal equivalents) during 1981-83. No other region exceeded the national average of 163 kilograms per capita. This variable suggests the importance that cassava has for food consumption and security in some regions. In this regard cassava seems to be less important in Bas-Zaire, Haut-Zaire, Equateur, Shaba, Kivu, and, of course, Kinshasa.

Reliable national data on the utilization of cassava for food and other purposes are not available. It is widely believed that 90-95 percent of cassava roots are consumed as food. The balance is used for feed, industrial raw materials, and illegal exports to neighboring countries. This estimate makes no allowance for waste. Estimates from the Food and Agriculture Organization of the United Nations (FAO) put domestic food use at 79 percent and feed use at 1 percent, with the rest being put to other uses, including waste.

No estimates of the utilization of cassava leaves are available. Although consumption is mostly limited to food, cassava leaves are used in negligible amounts as feed, mostly for pigs, and are also exported to neighboring countries.

Cassava is eaten in a variety of forms. The methods of processing vary and the quality of the end product depends upon the processing technique adopted. Fresh cassava roots are mainly transformed into cossettes (dry roots) and chickwange (cassava bread). Cossettes are converted into flour before they are consumed. The flour is mixed with boiling water and served with other foods. Some tribes in Kasai and Bandundu mix cassava flour with maize flour to make fufu, also known as bidia or nshima. The addition of maize increases the protein content of the food. Chickwange is the most common form in which cassava is consumed. It can be kept for five days, after which it hardens and starts to rot. Fresh cassava roots are also boiled or grilled, and are consumed in different combinations with maize or boiled bananas. Cassava leaves are consumed widely as vegetables, making up, on average, almost 70 percent of the total output of vegetables in Zaire between 1971 and 1984. They are usually boiled.

Distribution, marketing, and pricing of cassava products have never been controlled by the Zairean government. Demand and supply of cassava products are regulated by domestic market forces. Cassava products are distributed and marketed by a large number of small transporters and petty traders, most of whom are women. The number of marketing functions these traders carry out and the geographical extent of the domestic market depend on the nature of the cassava product being marketed and the state of the transportation network. The cassava products most often sold in Zaire are fresh roots, dry roots, chickwange, and leaves.

TRENDS

The area under cassava in Zaire increased rapidly between the early 1970s and the early 1980s, from 1.6 to 2.1 million hectares (see Table 1). This expansion proceeded at an annual average rate of 3.3 percent between 1971 and 1984. Most of this increase occurred between 1981 and 1984, when the annual growth rate reached as high as 5.9 percent.

The available data show that average yields did not exceed 6.8 tons of fresh roots per hectare between 1971 and 1984. This is lower than in the other major cassava-producing countries, Brazil, Thailand, India, and China. The trend showed a tendency to decline slightly, by about 0.3 percent per year.

There were three distinct phases for yield growth during the 1971-84 period. During the first, 1971-75, cassava yields increased at an annual rate of 1.0 percent. During the second, 1976-80, yields declined at an annual rate of 0.3 percent, and during the third, yields declined at a substantially faster pace, 1.6 percent per year. The decline in yields in the last two phases is associated with the outbreak of a bacterial blight.

The production of fresh roots grew at an annual rate of 3.0 percent between 1971 and 1984. Most of the increase in production occurred during the 1981-84 period, when the average annual growth rate reached 4.2 percent. It is important to note that with an annual average production of fresh roots of 14.2 million metric tons for the period, Zaire is the largest producer of cassava in Africa, and the third largest in the world, after Brazil and Thailand.

A comparison of area and yield data shows that cassava production has grown solely because of increases in area. Yields have not changed significantly.

Table 1--Trends in area, yield, production, and consumption of cassava, Zaire, 1971-84

Category	1971-75	1976-80	1981-84	1971-84
Area (1,000 hectares/year)	1,608	1,782	2,099	1,810
Yield (metric tons/hectare/year)	6.86	6.85	6.80	6.84
Production (1,000 metric tons/ hectare/year)				
Roots	11,044	12,208	14,246	12,374
Leaves	301	334	379	335
Consumption (kilograms/capita)				
Roots	141.8	136.6	136.1	138.3
Leaves	2.6	2.5	2.5	2.5
Roots and leaves	144.4	139.1	138.6	140.9
Growth rates (percent)				
Area	2.52	1.83	5.93	3.30
Yield				
Roots	0.95	-0.25	-1.59	-0.29
Leaves	0.72	0.50	-3.22	-0.58
Production				
Roots	3.49	1.57	4.17	2.96
Leaves	3.26	2.34	2.42	2.65
Consumption (per capita)				
Roots	0.8	-1.3	-0.1	-0.3
Leaves	0.4	-0.5	-0.5	-0.2

Sources: The figures for area, yield, and production were computed from data in Zaire, Département de l'Agriculture et de Développement Rural, Division des Statistiques Agricoles, La Synthèse de Statistiques Agricoles, (Kinshasa: Département de l'Agriculture et de Développement Rural, 1986). The consumption figures were computed from United Nations, World Population Prospects (New York: UN, 1986); and Zaire, Institut National des Statistiques, Annuaire Statistique (Kinshasa: Institut National des Statistiques, 1986).

Note: The figures for area, yield, and production are for fresh roots. The consumption figures are given in cereal equivalents.

Per capita consumption of cassava roots fell at an annual rate of 0.3 percent and leaves at 0.2 percent over the entire 1971-84 period. Like production, consumption showed three distinct phases. Per capita consumption grew at an annual rate of 0.8 percent during

1971-75 but fell during 1976-80 by 1.3 percent per year, and by 0.1 percent during 1981-84.

MAJOR ISSUES

In the early 1970s, Zaire suffered a widespread bacterial blight that destroyed cassava production throughout the country. A number of other diseases and pests threaten cassava production and pose a serious constraint to its expansion.

One response of the Zairian government to the blight of the early 1970s was to form the Cassava National Program (the Programme National Manioc, PRONAM) to conduct research on cassava with the help of the International Institute of Tropical Agriculture (IITA) at Ibadan, Nigeria. PRONAM has several significant achievements to its credit. These include an improved variety, 5097, that is resistant to diseases and pests, and identification of a number of local clones, such as Kinuani and Mpelolongi, which are cultivated in Bas-Zaire, and a number of local varieties with high yield potential, such as F100 and F162, which are cultivated in Bandundu.

It is unfortunate that efforts to promote widespread use of high-yielding cassava varieties (HYVs), other yield-enhancing technologies, and improved agricultural practices developed by this program and other research stations in the country have remained largely inadequate.

The adequacy of the infrastructure--that is, the road network and other transportation facilities--is critical to the distribution and marketing of cassava products. Because this infrastructure is inadequate in Zaire, leaves, fresh roots, and chickwange have limited marketing areas. Being the most perishable of the cassava products, they are generally sold in rural markets. When the infrastructure is adequate, these products can be carried over long distances. So Kinshasa, the largest consuming region in the country, receives most of its fresh cassava roots, leaves, and chickwange from Bas-Zaire, with which it is well connected. When the road network is poor, dry cassava roots become the cassava product that flows in the largest quantities between producing and consuming areas.

PROJECTIONS

A major concern of this study is to project the demand and supply of cassava in Zaire to 1990 and 2000. This was done on the basis of the trends between 1971 and 1984, described above. The projections were made using a number of assumptions. First, that cassava roots and leaves will continue to be a major source of carbohydrates, minerals, and vitamins. Second, that the population growth rate will not change significantly through 2000. And finally, that the existing shortages in cereals will continue through the next 10-15 years. That is, technological progress and policy reforms will come but slowly.

With this set of assumptions, the change in the area under cassava can be expected to be the main source of growth of cassava output. That change is projected to be an increase of 2.8 percent per year through 2000, reaching 2.5 million hectares in 1990 and 3.3 million hectares in 2000 (Table 2).

Table 2--Projections of the demand and supply of cassava to 1990 and 2000, based on 1984 values, Zaire

Category	1984	1990	2000
Supply			
Area (1,000 hectares)	2,151.05	2,538.17	3,344.30
Yield (metric tons/hectare)			
Fresh roots	6.80	6.77	6.71
Leaves	0.18	0.18	0.18
Production (1,000 metric tons)			
Fresh roots	14,627.14	17,183.41	22,440.25
Leaves	392.47	456.13	585.99
Roots and leaves	4,504.67	5,291.02	6,907.89
Demand			
Per capita food consumption (kilograms)			
Roots			
1984 level	134.54	134.54	134.54
Declining trend continued	134.54	131.22	125.83
Leaves			
1984 level	2.49	2.49	2.49
Declining trend continued	2.49	2.44	2.35
Roots and leaves			
1984 level	137.03	137.03	137.03
Declining trend continued	137.03	133.66	128.18
Total food consumption (1,000 metric tons)			
Roots			
1984 level	3,909.73	4,688.99	6,401.55
Declining trend continued	3,909.73	4,573.20	5,987.12
Leaves			
1984 level	72.36	86.78	118.48
Declining trend continued	72.36	85.04	111.82
Roots and leaves			
1984 level	3,982.09	4,775.77	6,520.03
Declining trend continued	3,982.09	4,658.32	6,098.94

Table 2--continued

Category	1984	1990	2000
Total demand[a] (1,000 metric tons)			
Roots			
1984 level	4,352.98	5,209.70	7,081.56
Declining trend continued	4,352.98	5,093.99	6,667.13
Leaves			
1984 level	75.97	90.98	123.87
Declining trend continued	75.97	89.24	117.21
Roots and leaves			
1984 level	4,428.95	5,300.68	7,205.43
Declining trend continued	4,428.95	5,183.23	6,784.34
Supply/demand balance (1,000 metric tons)			
Roots and leaves			
1984 level	75.72	-9.66	-297.54
Declining trend continued	75.72	107.79	123.55

Sources: Computed from United Nations, World Population Prospects (New York: UN, 1986); Zaire, Institut National des Statistiques, Annuaire Statistique (Kinshasa: Institut National des Statistiques, 1986); Zaire, Département de l'Agriculture et de Développement Rural, Division des Statistiques Agricoles, La Synthèse de Statistiques Agricoles (Kinshasa: Département de l'Agriculture et de Développement Rural, 1969-77); Banque du Zaire, Rapport Annuel, 1975 (Kinshasa: Banque du Zaire, 1975); and Banque du Zaire, Rapport Annuel 1986 (Kinshasa: Banque du Zaire, 1986).

Note: All figures in this table, unless otherwise noted, are given in cereal equivalents.

[a]These figures include figures for cassava used as animal feed, industrial raw materials, and waste, fixed at 10 percent of trend supply for roots and 5 percent for leaves.

Yields are not expected to increase significantly before 2000. Indeed, the projections have yields decreasing slightly, from 6.80 metric tons of fresh roots per hectare in 1984 to 6.71 metric tons in 2000. This is because widespread use of HYVs, fertilizers, pesticides, and other technological innovations are not foreseen.

Because of the increase in area, production of cassava is projected to increase significantly. Output of fresh roots is projected to increase from 14.6 million metric tons in 1984 to 17.2 million metric tons in 1990 and to 22.4 million metric tons in 2000. Production of leaves is expected to go up from slightly less than 0.4 million metric tons in 1984 to almost 0.5 million metric tons in 1990 and to almost 0.6 million metric tons in 2000. The increase in production of roots and leaves together, given in cereal equivalents, is projected to rise from 4.5 million metric tons in 1984 to 5.3 million metric tons in 1990 and to 6.9 million metric tons in 2000.

As there is no precise information on per capita consumption or the income elasticity of demand, projections for future demand must rely heavily on the assumptions made. Two sets of projections were made of the estimated demand for cassava roots and leaves in 1990 and 2000. In the first, per capita consumption was assumed to continue unchanged at the levels of 1984. In the second, it was assumed that the rates of decline of the past will continue. Both sets of projections use the projected estimates of population made by the United Nations (UN).

Annual per capita consumption of cassava roots in 1984 was 134.5 kilograms, in cereal equivalents, and 2.5 kilograms of cassava leaves. Given these figures, aggregate demand for cassava for human consumption in 1990 would be 4.7 million metric tons of roots and 86,780 metric tons of leaves. By 2000 this demand would rise to 6.4 million metric tons of roots and 118,480 tons of leaves.

If the decline in per capita consumption continues, per capita consumption would fall to 131.22 kilograms of roots and 2.44 kilograms of leaves in 1990. It would drop further to 125.83 kilograms of roots and 2.35 kilograms of leaves per capita in 2000. All these figures are in cereal equivalents. Given these figures and the UN projections of population, aggregate demand for cassava for human consumption in 1990 would be 4.6 million metric tons of roots and 85,000 metric tons of leaves. By 2000 this demand would be for 6.0 million metric tons of roots and 111,820 tons of leaves.

Assumptions must be made about other uses in order to get figures for total utilization. FAO's estimate that 21 percent of total supply goes to all other uses--feed, industrial uses, and wastage--seems to be too high. An estimate of 10 percent would probably be more accurate. This would take account of the scope that remains for increased use of cassava as feed and the reductions in wastage that are expected to come through improvements in harvesting and processing techniques. In addition, it is assumed that 5 percent of the output of leaves will be used as feed (mostly for pigs) and wastage.

On this basis, gross demand for cassava roots will range from 5.1-5.2 million metric tons in 1990. In 2000 the range will be between 6.7 and 7.1 million metric tons. Gross demand for cassava leaves will range between 89,200 and 91,000 metric tons in 1990 and 117,210 and 123,870 metric tons in 2000.

A comparison of the projections of supply and demand shows that there will be deficits if per capita consumption does not change after 1984. The deficit in 1990 would be 9,700 metric tons of roots and leaves. The deficit in 2000 will be much larger, 297,540 metric tons. But if per capita consumption continues its decline, the supply/demand balance will be in surplus, by 107,790 metric tons in 1990 and 123,550 metric tons in 2000.

POLICY IMPLICATIONS

The improvement of infrastructure and the promotion of processing of cassava will enhance the distribution and marketing of cassava into products that can be stored and marketed over long periods of time. Efforts in this direction will stabilize prices and promote the consumption and production of cassava. Improvements in the means of transportation and communication would also reduce the cost of distribution and contribute to increases in cassava's use in animal feed and as an industrial raw material.

The projections suggest that there is scope for encouraging more use of cassava as feed and industrial raw materials. Consideration also has to be given to legalizing exports of cassava to neighboring countries. But if the demand for cassava does not develop, the increase in area assumed for the projections will not materialize. If it does not, and if alternative crops are not grown, then income and employment in smallholder agriculture will fall in most areas of the country.

In general, cassava does not receive adequate attention in national policy. It is important, however, that cassava not be viewed in isolation, but that it be seen in the context of the entire cropping system, including the ways it fits into crop rotation and intercropping systems. As cassava is usually grown by smallholder farmers, increases in production and yield per hectare can be achieved through the adoption of new technology as well as through improvements in harvesting, processing, storage, distribution, and marketing. The adoption of new technology by farmers requires financial resources for purchasing improved cuttings, fertilizers, and so forth. Adequate credit and supply arrangements need to be made for this.

In regard to research, the government should continue to cooperate with the IITA in all matters relating to the selection of varieties, the fight against different diseases, and the improvement of harvesting, processing, and storage.

Given current agricultural technology, the production of cassava can be expanded more easily than that of cereals to provide cheap food of acceptable nutritional value for the poor and to meet some of the nutritional needs of the fast-growing population, at least in the short and medium terms.

To conclude, despite the high potential of cassava, expanding its production, like expanding the production of plantains, implies efforts to fully integrate the Zairean Basin into domestic food markets, to promote industries using cassava as a raw material, and to improve the processing of cassava into products that can be stored and marketed easily for a long period of time so that cassava is more readily available for human and animal consumption, for industrial use, and for exports.

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