J. S. SARMA AND
DARUNEE KUNCHAI

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute was established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs in the world, with particular emphasis on low-income countries and on the poorer groups in those countries. While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute's research program reflects world-wide interaction with policymakers, administrators, and others concerned with increasing food production and with improving the equity of its distribution. Research results are published and distributed to officials and others concerned with national and international food and agricultural policy.

The Institute receives support as a constituent of the Consultative Group on International Agricultural Research from a number of donors including Australia, Belgium, Canada, the People's Republic of China, the Ford Foundation, France, the Federal Republic of Germany, India, Italy, Japan, the Netherlands, Norway, the Philippines, the Rockefeller Foundation, Switzerland, the United Kingdom, the United States, and the World Bank. In addition, a number of other governments and institutions contribute funding to special research projects.

TRENDS AND PROSPECTS FOR CASSAVA IN THE DEVELOPING WORLD

J. S. SARMA AND DARUNEE KUNCHAI

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
1776 MASSACHUSETTS AVENUE, N.W.
WASHINGTON, D.C. 20036 U.S.A.

SEPTEMBER 1991

ISBN 0-89629-318-1

Contents

Tables

Illustrations

Figures

1

Summary

Cassava is a relatively neglected tropical root crop. Important in the economy of poor households, cassava is one of the major sources of subsistence and cash income to farmers in agroclimatically disadvantaged regions. It is a major staple food in several countries of Sub-Saharan Africa, Latin America, and Asia. Besides its direct use as food, cassava is also used as feed for livestock and poultry and as raw material for manufactured starch, tapioca, and snack foods. Exports of cassava pellets and dried roots earn considerable foreign exchange, particularly for Thailand. Cassava can adapt to diverse climatic conditions, survive long dry spells, and be harvested on a flexible schedule; it should therefore be treated as a food security crop. Apart from the farmer's own labor, cassava requires few purchased inputs and is thus inexpensive to produce. Its genetic potential is large and untapped, and the adoption of improved technology could make cheaper calories available per hectare.

The use of cassava varies by region. In Sub-Saharan Africa, many farmers grow cassava in backyard plots for their own consumption; however, significant quantities are traded in processed form in countries such as Nigeria and Ghana. Similarly, many farmers in Latin America feed their livestock with cassava. No reliable, time-series data exist, however, on the use of cassava for food and feed on farms or for commercial production at the regional or country level. Thus data on the amount of cassava marketed and retained on farms, as well as the amount consumed in rural and urban areas, are scanty. The forces affecting these subsectors of the cassava economy are many and complex, and in the absence of quantitative data, the analysis of past trends and future prospects of cassava in the developing world has been based on information for each country as a whole.

The analysis in this study is based on the international data series published by the Food and Agriculture Organization of the United Nations (FAO), supplemented by information from six case studies (sponsored by the International Food Policy Research Institute [IFPRI] and the International Development Research Centre [IDRC], Canada) and from the Delphi Survey (described in detail in Chapter 5).

PRODUCTION

The average annual output of cassava during 1983-85 was 130 million metric tons of fresh roots (equivalent to 40 million metric tons of cereals) from an area of 14 million hectares. These represent 29 percent of the output and 30 percent of the area under roots and tubers in the world. Cassava output formed only 2 percent of the global production of staple food crops. About 41 percent of the production of cassava in the developing countries was in Sub-Saharan Africa, followed by 37 percent in Asia and 22 percent in Latin America. In the developing world, a little more than half of the area under cassava was in Sub-Saharan Africa, which had the lowest yield per hectare, at 7.4 metric tons, of the three regions. The overall yield per hectare of fresh cassava roots averaged 9.5 metric tons from 1983 to 1985.

Between 1961-63 (the early 1960s) and 1983-85 (the mid-1980s) the output of cassava increased 2.6 percent per year. Over the same period, the area under the crop increased at an annual rate of about 1.6 percent. Thus yield improved about 0.9 percent per year, or a little more than one-third of the rate at which output increased.

Among the developing regions, Asia had the most rapid growth in output: more than

4.3 percent. The rate of growth in the second half of the period, from 1971-73 (early 1970s) to 1983-85 (mid-1980s), was faster than that in the early 1960s and 1970s. The bulk of the growth in Asia occurred in Thailand, in response to the large demand for cassava pellets to be used in livestock feed in the European Community (EC). This growth in demand was the result of a favorable tariff binding that cassava received from the General Agreement on Tariffs and Trade in 1968 and the high relative price of maize in the EC countries.

In Sub-Saharan Africa, although the area under cassava rose more slowly in the second decade than in the first, both yield and production increased much faster in the second period. The initial slow growth in yield was caused principally by pests and diseases that affected the crop in the 1960s and early 1970s and by other country-specific causes.

In Latin America, the reverse was true. Area, yield per hectare, and output all declined between the early 1970s and mid-1980s, but because area and output had grown rapidly in the 1960s, the overall growth rates from 1961-63 to 1983-85 remained positive. Only the yield per hectare declined, at about 0.5 percent per year. The decline in output in Latin America is attributed, among other factors, to distorted competition between cassava and imported, and often subsidized, cereals.

USE

Nearly 60 percent of the cassava produced in developing countries was consumed as food in 1983-85. Another 26 percent was used as feed, and of this nearly 62 percent was consumed in the developed countries, mostly in the European Community. The balance was used in industry or represents wastage.

Once again, regional variations exist. Of the 130 million metric tons of cassava produced, about 78 million metric tons were consumed as food (43 million metric tons in Sub-Saharan Africa, largely in the subregion of the humid lowlands and the coastal tropics, which includes Nigeria, and in the equatorial wet tropics subregion, which includes Zaire. Nearly 50 percent of the cassava used as food in Asia was consumed in the Association of Southeast Asian Nations (ASEAN) countries, excluding Thailand. In Latin America, Brazil consumed three-fourths of the cassava used for food and 78 percent of the cassava used for feed. Latin America consumed 10 million metric tons of cassava for feed, out of the 12.6 million metric tons used for feed by the developing countries as a whole. Waste and industrial use formed nearly 17 percent of the total domestic use of cassava (109 million metric tons) in the developing countries during 1983-85.

The total domestic use of cassava in the developing world rose 2 percent per year between the early 1960s and the mid-1980s. Its use as food increased more rapidly at 2.3 percent per year. The regional rates were 3.0 percent in Asia, 2.4 percent in Sub-Saharan Africa, and 0.9 percent in Latin America. These growth rates signify a decline in the per capita consumption of cassava in Sub-Saharan Africa and Latin America. At the aggregate level, domestic use grew slower from 1971-73 to 1983-85 than from 1961-63 to 1971-73.

The growth in production that occurred between the early 1960s and mid-1980s was associated with different components of use in Asia, Sub-Saharan Africa, and Latin America. In Asia the growth occurred in cassava produced for export, mainly from Thailand, and for food; in Sub-Saharan Africa it occurred predominantly in cassava produced for food, both for the rural and for the urban poor; and in Latin America, it occurred in cassava produced for food and feed used in the domestic economy. In the 1970s and 1980s, grain policies in Latin America favored cereals over cassava, and both the area and the production of cassava declined.

Exports of cassava increased from an average of 1.7 million metric tons of fresh root equivalents in 1961-63 to 20.0 million metric tons in 1983-85 (Thailand alone accounted for 17.2 million metric tons). The 69 countries studied imported 172,000 metric tons during 1983-85, and developing countries that did not produce cassava imported 652,000 metric tons.

Factors other than population growth also influence a given country's demand for cassava for food: degree of urbanization, level of income, price of cassava and alternative foods, historical food habits, consumption by producers, ability to store and process, and the form in which cassava is processed. Evidence presented in Chapter 5 indicates that the overall income elasticity of the demand for fresh cassava is positive and moderately large in rural areas, but small and even negative in urban areas. Fresh cassava is income elastic for low-income consumers and negative only in the highest quintile. The income elasticity of the demand for dried cassava in the form of *gari*, *gaplek*, or *farinha*, is negative in both rural and urban areas. Cassava for starch products and convenience foods has a positive demand elasticity in urban areas, particularly at higher incomes. The overall income elasticity of cassava depends on the proportions in which different cassava products are consumed in rural and urban areas. Time-series data confirm that the per capita consumption of cassava declined over the past two decades in developing countries as a whole.

Two other factors constrain the demand for cassava: toxicity and perishability. Both can be mitigated by appropriate processing. Further, fresh roots are bulky to transport, which constrains their marketability. Developing infrastructure and linking producers to markets would improve the demand for cassava.

Case studies of the use of cassava for feed in Asia show that although cassava may not always be a cost-effective substitute for coarse grains in livestock feed, given the existing relative prices, it could be used more often in feed mixes for poultry and pigs if its yield were increased and its unit costs lowered. The special marketing problems must also be resolved before cassava can be used to substitute for maize in livestock feed. There is also a need to integrate the markets for fresh cassava and for manufactured feed.

THE FUTURE OF CASSAVA PRODUCTION

The Delphi Survey shows that cassava yields on fertilized fields are generally 5 metric tons per hectare higher than those on unfertilized fields planted with existing varieties and without irrigation. Irrigation alone does not seem to improve yields. By 2000 the potential yields of existing varieties could reach 13 metric tons per hectare without fertilizer and irrigation and 22 metric tons per hectare with fertilizers and irrigation. The scientists who responded to the survey felt that by doubling the resources directed to research, even higher yields could be achieved. Thus the current constraint of low yields could be overcome through research and development efforts.

If past trends in the area allocated to cassava and yield per hectare continue, the developing countries could produce as much as 204 million metric tons by 2000, 62 million metric tons more than the trend value of output in 1985. The total domestic use of cassava for food, feed, industry, and wastage could reach 164 million metric tons. Adding the existing level of exports, would indicate a total use of 184 million metric tons. In this scenario, the projected supply would be 10 percent more than the projected use. If use did not increase sufficiently, however, the growth of supply would also slow down and the gap would not occur.

Whether these projections of supply and utilization are realized or not depends on whether the variables continue to grow as in the past. The analysis also suggests that growth in output will not constrain the development of cassava. In marginal cassava-growing areas of Asia and Latin America, the development of cassava should be given priority for equity considerations. In these areas, the net returns from cassava are higher than those from alternative crops given the existing level of yields and prices. If increased demand were created by developing alternative uses such as convenience foods, livestock feed, or industrial raw material, improved yields would increase net returns further.

In Thailand, the demand for cassava depends on export demand, especially from outside the European Community. Asian countries other than Thailand could expand their domestic use of cassava for livestock feed and adopt technology to improve yields, reduce unit costs, and make prices competitive with maize and protein supplements. The demand for livestock products is likely to increase rapidly in the coming years and to result in a rapid rise in the derived demand for feed. Cassava will probably meet part of this demand if, in addition to competitive prices, adequate processing, storage, and marketing are developed. The prospects for food use are less bright in Asia.

In Latin America, governments could modify their interventions to encourage cassava and thus slow, and perhaps arrest, the decline in area, yield, and output. Cassava is competitive with other feed grains over large parts of tropical Latin America. Here, too, the development of processing and storage technologies could encourage greater use of cassava for food and feed.

The future of cassava in Africa is uncertain. One view is that the importance of cassava will decline in the long run and that maize or sorghum will replace cassava in the human diet. Another view is that the production of cassava will expand substantially to meet the demands of low-income rural and urban populations and that this trend will be aided by improvements in the technology of processing and storing cassava.

In the humid forest areas of Sub-Saharan Africa, cassava has a comparative advantage over cereal grains. Even in the savannah and drier areas where cereals can be grown profitably, the immediate contribution of cassava to food security should be recognized. A question of the relative priority that should be given to cassava and cereals, mainly maize or sorghum, may eventually arise. Cassava's lower net returns and higher labor requirements for cultivation and on-farm processing may be an issue in the future, but given the immediate needs of food security in the region and cassava's ability to meet those needs, priority must be given to evolving high-yielding and disease-resistant varieties and improving agronomic practices.

Improving the processing facilities and thus overcoming the twin problems of perishability and toxicity would increase the availability and use of cassava in rural and urban areas of all three regions. Developing proper linkages between production and marketing centers would help increase the demand for processed products using cassava. However, more research and development of postharvest technologies, including processing, are necessary to meet the increased demand from urban areas. So are research in the postharvest processing and use phases and in developing commercial products.

International agricultural research centers, national agricultural research institutes, and universities should pool their resources and give greater priority to the postharvest phase so that their activities complement one another. Their collaboration should extend to sharing information on food processing and the range of opportunities that exist for using cassava.

The lack of incentives is a basic constraint to realizing cassava's potential for greater yield. Governments need to encourage cassava production through their policies on prices, access to input supplies, credit, extension services, and markets, particularly in areas where developing cassava is essential for attaining food security and alleviating poverty. In addition, they must develop infrastructure to facilitate marketing of cassava for use in industry and as an ingredient in compound feed. The private sector should also play an important role in developing processing and feed industries.

National governments should take steps to improve the timeliness and reliability of the data relating to the area, production, use, and trade of cassava. Appropriate data collection methods may have to be devised through special studies that take into account the unique conditions under which cassava is grown and harvested.

2

Introduction

Cassava,[1] a tropical root crop rich in carbohydrates, is cultivated by small farmers in the marginal lands of Asia, Latin America, and Sub-Saharan Africa, providing them subsistence as well as cash incomes. Its cultivation and on-farm processing is a source of rural employment, particularly for women. It is the principal source of calories in equatorial Africa, the second-most important source in the southern and humid parts of West Africa, and the fourth in drier areas of West Africa. It can adapt to diverse climatic conditions, survive long dry spells, and be harvested and stored on a flexible time schedule, all of which qualifies it as a food security crop. Cassava leaves are rich in protein and are consumed as a vegetable in Zaire and other parts of Central Africa. The two disadvantages of cassava are that some varieties are toxic and that the roots are perishable once harvested. Both of these disadvantages can be remedied by appropriate processing techniques.

Cassava is generally grown on soils with poor fertility, where no other field crop can be grown, as in northeastern Thailand. The infrastructure of rural roads and markets is also poor, as in northeastern Brazil. Cassava farms are generally small, particularly in Asia, although no global data are available. In India, 84 percent of cassava growers in the main cassava-growing area of Kerala cultivate less than 1 hectare of land and another 10 percent have farms between 1 and 2 hectares. Even in Thailand, the average cassava grower reportedly has 3.3 hectares. In Southern Nigeria, three-fourths of the farms are under 1 hectare in size. In Latin America, cassava farms are relatively large, although wide variations exist among countries and even among regions within the same country (Cock 1985).

Most cassava farmers use traditional production methods, although in Thailand and some Latin American countries they use tractors to prepare the land for planting. Land prepared manually requires an estimated 100-200 days of labor per hectare of cassava, although this figure varies considerably.

Women, particularly in Sub-Saharan Africa, are employed in various operations including postharvest processing, although here, too, no national or regional data are available. Recent studies in Nigeria indicate that women are involved in all stages of production, processing, and marketing, although their role in clearing land is minimal. Assessments from five Nigerian states indicate the extent of their participation in the following field operations:

	Percent
Field preparation (including destumping and hand harrowing)	34
Planting	77
Weeding	86
Harvesting	77

In general, women complete all the processing, storing, and marketing of cassava (Ikpi et al. 1986, 34).

To assess the prospects for cassava in the future, IFPRI examined the trends and prospects for production, use, and trade of cassava in the developing countries under a special project partially funded by the IDRC of Canada. In addition to the analysis of international data at the global and regional level, case studies were undertaken in six countries: India, Indonesia, the Philippines, and Thailand in Asia and Nigeria and Zaire in Sub-Saharan Africa. Analyses of cassava in the developing world were also undertaken at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. Project researchers, cassava scientists, and representatives of international organizations then discussed the results of these studies and analyses in a workshop held in Washington, D.C., in August 1987. The report on the proceedings of that workshop and the results of the individual case studies have been published separately. This report seeks to bring the results of all these studies together, to draw their essence, and to present policy issues that must receive attention for the development potential of cassava to be realized. This effort is particularly important because of cassava's significant contribution to achieving food security and alleviating poverty.

WORLD OUTPUT

The world's average annual output of cassava during 1983-85 was 130 million metric tons,[2] equivalent to 40 million tons of cereals.[3] This formed about 2 percent of the world's production of staple food crops and nearly 29 percent of that output of root and tuber crops. Cassava was grown on 14 million of the 46 million hectares of land devoted to roots and tubers in the world. The entire cassava-growing area is located in the developing countries and is confined largely to Sub-Saharan Africa, Asia, and Latin America, as shown in Table 1.[4] About 41 percent of the production of cassava was from Sub-Saharan Africa, followed by 37 percent from Asia and 22 percent from Latin America. The area under cassava in Sub-Saharan Africa was a little more than half of the total for the developing world, but its yield per hectare was 78 percent of the total yield, the lowest of the three regions. The overall yield per hectare of cassava was 9.5 tons.

WORLD USE

Nearly 60 percent of the world's production of cassava was used as food in the developing countries (see Table 2). Another 26 percent was used as feed, of which nearly 62 percent was used in developed countries as an ingredient of compound feed mixtures. Developed countries—mostly from the European Community—import cassava from Asia in the form of dried pellets or chips. Other uses include industrial purposes and wastage. Less than 1 percent was used to manufacture ethyl alcohol, mostly in Brazil.

Table 1--Distribution of area, production, and yield of cassava, by region, 1983-85

Region[a]	Area	Production[b]	Yield/ Hectare[b]
	(million hectares)	(million metric tons)	(metric tons)
Asia	3.9	47.9	12.2
Sub-Saharan Africa[c]	7.3	54.0	7.4
Latin America	2.6	28.4	11.1
Total	13.7	130.3	9.5

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

[a] Excludes small island states, whose aggregate production is reported to be 140,000 metric tons.

[b] Fresh roots.

[c] Cassava is also grown in Sudan (45,000 hectares), but the data for this country are included in Sub-Saharan Africa throughout the paper.

Table 2—Use of cassava in developed and developing countries, 1983-85

Use	Developing Countries	Developed Countries	Total World
	(million metric tons in fresh root equivalents)		
Food	78.0	0.0	78.0
Feed	12.6	20.8	33.4
Other uses, including allowance for wastage	18.8	0.6	19.4
Net exports	+19.2	−21.4	−2.2[a]
Changes in stock	+1.7	0.0	+1.7
Total output	130.3	0.0	130.3

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

[a] This is the difference between total net exports from developed countries and total net imports to developing countries, treated as a statistical discrepancy.

Developing countries exported an average of nearly 20 million tons of cassava in fresh root equivalents during 1983-85. Of these, 17.2 million tons were from Thailand. These same countries imported 0.8 million tons from other developing countries so that total net exports were 19.2 million tons in 1983-85. The corresponding net exports during 1961-63 were only 1.7 million tons, mainly in the form of cassava flour, even though developing countries only imported 50,000 tons at that time. The rapid increase in exports during the 1970s is mainly the result of increased imports into the European Community.

The role of cassava in the economies of the developing countries differs from region to region and from country to country even within the same region. In Thailand, for example, the stimulus for extending the cultivation of cassava was the external demand for its use as an ingredient in livestock feed. Nevertheless, cassava is grown in areas that are politically sensitive and where the farmers are poor. The Royal Thai government is interested in maintaining the incomes of the poor; however, the proposals for diversifying the crops in these areas have met with little success. Any technological breakthrough in cassava that would improve yield could make cassava competitive with corn. In India, cassava has played two different roles; in Kerala State, it is a safety food, whereas in Tamil Nadu State, it provides the raw material for industrial processing.[5] In Indonesia, the crop played a role in food security in the past by preventing famine and keeping food prices from rising unduly. More recently, however, after the rapid growth of rice output, it is being used mainly as a convenience food. Indonesia also exports cassava pellets to the European Community but its exports are below quota, mainly because of infrastructure constraints. In the Philippines, cassava is a safety food that is consumed when rice is scarce and helps raise the income of the poor. Infrastructure constraints affect, however, the marketing of cassava, and yields must be improved if it is to be used domestically as livestock feed and starch. In China, cassava is mostly grown for domestic use, although China does export some cassava to earn foreign exchange.

In the humid and subhumid areas of West and Central Africa, cassava is the major staple or at least one of the principal staples. It is an important famine-relief crop and contributes to food security in the savannah and drier areas of West, East, and Southern Africa. Its use as food varies, however, by region and country: both roots and leaves are of major nutritional importance in Liberia, Sierra Leone, and Zaire, whereas in Ghana and Nigeria, cassava is grown mainly for its roots. In Zaire, cassava is consumed differently in different zones.

The nature of production in Sub-Saharan Africa is unclear. Some consider it to be mainly subsistence production with plantings in backyard gardens and consumption in fresh form. But Lynam (1984) points out that processed cassava is traded extensively in Ghana and Nigeria, where it is emerging as a staple food for low-income groups in urban areas (Welsch 1986, 45).

In Latin America cassava is used principally as food. The diversification of cassava use, as in Asia, has not taken place in Latin America despite structural changes of the postwar period and marked changes in food consumption patterns. Latin America does, however, use cassava for livestock feed more often than do Asia and Africa.

DELINEATION OF SUBREGIONS

For a better understanding of how cassava is distributed in the three regions of the developing world and of the trends in the area, production, and yield per hectare of cassava over the past two decades, cassava-growing countries were grouped into 14 geographical or climatic subregions. An ideal typology would have been to divide the cassava-growing areas by their agroclimatic conditions. Such a classification was difficult, however, because cassava is grown under a wide range of conditions within each country and separate data are not available for each zone. Where climate was used as a factor for grouping, a country was classified on the basis of the bulk of its cassava-growing areas. In Asia, only a broad geographical classification was possible. Lastly, large cassava-growing countries, such as Brazil, Thailand, and China, were treated as subregions. The 14 subregions were distributed as follows: 5 in Asia, 4 in Sub-Saharan Africa, and 5 in Latin America.

The five subregions in Asia are South Asia, China, Thailand, ASEAN (excluding

Thailand), and Indo-China and the Pacific Islands. South Asia comprises Burma, India, and Sri Lanka. Indonesia, Malaysia, the Philippines, and Singapore form the ASEAN (excluding Thailand) subregion. The remaining cassava-growing countries in Asia are grouped under Indo-China and the Pacific Islands subregion.

The 34 countries of Sub-Saharan Africa are divided into 4 subregions based on agroclimatic characteristics. These are semi-arid tropics, humid lowlands and coastal tropics, equatorial wet tropics, and modified tropics (which includes subtropics as well as countries in the tropical climate that are modified by elevation or other characteristics). Sudan is included under the semi-arid tropics. Of the large cassava-growing countries in Sub-Saharan Africa, Zaire is included in equatorial wet tropics, Nigeria in humid lowlands and coastal tropics, and Tanzania in modified tropics.

In Latin America, Brazil, which accounted for nearly 80 percent of the region's cassava production, is treated as a separate subregion. The remaining countries in South America are divided into three subregions: seasonally dry tropics, subtropics, and wet tropics. The seasonally dry tropics comprise Colombia, Ecuador, and Venezuela, where cassava is grown in areas with a three- to four-month dry season. In Peru and Bolivia, cassava is grown principally in the Amazon Basin, and these countries are therefore placed in the wet tropics. The subtropics subregion includes Paraguay and Argentina, where the climate is subject to a dry season but where cassava is grown in winter when transpiration is low. The remaining cassava-growing countries in Latin America are grouped into a subregion comprising Mexico and the countries in Central America and the Caribbean. A list of countries, arranged by subregions, is presented in Appendix 1. This list was finalized in consultation with the Centro Internacional de Agricultura Tropical (CIAT) and the International Institute of Tropical Agriculture (IITA).

DATA

The principal source of the data presented on the area and production of cassava is the data base of FAO. Doubts are often expressed about the reliability of these statistics. These doubts are particularly strong for Sub-Saharan Africa, where the basic agricultural statistics on cereals are poor and those on roots and tubers are even worse for several countries. National data are not available in many cases, and those that are available are incomplete, unreliable, and out of date and cannot be compared over time. Among the principal reasons for these defects are inaccessible terrain, shifting cultivation, mixed cropping and other cultivation practices, subsistence cultivation, the absence of trained statistical personnel, and so on (Sarma 1984). The difficulties of collecting data on the area and production of cassava are more severe. In some areas, the cassava crop is in the field for more than 12 months, and the distinction between old and new areas is unclear. Farmers harvest the crop as they need it and leave the rest in the ground. They often grow cassava with other crops, and allocating area to the different crop mixtures is difficult. In countries such as Nigeria a commercial (modern) sector coexists with a subsistence sector, but the national survey data refer only to the subsistence sector. FAO does attempt to obtain the relevant data from national governments or from local experts, representatives, and other knowledgeable persons. In some cases it uses benchmark data based on agricultural censuses or other ad hoc surveys and then extrapolates data from them for subsequent years. Thus although the data are not always reliable, they are the best estimates available on a cross-country basis.

Tables 36 and 37 in Appendix 2, give the FAO data on area and production of cassava for 20 countries for the years 1976-85. In the absence of reliable annual data, rough estimates were used that were kept constant over a number of years or that increased in an arithmetic progression using rounded increments in area or production. The results of trend analysis based on such data must be interpreted with caution.

Data on use are also approximate in most of the countries in Asia and Latin America as well as in Sub-Saharan Africa. When use for a specific purpose is estimated as a fixed percentage of production, annual variations in use reflect changes in production. In several countries household surveys were conducted, and wide discrepancies exist between the per capita consumption of cassava as food based on these surveys and the consumption based on food balance sheets. The concept and definition adopted for wastage also vary widely; in some countries, such as Thailand, no allowance is made for wastage, while in others, such as some Sub-Saharan African countries, an allowance as high as 20 percent is made.

METHODOLOGY

To gain a proper understanding of past trends in the cassava economy and to assess future prospects, it would have been desirable to analyze subsistence and commercial sectors separately, since the factors influencing each sector's use of cassava as food, feed, and other purposes are different. Such data are, unfortunately, not available on a global or regional level. Similarly, separate data on using cassava in on-farm feed and in manufactured livestock feed are also scanty. The best use has therefore been made of the available data, adopting IFPRI's methodology for food gap analysis, which is broadly described below.

The analysis of past area, production, yield per hectare, and use is based on data for the years 1961 to 1985. The average growth rate in each is based on the compound growth rate between the triennial averages for 1961-63, 1971-73, and 1983-85. Production projections assume that the historical trends of each group of countries will continue in area and yield per hectare and that the projected output is the product of the projected area and projected yield per hectare. These projections were at-tempted for each of the 14 subregions of the developing countries. The subregional projections were aggregated to yield estimates for each region and for the developing world as a whole. An alternative projection was based on past trends in the output of cassava in each of the 24 countries that produced more than 500,000 tons in 1983-85; for the remaining 45countries, annual estimates of production were aggregated and the aggregate was also projected. The resultant projections were summed to give the estimated production of the 69 countries.

The projected use of cassava was worked out separately for food, feed, and other purposes, including allowance for wastage. The demand for food was estimated in two ways. The first took into account the trend level of per capita consumption in 1985, the rate of growth in per capita income, and the income elasticity of demand. The second took into account the constant trend estimate of per capita consumption in 1985, and assumed that income elasticity of cassava for food was zero. Both approaches used the United Nations' medium variant population projections for 2000 for each country. The country estimates of demand were aggregated for each subregion and region and for the developing countries as a whole. Past trends in the demand for cassava for feed were projected in each subregion to obtain the estimated demand in 2000. Other uses bore the same proportion to the output in 2000 as they had in 1983-85.

ORGANIZATION OF THE REPORT

Chapter 3 presents the current situation and past trends in the area, yield, and production of cassava and in its use in different regions and subregions. Chapter 4 considers the factors influencing the use of cassava for food and feed, while Chapter 5 discusses the potential yield of cassava. Chapter 6 presents scenarios of projected cassava output and use in 2000. Chapter 7 concludes by summarizing the policy implications and conclusions of the study.

3

Trends in Production and Use

The average production of cassava in the developing world during 1983-85 was 130 million tons from an area of 13.7 million hectares. Out of the 69 countries in the three regions studied, 5 countries (Brazil, 17 percent; Thailand, 15 percent; Zaire, 12 percent; Indonesia, 10 percent; and Nigeria, 9 percent) produced nearly 63 percent of all the cassava. Each of these countries produced more than 10 million tons of cassava a year. Another 19 countries added 42 million tons or 32 percent of total production. The remaining 45 countries shared about 5 percent of the output (see Appendix 2, Table 38).

Even in the five principal producers, the production of cassava is concentrated in regions with the appropriate agroclimatic and other factors. In Brazil, for example, cassava is increasingly produced in the North and Northeast regions, which have relatively marginal agroclimatic conditions. In Thailand, cassava is also cultivated largely in the Northeast on land unsuitable for other crops and vulnerable to drought. Although cassava is grown throughout Zaire, it is relatively more important in the western region, where it is rotated with other food crops. About two-thirds of Indonesia's cassava is produced in Java, principally East Java. Outside Java, Lampung Province in Sumatera is an important cassava-growing area. In Nigeria, most cassava is produced in the southern states and the middle of the country. The overall distribution of area, production, and yield per hectare of cassava by region is given in Table 1.

Out of this average production of 130 million tons of cassava during the mid-1980s, 19.2 million tons were exported to developed countries and 0.8 million to other developing countries such as the Republic of Korea and Hong Kong. The balance of 110 million tons of cassava remained in the 69 countries studied. Allowing for changes in stocks, the total domestic use of cassava in these countries was about 109 million tons. About 71 percent of this quantity was used for food, 12 percent for feed, and 5 percent for industrial purposes; the balance represented wastage. A little less than 50 percent of the total domestic use was in Sub-Saharan Africa, with the remaining distributed between Asia and Latin America almost equally. In Sub-Saharan Africa, 43 million of the 54 million tons of cassava used domestically were for food and 1.1 million tons for feed. In Latin America, about 12.2 million tons, or nearly 43 percent, were used for food and 10 million tons for feed. In Asia, 82 percent of domestic use was for food and only 1.4 million tons, or 5 percent, were used for feed (see Tables 3 and 4). These regional differences in domestic use are largely due to historical factors.

Cassava is consumed as food in a variety of forms, as cooked fresh cassava or as processed cassava, mainly flours and meals, and is known by different names in different countries.[6] Expressed in fresh root equivalents, 78 million tons of cassava were used for food in 1983-85: 43 million tons in Sub-Saharan Africa (56 percent) and 22 million tons in Asia (29 percent). In Latin America, where on-farm feeding is relatively important, 79 percent of the cassava consumed was used for feed. Approximately 18.6 million tons of cassava were used for other purposes: in Sub-Saharan Africa, most of the 9.3 million tons so designated represented wastage. In Latin America, the 6.0 million tons reported as other included 2.5 million tons used to manufacture starch and gasohol and 3.5 million tons for wastage. Estimates of wastage for 1983-85 by region were not readily available. Data for 1984, however, show that about 12.3 million tons of fresh root equivalents were wasted. Of this, 50

Table 3—Domestic use of cassava in developing countries, by region, 1983-85

Region/Share	Food	Feed	Other	Total
		(percent)		
Share of each region in total domestic use				
Asia	28.5	11.5	17.9	24.7
Sub-Saharan Africa	55.8	9.1	49.8	49.4
Latin America	15.7	79.4	32.3	25.9
Total	100.0	100.0	100.0	100.0
Share of each use in total domestic use				
Asia	82.3	5.4	12.3	100.0
Sub-Saharan Africa	80.6	2.1	17.3	100.0
Latin America	43.3	35.4	21.3	100.0
Total	71.4	11.5	17.1	100.0

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

Note: Other uses include industrial purposes and wastage. Absolute figures are given in Table 5.

Table 4—Area, production, and yield of cassava in developing countries, by subregion, 1983-85

Region/Subregion	Area	Production[a]	Yield/ Hectare[a]
	(million hectares)	(million metric tons)	(metric tons)
Asia	3.92	47.91	12.22
South Asia	0.37	6.35	17.04
China	0.24	3.80	15.54
Indochina and the Pacific Islands	0.53	3.18	6.05
Thailand	1.24	19.41	15.61
ASEAN (excluding Thailand)	1.53	15.17	9.89
Sub-Saharan Africa	7.28	53.96	7.42
Semi-arid tropics	0.16	0.74	4.78
Humid lowland and coastal tropics	3.54	25.8	67.31
Equatorial wet tropics	2.45	16.62	6.77
Modified tropics	1.13	10.73	9.50
Latin America	2.55	28.40	11.13
Seasonally dry tropics	0.22	1.98	8.88
Subtropics	0.20	2.78	14.20
Wet tropics	0.06	0.63	10.08
Brazil	1.91	22.14	11.56
Mexico, Central America, and the Caribbean	0.16	0.87	5.60
Developing countries	13.75	130.27	9.48

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

[a]In fresh root equivalents.

percent was in Sub-Saharan Africa, 30 percent in Latin America, and 20 percent in Asia.

SUBREGIONAL PATTERNS OF PRODUCTION AND USE

Asia

Estimates of area, production, and yield per hectare of cassava are given by subregions in Table 4. The ASEAN subregion (excluding Thailand) produced about 15 million tons of cassava on an average during the mid-1980s. India, which is included in the South Asia subregion, produced 5.6 million tons of the subregion's total production of 6.3 million tons. South Asia, Thailand, and China produced more than 15 tons of cassava per hectare. The Indochina and the Pacific Islands subregion produced the lowest yields in Asia: 6 tons per hectare. The subregional details of use are given in Table 5. The ASEAN countries, excluding Thailand, consumed nearly half of the cassava used for food in Asia, and Indonesia consumed 9.6 million of the 11.6 million tons consumed in the subregion. Next in importance is the South Asia subregion, which consumed 5.8 million tons, of which India consumed 5.2 million tons. In India, most of the cassava used for food was consumed in Kerala State. The cassava produced in Tamil Nadu State is used primarily to manufacture starch and sago.

Table 5—Domestic use of cassava in developing countries, by region and subregion, 1983-85

Region/ Subregion	Food	Feed	Other, Including Waste	Total[a]
	(million metric tons of fresh root equivalents)			
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 the 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
Semi-arid 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
South America				
Seasonally dry tropics	1.39	0.29	0.33	2.01
Subtropics	0.64	1.71	0.28	2.63
Wet tropics	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
Total	77.69	12.56	18.60	108.85

Source: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1984," FAO, Rome, 1986; and Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," FAO, Rome, 1987 (computer printout).
Note: Parts may not add to total due to rounding.
... Negligible.
[a]Production minus net trade and change in stocks.

Sub-Saharan Africa

In Sub-Saharan Africa, little cassava is grown in the semi-arid tropics. The bulk of cassava is grown in the humid lowlands and the coastal tropics (which includes Nigeria) and the equatorial wet tropics (which includes Zaire). The yield per hectare in the modified tropics was relatively high: 9.5 tons compared with the 7.4 tons per hectare average for the Sub-Saharan Africa region as a whole. The semi-arid tropics had the lowest yield: 4.8 tons per hectare.

Again, the humid lowlands and the coastal tropics accounted for 47 percent of the total domestic use of cassava in Sub-Saharan Africa, most of which was used for food. Nigeria used 9.3 million tons of cassava as food, and the equatorial wet tropics and the modified tropics used 31 and 20 percent of total domestic use, respectively. In some countries, notably Zaire, cassava leaves are also consumed as food, although the estimates of domestic use do not include them.

Latin America

In Latin America, apart from Brazil, the seasonally dry tropics and subtropics produced nearly 4.8 million tons of cassava during 1983-85. Yield per hectare in the subtropics of South America was high (14.2 tons), followed by 11.6 tons in Brazil. The average yields of both subregions were higher than the regional average of 11.1 tons per hectare. Yields in Mexico, Central America, and the Caribbean were about half the regional average. Brazil accounted for nearly 78 percent of Latin America's total domestic use by consuming approximately 7.8 million tons for feed and 9.1 million tons for food. The use of cassava for feed in Brazil may, however, be overestimated. In the subtropics of South America, cassava seems to be more important as a source of feed than of food.

PER CAPITA CONSUMPTION OF CASSAVA AS FOOD

The average per capita consumption of cassava as food during 1983-85 was 26 kilograms of fresh root equivalents or 8 kilograms of cereal equivalents per year for the 69 countries as a whole. Consumption varies considerably within regions, however. The average consumption is 121 kilograms (37 kilograms of cereals) in Sub-Saharan Africa, 29 kilograms (9 kilograms of cereals) in Latin America, and about 10 kilograms (3 kilograms of cereals) in Asia. Asia's average is low because the cultivation and direct consumption of cassava as a food staple in India and China are confined to specified areas. Table 6 presents the frequency distribution of specified levels of per capita consumption of cassava by region, which is more telling than the overall figures.

Of the 15 countries that consume at least 100 kilograms of cassava per capita, 14 are in Sub-Saharan Africa. Zaire consumes the most per capita, around 410 kilograms (124 kilograms of cereals) a year.

PRICE TRENDS

Changes in the pattern of the domestic use of cassava for food can be partly explained by the behavior of relative prices. However, comprehensive data on the retail price of cassava compared with that of substitute crops are not available. Some data are available from the case studies sponsored by IFPRI in India and Nigeria, and these are summarized in Tables 7 and 8.

Table 7 indicates that in Kerala, the ratio of the retail price of rice to that of cassava has declined steadily from 6.8 in 1973 to 3.2 in 1983, reflecting the increased availability of rice and the consequent decline in the consumption of cassava. In Nigeria, the ratio of the wholesale price of cassava to that of maize declined from 1980 to 1982, but increased thereafter (Table 8). Table 9 provides the annual percentage change in the retail price of fresh cassava, wheat flour, and rice (at constant prices) in select countries of Latin America over the past decade and a half. In general, while the real price of fresh cassava increased (with the exception of Brazil), that of wheat flour (except in Venezuela) and rice declined.

TRENDS IN PRODUCTION AND USE

Figures 1 and 2 show the annual area, production, and yield per hectare of cassava in developing countries from 1961 to 1985. Although the yield per hectare increased more

Table 6—Distribution of per capita consumption of cassava as food in developing countries, by region, 1983-85

Average/Capita[a] Consumption	Asia	Sub-Saharan Africa	Latin America	Total
(kilograms)		(number of countries)		
Less than 10	3	8	11	22
10-49	9	7	8	24
50-99	2	5	1	8
100-199	...	8	1	9
200 and above	...	6	...	6
Total	14	34	21	69

Sources: Derived from Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1984," FAO, Rome, 1986; and Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," FAO, Rome, 1987 (computer printout).
Note: One kilogram of cassava in fresh roots equals 0.303 kilograms of cereal equivalent. ... Negligible.
[a]In fresh root equivalents.

Table 7—Wholesale and retail prices of cassava and the ratio of retail prices of rice to cassava in Kottayam District, Kerala, India, 1973-83

Year	Wholesale Price of Cassava	Retail Price of Cassava	Ratio of Retail Price of Rice to Cassava
	(Rs/kilogram)		
1973	0.39	0.45	6.8
1974	0.48	0.56	6.2
1975	0.51	0.59	5.3
1976	0.43	0.57	4.4
1977	0.33	0.50	4.5
1978	0.41	0.55	3.8
1979	0.44	0.63	3.6
1980	0.46	0.66	3.6
1981	0.55	0.75	4.2
1982	0.66	0.89	3.8
1983	0.73	1.01	3.2

Source: P. S. George, *Trends and Prospects for Cassava in India*, Working Paper on Cassava 1 (Washington, D.C.: International Food Policy Research Institute, 1988).

Table 8—Wholesale price indices of cassava and maize in Nigeria, 1980-84

Year	Cassava	Maize	Ratio of the Price of Cassava to Maize
	(1979 = 100)		
1980	105.4	62.3	169.2
1981	182.0	148.9	122.2
1982	186.3	165.7	112.4
1983	247.0	177.0	139.5
1984	294.6	182.6	161.3

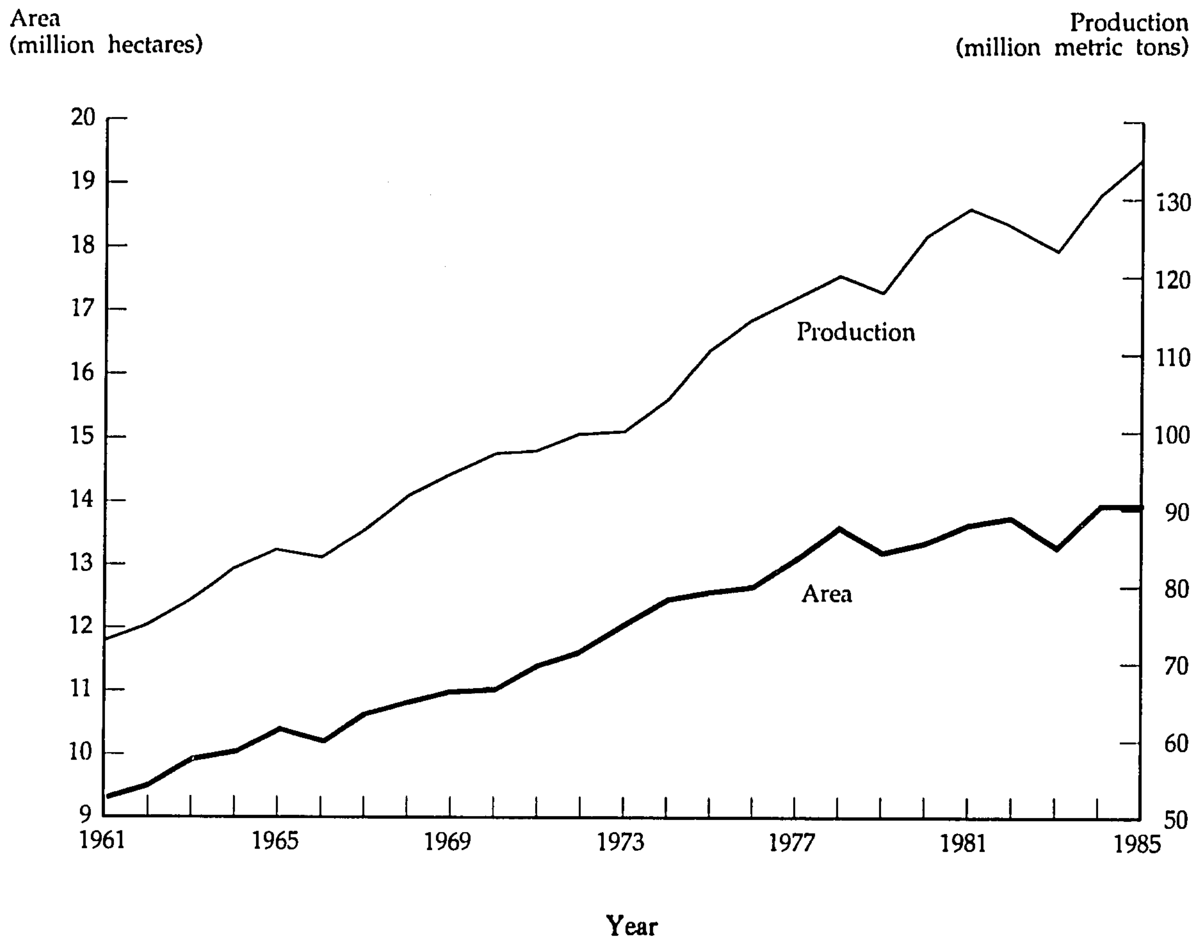
Source: S. O. Adamu, *Trends and Prospects for Cassava in Nigeria*, Cassava Working Paper 5 (Washington, D.C.: International Food Policy Research Institute, 1989).

Table 9—Annual change in the retail price of fresh cassava, wheat flour, and rice in selected countries of Latin America, various years, 1960-85

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

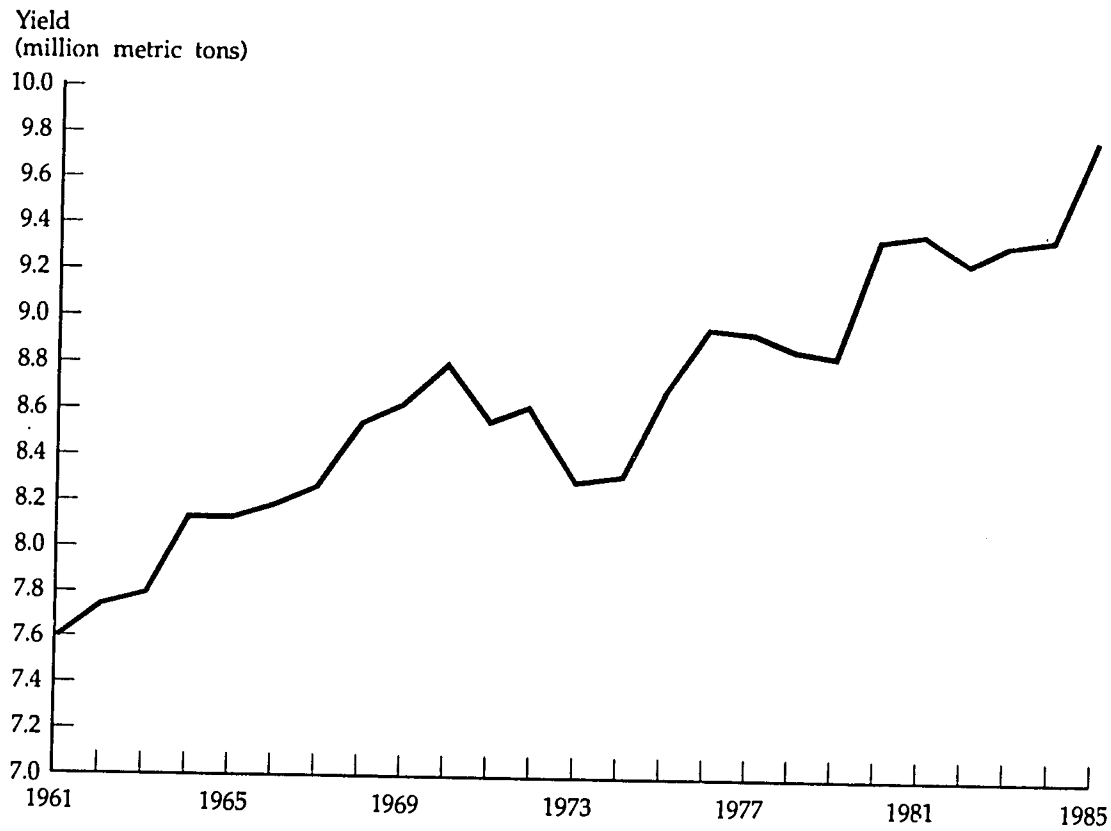
Source: John K. Lynam. "The Evaluation of Cassava Consumption in Latin America," in *Summary Proceedings of a Workshop on Trends and Prospects of Cassava in the Third World*, ed. J. S. Sarma, (Washington, D.C.: International Food Policy Research Institute, 1989).

Figure 1—Area and production of cassava in developing countries, 1961-85



Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

Figure 2—Yield per hectare of cassava in developing countries, 1961-85



Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

or less steadily, the growth in area declined beginning in the late 1970s. To analyze trends more systematically triennial averages and compound rates of growth were computed for the periods 1961-63, 1971-73, and 1983-85.

The average yearly output of cassava increased from 74.2 million tons of fresh roots in 1961-63 to 130.3 million tons in 1983-85 (that is, at an average rate of 2.6 percent a year). Over the same period, the area under the crop increased from 9.6 million to 13.7 million hectares (that is, at an average rate of 1.6 percent a year). This implies that the yield improved from 7.7 tons per hectare in the early 1960s to 9.5 tons per hectare in the mid-1980s (that is, an average growth of 0.9 percent a year). The developing countries thus increased their output of cassava 56 million tons during the two decades; of these, 29 million tons came from Asia, 22 million tons from Sub-Saharan Africa, and 5 million tons from Latin America. The largest single contribution to this increase in output came from Thailand, whose average yearly output rose dramatically from 2 million tons in the early 1960s to 19 million tons in the mid-1980s. Nearly half of the increase in area occurred in Sub-Saharan Africa, where cassava was the main staple food in some of the subregions. Since the yield per hectare was low, however, the contribution that this increase in area made to the increase in output was also low. For the developing countries as a whole, the increase in area contributed 63 percent of the growth in output, while improved yields contributed only 37 percent.

Table 10 gives the growth rate in area, production, and yield per hectare of cassava by region for the periods 1961-63 to 1971-73 and 1971-73 to 1983-85 as well as the overall growth rates between the early 1960s and the mid-1980s. For the developing countries as a whole, area and output grew more slowly during the 1970s than during the previous decade.

Table 10--Annual growth of area, production, and yield per hectare of cassava in developing countries, by region, 1983-85

Region/ Indicator	Average 1983-85	Average Annual Growth Rate 1971-73 over 1961-63	1983-85 over 1971-73	1983-85 over 1961-63
		(percent/year)		
Asia				
Area[a]	3.92	1.36	3.34	2.44
Production[b]	47.91	3.13	5.42	4.37
Yield[c]	12.22	1.74	2.01	1.89
Sub-Saharan Africa				
Area[a]	7.28	1.77	1.03	1.37
Production[b]	53.96	2.33	2.51	2.43
Yield[c]	7.42	0.55	1.46	1.04
Latin America				
Area[a]	2.55	3.47	−0.52	1.27
Production[b]	28.40	3.81	−1.60	0.82
Yield[c]	11.13	0.33	−1.08	−0.45
Developing countries				
Area[a]	13.75	2.04	1.29	1.63
Production[b]	130.27	3.02	2.23	2.59
Yield[c]	9.48	0.96	0.93	0.94

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.
[a]Million hectares.
[b]Million metric tons.
[c]Tons per hectare.

Since cassava exports from developing countries, particularly Thailand, rose very rapidly between 1961-63 and 1983-85, their total domestic use of cassava, which grew 2.3 percent a year, rose more slowly than their production (see Table 11). In the second period, domestic use reflected the slower growth in production and thus also rose more slowly. This can be attributed to trends in Latin America, where the use of cassava for food, feed, and other purposes declined in absolute terms.

The overall use of cassava for food in the developing world rose 2.3 percent a year: 2.6 percent in the first period and 2.0 percent in the second period. In all three regions, the use of cassava for feed grew faster than its use for food, over the entire period.

Of the increase of 37.3 million tons in the total domestic use of cassava between the early 1960s and the mid-1980s, 60 percent was from Sub-Saharan Africa, 28 percent from Asia, and 12 percent from Latin America. Again, the bulk of the increase was in food use (80 percent; see Table 12).

The factors influencing the growth, or the absence of growth, in production and use of cassava in different regions and subregions are discussed below.

Asia

In Asia, growth in the area devoted to cassava accounted for nearly 56 percent of the growth in cassava production between the early 1960s and mid-1980s. The area under cassava

Table 11—Trends in the domestic use of cassava in developing countries, by region, 1961-85

Region/ Use	Average Use, 1983-85[a]	Average Annual Growth Rate 1971-73 over 1961-63	1983-85 over 1971-73	1983-85 over 1961-63
	(million metric tons)		(percent/year)	
Asia				
Food	22.16	2.83	3.06	2.96
Feed	1.45	3.37	4.97	4.24
Other	3.32	−1.73	−0.39	−1.00
Total availability	26.92	1.86	2.63	2.28
Sub-Saharan Africa				
Food	43.34	2.07	2.69	2.40
Feed	1.14	10.62	−2.33	3.36
Other	9.27	2.77	2.64	2.70
Total availability	53.75	2.40	2.53	2.47
Latin America				
Food	12.20	3.74	−1.47	0.86
Feed	9.97	3.81	−1.33	0.97
Other	6.01	3.96	−2.44	0.42
Total availability	28.18	3.82	−1.64	0.80
Total				
Food	77.69	2.63	1.96	2.27
Feed	12.56	4.32	−0.92	1.43
Other	18.60	2.18	0.04	1.19
Total availability	108.85	2.77	1.29	1.96

Sources: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1984," FAO, Rome, 1986; and Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," FAO, Rome, 1978 (computer printout).

Notes: Parts may not add to the total due to rounding. The domestic use of 609,000 metric tons of cassava in noncassava-producing countries is excluded.

[a]In fresh root equivalents.

Table 12—Total domestic use of cassava, by region and type of use, 1961-63 and 1983-85

Region/Use	1961-63	1983-85	Increase
		(million metric tons)	
Region			
Asia	16.4	26.9	10.5
Sub-Saharan Africa	31.4	53.8	22.4
Latin America	23.6	28.2	4.6
Use			
Food	47.5	77.7	30.2
Feed	9.2	12.6	3.4
Other	14.8	18.6	3.8
Total	71.4	108.9	37.5

Sources: Food and Agriculture Organization of the United Nations, "Agricultural Supply/Utilization Accounts Tape, 1984," FAO, Rome, 1986; and Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," FAO, Rome, 1978 (computer printout).

Note: Parts may not add to the total because of rounding.

rose two-and-a-half times faster in the 1970s than in the 1960s, largely because of the rapid increase in Thailand's production. Output expanded at 5.4 percent a year in the 1970s, which was nearly 75 percent higher than the growth rate in the 1960s. In India, yields expanded rapidly in the 1960s as a result of the introduction of new varieties. The Philippines reported increased yields in the 1970s following a decline in the 1960s. The causes that led Thailand to expand rapidly the area devoted to and the output of cassava are well known. With the introduction of the Common Agricultural Policy in the European Community, the favorable tariff binding given cassava in the 1968 General Agreement on Tariffs and Trade (GATT) negotiations, and the high relative price of maize, the EC countries rapidly increased their demand for cassava to be used as cattle feed. Thailand responded to this demand by increasing the area devoted to and the production of cassava and by exporting dried chips in the mid-1960s, native pellets toward the end of the 1960s, and hard pellets in the early 1980s. Other conditions also encouraged the expansion of cassava cultivation in Thailand. These include the country's need to develop its Northeast region, which is poverty stricken, the availability of infrastructure such as roads and the readiness of traders to take advantage of the demand for exports. Subsequently, however, the government of Thailand entered into a voluntary agreement with the European Community and restricted its exports to a sliding scale of fixed quotas. This limited further expansion of cassava output. In Indonesia, the output of cassava expanded relatively rapidly in the 1970s, mainly as a result of rising yields, although the area under cassava declined slightly.

FAO estimates that China increased its output of cassava from 1.2 million tons in the early 1960s to 3.8 million tons in the early 1980s. Average yields rose from 11.7 tons to 15.5 tons per hectare over the same period. Cassava production in Indochina and the Pacific Islands also increased, mainly as a result of an increase in area.

Domestic use of cassava for food and feed rose rapidly in Asia, particularly in the 1970s. In the subregion of South Asia, the use of cassava for food rose from 1.9 million tons in 1961-63 to 5.8 million tons in 1971-73, largely as a result of increased production and consumption in India. Although the level remained unchanged in 1983-85, the overall growth in the use for food remained large: 5.2 percent a year for the entire period. In China, food use also grew rapidly (6.7 percent a year) between the early 1960s and 1970s, but the growth declined to 0.7 percent a year during the second period. In ASEAN countries, excluding Thailand, on the other hand, the growth in the use of cassava for food was more rapid in the second period, 1971-73 to 1983-85, than in the first, which experienced a decline of 1 percent a year. The domestic use of cassava as food in Thailand was very small: 640,000 tons in the mid-1980s.

In Asia the use of cassava for feed rose from 580,000 tons in 1961-63 to 1.45 million tons in 1983-85 (that is, at an annual rate of 4.2 percent). China, which accounted for nearly 50 percent of the use for feed in Asia exhibited a rapid growth of 6.3 percent a year in 1983-85. South Asia does not use cassava for feed, which once again highlights weaknesses in the data.

Sub-Saharan Africa

In Sub-Saharan Africa, the area under cassava rose more slowly in 1983-85 than in 1961-63. Nevertheless, yields increased much faster in the 1980s, and so did production. As in Asia, the growth in area devoted to cassava contributed 56 percent of the growth in output from 1961-63 to 1983-85. Within Sub-Saharan Africa's subregions, output increased in the humid lowlands and the coastal tropics as well as in the equatorial wet tropics at about 2.2 percent a year. In the former subregion, Nigeria was the principal country influencing the growth rate. In the equatorial wet tropics, the output of cassava in Zaire rose 70 percent, from 8.9 million tons in 1961-63 to 15.0 million tons in 1983-85. Most of this increase in production was the result of an increase in the area devoted to cassava. Yields remained between 6.5 and 7.0 tons per hectare during the two decades. In the modified tropics, Tanzania and Uganda were the principal cassava-growing countries. In Uganda, production of cassava trebled from 1.1 million tons to 3.3 million tons, largely as the yield per hectare grew. In Tanzania, the area under cassava reportedly declined between 1961-63 and 1983-85, even though the yield per hectare in 1983-85 (12.2 tons) was nearly two-and-a-half times the yield in 1961-63. It is not clear to what extent these differences are due to problems in reporting the data. In Rwanda, cassava output increased nearly three times, reaching 435,000 tons over the two decades; increases in both area and yield contributed to this increase in output. In the semi-arid tropics, the output of cassava in Chad rose from 39,000 tons in the early 1960s to 273,000 tons in the early 1980s, whereas in Senegal, it declined from 152,000 tons to 15,000 tons over the same period. The need for reliable data is acute if researchers are to draw valid conclusions on trends in area and production.

In Sub-Saharan Africa, the domestic use of cassava for food rose 2.4 percent a year. Since this is less than the rate of population growth, per capita consumption declined. Further, the rapid growth in the use of cassava for feed in the 1960s (over 10 percent a year) is apparently due to a statistical discrepancy. In the modified tropics subregion, for example, the use of cassava for feed, which was reported at 15,000 tons in the early 1960s, increased to 870,000 tons in the early 1970s, but declined to 311,000 tons in the mid-1980s. This re-emphasizes the difficulty in analyzing trends using a poor data base.

Latin America

In Latin America, area, production, and yield per hectare of cassava declined during the period 1971-73 to 1983-85 following a period of rapid growth in both area and production during the 1960s. In Brazil, the area under cassava increased from 1.5 million hectares in the early 1960s to 2.0 million hectares in the early 1970s and remained more or less stagnant in the early 1980s. The yield per hectare increased marginally to 13.9 tons by 1971-73, but declined to 11.6 tons in the next decade. Consequently, output, which reached 28.9 million tons during 1971-73, declined to 22.1 million tons during the 1980s. The reason for this decline was the decrease both in the relative profitability and in the overall demand for cassava. Moreover, the area under cassava was, in relatively productive areas, diverted to other crops.

In the seasonally dry tropics, the output of cassava increased at an annual rate of 2 percent a year over the reference period, because both yield and area under cassava expanded. In the subtropics it increased much faster, at 3.8 percent, mostly because the area under cassava expanded. Within Latin America, yields were high in Paraguay at nearly 14.7 tons per hectare in 1983-85. Mexico reported average yields of 20.0 tons per hectare in the early 1960s and 1970s, which declined to 17.6 tons in 1983-85. Meanwhile, the area under cassava in Mexico increased from 1,500 to 2,500 hectares over the two decades.

The domestic use of cassava in Latin America rose at 3.8 percent a year between the early 1960s and early 1970s with individual components increasing between 3.7 and 4.0 percent. Over the second period, the domestic use declined overall, and the growth rate even turned negative. From 1961-63 to 1983-85, the overall growth in domestic use was only 0.8 percent a year.

The decline in the area, output, and domestic use of cassava in Brazil can be attributed largely to the government, which began to subsidize the producers and consumers of wheat. The result of this intervention was that wheat cost less than *farinha*, the form in which cassava is consumed in Brazil. Consequently, per capita consumption of *farinha* decreased from 26.3 kilograms in 1960 to 12.0 kilograms in 1980, while wheat consumption rose from 26.2 kilograms to 45.5 kilograms (Lynam 1989). In Latin America's seasonally dry tropics and wet tropics, the domestic use of cassava for food, feed, and other purposes declined in both periods. These trends influenced the overall decline in Latin America's total domestic use of cassava between the early 1970s and the mid-1980s.

NET TRADE

As mentioned earlier, the average annual net exports of cassava from developing countries were on the order of 19.2 million tons during 1983-85, and total exports were 20.0 million tons. Of these, Thailand alone exported 17.2 million tons. The two other major exporters were China (1.3 million tons) and Indonesia (1.4 million tons), which, like Thailand, exported dried cassava for livestock feed. Malaysia also exported 24,000 tons. Latin America exported 48,000 tons, and

Sub-Saharan Africa exported 32,000 tons in fresh root equivalents.

The exports from Thailand in the 1960s consisted mainly of cassava flour, with smaller amounts of tapioca granules and starch (sago), dried cassava chips, and cassava meal. Since the early 1970s, cassava pellets have gained importance as a form of cassava exports. They comprise 86 percent of total exports in 1984 (see Table 13). Moreover, the foreign exchange earned from cassava exports contributes 16.3 percent of Thailand's total agricultural exports, or 10.7 percent of its overall earnings from exports. Like Thailand, Indonesia has a quota for exports in the European Community, but it was unable to meet it fully for want of infrastructure facilities. Thailand thus has a comparative advantage over Indonesia.

The developing countries studied imported an average of 172,000 tons of cassava a year during the reference period. Indonesia (85,000 tons), Singapore (65,000 tons), and Malaysia (16,000 tons) received the bulk of these imports. In addition, countries such as the Republic of Korea (587,000 tons) and Hong Kong (61,000 tons) that do not produce cassava imported cassava from other developing countries. Developed countries imported net average of 21.4 million tons of cassava. The difference between the net exports of developing countries and the net imports of developed countries is attributed to a statistical discrepancy. Of the developed countries, the principal importers are the Netherlands (7.8 million tons), the Federal Republic of Germany (6.3 million tons), and Belgium and Luxembourg (3.0 million tons). France imported less than 1.0 million tons. Japan, which imported less than 1.0 million tons in 1983-85, imported 2.0 million tons in 1985. It therefore imported an average of 0.9 million tons for the period 1983-85 (see Table 14).

Table 13—Thailand's exports of cassava by type of product and use, 1960-84

	Animal Feed				Food and Industrial Uses	
Year	Chips	Pellets	Meal	Total in Fresh Root Equivalents[a]	Flour[b]	Total in Fresh Root Equivalents[a]
				(1,000 metric tons)		
1960	3	...	25	120	242	1,089
1965	401	...	98	1,444	221	995
1970	8	1,164	6	3,015	149	671
1975	71	2,169	1	5,713	145	653
1980	159	4,811	...	12,666	247	1,112
1984	138	5,975	2	15,590	455	2,048

Source: Chaiwat Konjing, *Trends and Prospects for Cassava in Thailand*, Cassava Working Paper 6 (Washington, D.C.: International Food Policy Research Institute, 1989).
... Negligible.
[a]The conversion factors for fresh root equivalents are 4.5:1.0 for roots to flour; 2.5:1.0 for roots to chips; 2.5:1.0 for roots to pellets.
[b]Includes tapioca.

Table 14—Net imports of cassava into developed countries, 1983-85

Country	Net Imports
	(million metric tons)
Netherlands	7.79
Germany, Federal Republic of	6.32
Belgium-Luxembourg	2.99
France	0.99
Japan	0.93
United Kingdom	0.63
Portugal	0.46
Italy	0.38
U.S.S.R.	0.28
Ireland	0.14
United States	0.13
Switzerland	0.09
Others	0.25
Total	21.37

Source: Food and Agriculture Organization of the United Nations, "FAO Standardized Commodity Balances for Cassava," FAO, Rome, 1987 (computer printout).

Notes: Net imports are in fresh root equivalents. Exports were subtracted from imports.

SUMMARY

The foregoing review of the trends in production and use of cassava showed that at the aggregate level for the developing countries as a whole, the rate of growth in area and production of cassava declined during the early 1970s to the early mid-1980s, compared with the early 1960s to the early 1970s. The behavior of total domestic use was similar, but the trends at the regional level were not.

In Asia, area, production, and yield per hectare rose rapidly in the early 1970s to mid-1980s: the growth in area and production was driven by developments in Thailand, and the growth in yield was driven by events in India. In Sub-Saharan Africa, yields in the second period rose faster than in the first period, and, despite a decline in area, overall production rose at a marginally higher rate. In Latin America, however, area, production, and yield actually declined in the second period, largely because of the developments in Brazil. For all the countries as a whole, area and production grew between 1971-73 and 1983-85 at a slower pace than between 1961-63 and 1971-73. The rate of growth in yield also declined marginally in the second period.

The domestic use of cassava increased at a slower rate than did production (2.0 percent and 2.6 percent, respectively) because Thailand exports most of its output. Also, total domestic use grew slower in the second than in the first period, largely because of trends in Latin America, which partly compensated for the growth in Asia and Sub-Saharan Africa. In Asia, food use increased at about 3 percent a year, which is higher than population growth, whereas the reverse was true in Sub-Saharan Africa (2.4 percent) and Latin America (0.9 percent). The rate of growth in the use of cassava for food was negative in Latin America in the second period; in the other two regions, it was positive and higher in the second period than in the first. The use of cassava for feed, at 5 percent a year, rose faster in Asia than its use for food, whereas in Sub-Saharan Africa and Latin America its use for feed declined in the second period.

4

Factors Influencing the Use of Cassava

USE FOR FOOD

As shown in Chapter 3, the use of cassava for food represents the largest share of its domestic use. Apart from growth in population, other factors influence the demand for cassava for food: degree of urbanization, level of income, the relative price of cassava and of alternative foods, historical food habits, consumption by producers, storability, ease of processing, and the form in which cassava is produced.

The income elasticity of the demand for fresh cassava and *gaplek* in Indonesia was studied by Dixon (1984) using the data from the Susenas V Survey, which was conducted in 1976. The per capita level of consumption and the expenditure elasticity for cassava found by that study are presented in Tables 15 and 16.

Table 15—Per capita consumption of cassava, by expenditure group and location, Java, Indonesia, 1976

Form of Cassava Consumed/Location	Expenditure Group			Weighted Average
	Low	Medium	High	
		(kilograms)		
Fresh cassava				
Rural	21.9	29.3	24.8	25.0
Urban	7.4	7.2	5.3	7.0
Gaplek				
Rural	27.2	23.8	5.8	24.0
Urban	n.e.	n.e.	n.e.	n.e.
Starch				
Rural	7.3	14.2	30.5	12.0
Urban	2.5	5.0	11.9	5.0
Total				
Rural	56.4	67.3	61.1	61.0
Urban	9.9	12.2	17.2	12.0

Source: Adapted from John A. Dixon, "Consumption," in *The Cassava Economy of Java*, ed. Walter P. Falcon (Stanford, Calif., U.S.A.: Stanford University Press, 1984).
n.e. Not estimated because consumption was insignificant.

Table 16—Expenditure elasticity of the demand for cassava, by expenditure group and location, Java, Indonesia, 1976

Form of Cassava Consumed/Location	Expenditure Group Low	Medium	High	Weighted Average
Fresh cassava				
Rural	0.74	0.13	-0.57	0.29
Urban	0.11	-0.18	-0.53	-0.18
Gaplek				
Rura	10.57	-0.97	-2.75	-0.58
Urban	n.e.	n.e.	n.e.	n.e.
All cassava[a]				
Rural	0.69	-0.07	0.01	
Urban	0.33	0.33	0.53	

Source: Adapted from John A. Dixon, "Consumption," in *The Cassava Economy of Java*, ed. Walter P. Falcon (Stanford, Calif., U.S.A.: Stanford University Press, 1984).
n.e. Not estimated because consumption was insignificant.
[a]Includes cassava starch, whose expenditure elasticity is assumed to be +1.0 for all income groups.

In rural areas, the elasticity of fresh cassava was positive and high (0.74) in the low-income group, and per capita consumption increased as the income level increased from low to medium. The level of consumption declined, however, as income moved from medium to high, and the elasticity became negative. The overall weighted average elasticity (0.29) was low, but positive. In urban areas, the overall elasticity for fresh cassava was small and negative (−0.18). For the low-income group, elasticity was positive, but declined rapidly as income increased. For *gaplek*, or dried cassava, the elasticity in the middle- and high-income groups was negative in rural areas as was the overall elasticity for all income groups. The consumption of *gaplek* in urban areas was insignificant, and hence no elasticities were given. Table 16 also presents expenditure elasticity for all cassava, including cassava starch. In rural areas, the expenditure elasticity remained high for the low-income group, and became negative for the medium-income group. For the high-income group it was small, but positive. In urban areas, the expenditure elasticity was 0.33 for both low and middle income groups. For the high-income groups in the rural and urban areas the elasticities increased, which reflects the increased consumption of processed forms of cassava (particularly starch).

George (1988) estimated expenditure elasticities for cassava in rural and urban areas of Kerala State in India using data from three rounds of the National Sample Survey (see Table 17). All three surveys found positive and high income elasticities in both rural and urban areas for the lowest expenditure groups. As incomes rose, the elasticities declined and became negative for the urban areas in the eighth or the ninth expenditure group and for rural areas in the highest expenditure group. The overall elasticities for urban areas were negative, but they were low and positive for rural areas (George 1988). Even in low-income groups, the elasticities seem to be lower in 1983 than in 1970. The monthly per capita consumption of cassava in Kerala in 1977/78 is given in Table 18. The consumption in urban areas was consistently lower than in rural areas. The expenditure group that consumed the most cassava was Rs 80-100 per month in rural areas and Rs 60-70 in urban areas.

Demand elasticities for fresh cassava based on time-series data from CIAT studies in four Latin American countries also indicate fairly high and positive income elasticities in Colombia and Ecuador (see Table 19). In Paraguay,

Table 17—Expenditure elasticity of the demand for cassava, by level of income, Kerala State, India, various years, 1970-83

Income Group	1970/71 Survey		1977/78 Survey		1983 Survey	
	Rural	Urban	Rural	Urban	Rural	Urban
Lowest						
1	2.519	2.673	2.304	5.725	2.347	3.249
2	1.693	1.752	1.058	2.787	1.601	2.156
3	1.275	1.427	0.770	1.789	1.210	1.477
4	1.039	0.958	0.522	0.956	0.953	1.074
5	0.833	0.745	0.402	0.511	0.789	0.786
6	0.671	0.462	0.342	0.327	0.629	0.536
7	0.546	0.254	0.279	0.119	0.498	0.310
8	0.437	0.095	0.220	−0.076	0.377	−0.115
9	0.323	−0.072	0.177	−0.219	0.269	−0.064
10	0.209	−0.251	0.149	−0.318	0.175	−0.216
11	0.101	−0.407	0.118	−0.423	0.092	−0.358
12	0.007	−0.542	0.075	−0.568	0.036	−0.447
13	−0.124	−0.765	0.039	−0.682	−0.080	−0.628
Highest						
14	...	...	−0.001	−0.766	...	...
15	...	...	...	−0.853	...	...
Average	0.289	−0.156	0.145	−0.457	0.253	−0.086

Source: Data were collected in three rounds of the National Sample Survey. See P. S. George, *Trends and Prospects for Cassava in India*, Cassava Working Paper 1 (Washington, D.C.: International Food Policy Research Institute, 1988).
... Negligible.

Table 18—Monthly per capita consumption of cassava, by location, Kerala State, India, 1977/78

Income Level	Rural	Urban
(Rs)	(kilograms)	
0-10	1.24	0.06
10-15	3.45	1.87
15-20	3.18	1.91
20-30	4.16	2.48
30-35	4.53	3.07
35-40	5.01	3.33
40-50	5.76	2.46
50-60	6.17	2.98
60-70	5.75	3.72
70-80	5.82	2.67
80-100	7.06	2.55
100-150	5.60	2.30
150-200	4.74	1.84
200-300	...	1.29
More than 300	5.24	1.22
Total	5.55	2.59

Source: India, Department of Statistics, National Sample Survey Organization, *The National Sample Survey, Thirty-Second Round*, 1977/78 (New Delhi: Controller of Publications, 1985).
... Negligible.

where consumption levels were already high, the elasticity was negative. For Peru, the elasticity was low, but positive. Cross-sectional estimates of demand elasticity for fresh cassava support these conclusions. Analyzed by income strata, the data show that as income increased, elasticity declined, turning negative in the highest income stratum (see Table 20). Available information also indicates a similar pattern for Brazil. The consumption of cassava as fresh roots responded positively to increasing income, with the lower-income strata being particularly responsive. Demand for *farinha*, on the other hand, had a negative income elasticity in all income groups in rural areas and in all but the lowest group in urban areas of Northeast Brazil (see Table 21).

Similar information on income elasticity of demand for cassava and cassava products in Sub-Saharan Africa is hard to obtain. Adamu (1989) estimated the elasticity coefficient for Nigeria, based on the National Consumer Survey, to be 0.124 for urban areas and 0.743 for rural areas. The estimates are considered to be too high. FAO estimated Nigeria's elasticity of demand to be −0.2 overall.

Thus the overall income elasticity of demand for fresh cassava is positive and moderately large in rural areas, but small and even negative in urban areas. Fresh cassava is very income elastic for low-income rural consumers; it is negative only in the highest quintile. For dried cassava in the form of *gari*, *gaplek*, or *farinha*, the income elasticity is negative in both rural and urban areas. Starch products and convenience foods made with cassava have a positive elasticity in urban areas, particularly at higher incomes. The overall income elasticity for cassava therefore depends on the proportions in which different cassava products are consumed in rural and urban areas.

Table 19—Time-series estimate of the demand elasticity for fresh cassava, Latin America, 1965-84

Indicator	Colombia	Ecuador	Paraguay	Peru
Own price of cassava	−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
Price of wheat	n.a.	0.45	0.07	0.11
Price of rice	n.a.	2.42	...	−0.64

Source: CIAT estimates published in John K. Lynam "The Evaluation of Cassava Consumption in Latin America," in *Summary Proceedings of a Workshop on Trends and Prospects of Cassava in the Third World*, ed. J. S. Sarma (Washington, D.C.: International Food Policy Research Institute, 1989).
Note: n.a. is not available.

Table 20—Cross-sectional estimate of the demand elasticity for fresh cassava, by income level, Colombia, 1981

Income Quintile	Price	Income
Low		
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
High		

Source: Luis Sanint, "Colombia: Potential Demand for Cassava" (CIAT, Cali, Colombia, 1986, mimeographed).

Table 21—Income and price elasticities for *farinha*, Northeast Brazil

Income Group	Income Elasticity		Price Elasticity	
	Rural	Urban	Rural	Urban
Low				
1	-0.03	...	-0.53	-0.67
2	-0.19	-0.18	-0.49	-0.65
3	-0.35	-0.37	-0.45	-0.62
4	-0.57	-0.61	-0.39	-0.58
5	-0.68	-0.73	-0.37	-0.56
High				

Source: John K. Lynam "The Evaluation of Cassava Consumption in Latin America," in *Summary Proceedings of a Workshop on Trends and Prospects of Cassava in the Third World*, ed. J. S. Sarma (Washington, D.C.: International Food Policy Research Institute, 1989).
... Negligible.

Dixon (1982) analyzed data on food consumption in Java, Indonesia, and found a negative price elasticity (−0.81 for fresh cassava and −1.86 for *gaplek*) in rural areas and a positive but small elasticity (0.44 for fresh cassava) in urban areas (see Table 22).[7] On the other hand, the price elasticity for fresh cassava in Colombia and for *farinha* in both rural and urban areas of Northeast Brazil are negative for all income groups (Tables 20 and 21). The price of cassava compared with that of substitute foods also influences its consumption. Past evidence shows that the consumption of cassava increased in the Philippines and Indonesia when the price of rice was high, and the consumption of *farinha* in Brazil declined when wheat was subsidized.

The form in which cassava is consumed is also important in determining the total demand of cassava for food. Cassava is consumed either as fresh roots or as cassava meal, either fermented or unfermented. Fresh cassava is cooked and eaten as a soup or gruel. Cassava meal is consumed in various forms, and known by different names in different regions; the methods for processing it also vary. The main drawbacks to the consumption of cassava are its toxicity and perishability. Cassava roots contain cyanogenic glycosides and prussic acid, which can, however, be reduced through processing.[8]

Cassava comes in two broad varieties, the sweet and the bitter. Bitter cassava contains the highest amount of toxic substances. Also, fresh roots of cassava are liable to deteriorate within two to three days, depending on the variety. Processing cassava into a dry product is designed to prolong its shelf life. Nevertheless, because of these two characteristics, urban demand is constrained. In addition, fresh roots are bulky because they are, on average, two-thirds water and difficult to transport. The perishability and bulkiness of cassava constrain marketing as well. The chain that links the producer, wholesale trader, and retailer must be short or much of the product will deteriorate and be lost, thus adding to the cost of marketing. Developing urban markets is different from developing rural markets.

The method of processing and the resulting end product vary with the means adopted to solve the twin problems of perishability and toxicity. The most important end products are *gaplek* in Indonesia, *gari* in Nigeria, and *farinha* in Brazil, but a large number of other cassava products are also used as food. Cassava flour is used in snacks and as an ingredient in bread. Most of the flour is processed by traditional methods, although recently some of the processing has begun to be done by machines. There is need and scope for research in postharvest technology and to develop products.

One of the issues for study relates to the location of the processing industry. Since the raw material is bulky, processing factories could perhaps be located in rural or semiurban areas near the centers of production. Processing is labor intensive, and locating processing near production facilities would create employ-

Table 22—Measured own-price elasticity of cassava, by location, Java, Indonesia, 1976

Own-Price Elasticity	Expenditure Group Low	Medium	High	Whole Sample
Fresh cassava				
Rural	−1.09	−0.82	−0.67	−0.81
Urban	1.27	0.14	...	0.44
Gaplek				
Rural	−2.49	−2.06	−2.18	−1.86
Urban	n.e.	n.e.	n.e.	n.e.

Source: John A. Dixon, *Food Consumption Patterns and Related Demand Parameters in Indonesia: A Review of Available Evidence*, Rice Policies in Southeast Asia Working Paper 6 (Washington, D.C.: International Food Policy Research Institute, 1982).
n.e. Not estimated because consumption was insignificant.

ment and income opportunities in rural areas. On the other hand, consideration of economies of scale may suggest that larger processing units be located near centers of consumption, as are other cereal processing units. Perhaps locating the preliminary processing (drying) near rural production centers and factories for manufacturing cassava products in urban areas might be a viable option (Phillips 1988). This question must be considered for each product and each area.

Studies by the Centro Internacional de Agricultura Tropical (CIAT) have revealed that because of rapid urbanization in Latin America, the locus of consumption is shifting from rural areas where per capita consumption is high to urban areas where it is relatively low. This shift in consumption may indicate a change in the preference for cassava as a vegetable crop to cassava as a starchy staple. CIAT and the United Kingdom's Overseas Development and National Resources Institute recently developed a low-cost method of fungicide spraying and polythene packing, which extends shelf life to two weeks and reduces waste 50 percent. This approach, which has been adopted in Colombia and the Caribbean, is expected to reduce the cost of marketing and increase the demand for fresh cassava.

USE FOR FEED

One of the objectives of the case studies undertaken in Asia by IFPRI's Cassava Project is to study the scope that exists for using cassava as livestock feed. These studies indicate that, although cassava may not always be a good substitute for coarse grains given the present yield and relative price of cassava, higher yields and lower unit costs could increase the scope for using cassava in feed mixes for dairy animals, poultry, and pigs. IFPRI's Food Gap Analysis suggests that as incomes rise in developing countries, the demand for livestock products is likely to rise faster than the demand for major food crops. Thus the derived demand for using cereals as livestock feed would also rise rapidly, at an annual rate of about 5 percent a year (Sarma 1986). In order to assess the future role of cassava in meeting this growing derived demand, the case studies sought specifically to ascertain the levels of yield and price at which cassava, supplemented by protein, could replace maize or sorghum in poultry and pig feed.

Evidence from India showed that the economic price of Rs 360 per ton of cassava (US$28) offers a viable price for farmers who achieve yields of at least 26 tons of fresh roots per hectare of high-yielding varieties. Such a price would enable farmers to use cassava in manufactured feed (George 1988).

In Thailand the price of cassava had to be at least 29 percent lower than the price of maize for farmers to use cassava instead of maize in broiler rations. For pig rations, the price differential had to be between 10.7 and 32.5 percent (Konjing 1988).

The general rule of thumb followed in the Philippines is that when substituting 4 kilograms of cassava with 1 kilogram of soybean meal costs less than 4 kilograms of maize, cassava can compete with maize (Cabanilla 1988).

In Jakarta, Indonesia, if soybean meal costs $335 per ton in 1983/84 prices, dried cassava (*gaplek*) must cost $57 per ton less than maize. In 1984, however, the price of cassava chips and maize was $82 and $114 per ton, respectively (Kasryno 1988). But both in the Philippines and Indonesia, economic forces are operating that could encourage the use of cassava as feed if infrastructure facilities were improved. These special marketing problems must be resolved before cassava can replace maize in livestock feed.[9]

In Sub-Saharan Africa, data are problematic, which makes getting a realistic picture of past trends, particularly in the modified tropics, and the factors influencing those trends, difficult. Even the IFPRI case studies in Nigeria and Zaire refer to the practice of feeding cassava to pigs without giving precise figures. Adamu (1989) refers to the difficulty in deriving the current feed use of cassava from the existing data on total domestic use.

Apart from its use as an ingredient in feed mixes, dried cassava is also used in on-farm feeding of livestock, a practice that prevails in several Latin American countries.[10] The advantages of on-farm use of feed is that it avoids marketing constraints. Latin America, largely Brazil, accounts for nearly 80 percent of the use of cassava for feed in the developing world. However, the use of cassava feed in this region declined from 11.7 million tons in 1971-73 to nearly 10.0 million tons in 1983-85 (in Brazil alone, use fell from 10.2 million to 7.8 million tons). This raises doubts about the scope for expanding the use of cassava unless the forces influencing the present trends are modified.

Lynam (1989b) has carefully analyzed the factors influencing the use of cassava in manufactured feed in Latin America. In Mexico, the profitability of cassava at the farm level competes favorably with that of maize; the same is true in several other countries in the region. Also, the price of dried cassava for feed factories compares favorably with that of competing grains. Over the past two decades, however, governments began to intervene heavily in feed grain markets, which affected the private profitability of cassava. After the recent debt crisis, several countries modified their foreign exchange rates and domestic pricing policies. This created an environment in which cassava can now compete with other grains in the feed ingredient market.

Lynam also notes that because of factors associated with risk and quality, the prices set in the fresh cassava markets do not match costs, and market access may be rationed. The cassava markets are also spatially fragmented, which introduces year-to-year variations in prices. These market failures can, however, be corrected through appropriate interventions. If this is done, potential for using cassava in livestock feed in the Latin American region may be considerable.

INDUSTRIAL USE

Starch is the principal industrial product manufactured from cassava, and significant quantities of cassava are used for starch in several cassava-producing countries, particularly in Asia. Cassava starch was competitive before corn (maize) starch became cheaper and its quality better as a result of technological improvements in processing. The main use of cassava in the Tamil Nadu State of India is still to manufacture starch. In the Philippines, the share of cassava starch in the total use of starch is increasing as the price ratio of cassava starch to corn starch declines (see Table 23).

The Philippine government is encouraging the manufacture of starch through special incentives. Contract farming of cassava is developing among farmers who are growing cassava to be converted into starch. In Indonesia, about 70 percent of cassava starch is used to manufacture *krupuk*, a popular snack, and the demand for this starch is expected to grow rapidly as a result of import substitution policies. In Thailand, the bulk of starch is exported. In Brazil, starch is used in the textile and paper industries.

As with the demand for cassava for food and feed, the demand for cassava for industrial use depends on the relative price of cassava and its substitutes and the quality of the product. Also the commodity characteristics of cassava that is used for food are different from those of cassava that is used industrially.

Table 23—Price of cassava and corn starch in the Philippines, 1976-81

Year	Price of Cassava Starch	Price of Corn Starch	Ratio of Cassava Price to Corn Starch Price
	(pesos/50 kilograms)		
1976	121.50	106.05	1.14
1977	113.26	112.11	1.01
1978	104.16	115.80	0.90
1979	108.16	117.37	0.92
1980	123.69	137.18	0.90
1981	142.67	162.50	0.88

Source: L. S. Cabanilla, *Trends and Prospects for Cassava in the Philippines*, Cassava Working Paper 2 (Washington, D.C.: International Food Policy Research Institute, 1988).

Cassava for food is of higher quality and commands a higher price than cassava for industrial purposes. Also, processing cassava using traditional methods reduces the quality of the product; sun-dried cassava chips, for example, can contain sand and other impurities. The quality of the raw material affects the quality of the product, and poor quality can have an adverse effect on its price and marketability.

Cassava can also be used to produce alcohol. Such use is reported mainly for Brazil, although attempts have also been made to set up pilot scale plants for manufacturing alcohol in other countries, for example, Thailand. Another possible use of cassava is to produce high-fructose syrup, but the economics of domestic compared with imported syrup still need to be worked out.

WASTAGE

The allowance for wastage is particularly high in Sub-Saharan Africa. Part of the wastage is due to traditional methods of processing. According to data quoted by Jones (1959), in the rainy season, when freshly dug roots are caked with mud, about 40 percent of the harvest weight of cassava roots is lost in preparation (Jones 1959). Even in the dry season, 25 percent is wasted, probably because of the type of kitchen utensils used. The FAO data on wastage in different countries may not be comparable because they lack a uniform definition of what constitutes wastage.

5

Potential Yields of Cassava

In 1985 the average yield of cassava in developing countries was 9.7 tons of fresh roots per hectare. The yields in Asia and Latin America were higher (about 12 tons per hectare), while those in Sub-Saharan Africa were lower (about 8 tons). The genetic potential of cassava is very high, and yields four to five times higher than the average for the developing world have been reported. To assess the potential yield of cassava in 2000, IFPRI carried out the Delphi Survey to ascertain the views of scientists who are working or have worked on cassava.[11]

The main objective was to find out if scientists thought that yield-based growth in cassava production was a major problem. A simple questionnaire was developed that sought information on the yields in 1985 (current levels at that time) and potential yields in 1990 and 2000 given different soil and climatic conditions and agronomic practices. It also asked scientists to rank 12 constraints limiting the ability of farmers to achieve the potential yields. Scientists ranked them in order of importance both for inferior soils of low fertility and for optimum soil and climatic conditions.[12]

YIELDS ON INFERIOR SOIL

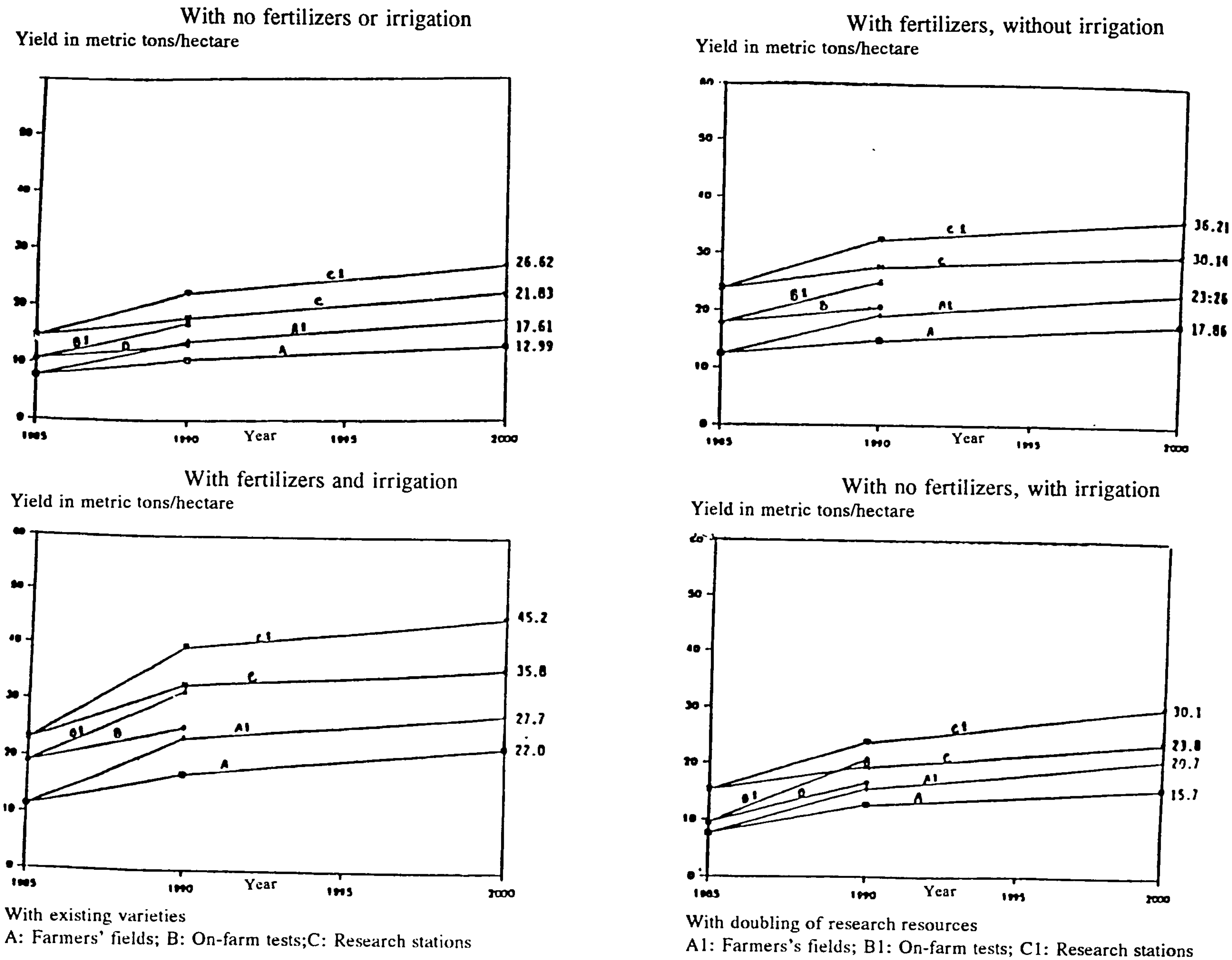
According to the 168 responses analyzed,[13] the average current (1985) yield was 9.4 tons of fresh roots per hectare; this figure compares well with the FAO estimate of 9.7 tons as the average for the developing world in 1985. By region, the average yield per hectare was 9.4 tons in Asia, 7.1 tons in Sub-Saharan Africa, and 11.2 tons in Latin America.

Fertilized soil generally yields 5 tons more per hectare than unfertilized soil. The respondents agreed that without fertilizers, irrigation will not produce higher yields. With both irrigation and fertilizers, however, average yields on inferior soil are 11.3 tons per hectare. Yields are obviously higher given optimum soil and climatic conditions. The survey also revealed large gaps between the actual yields achieved by farmers and those achieved by on-farm tests and between the latter and those achieved at research stations. The yields achieved by farmers, on-farm tests, and research stations on inferior soils are presented in Figure 3. Detailed data are given in Appendix 2, Tables 39, 40, and 41.

The varieties of cassava currently in use could, by 2000, yield between 13 tons per hectare on fields without fertilizers and irrigation and 22 tons per hectare on fields with both. With improved varieties, the corresponding range would be from 17.6 to 27.7 tons per hectare. The weighted average of the potential yield per hectare for these inputs is 16.1 tons for existing varieties and 21.1 tons for improved varieties. The current average yield is 9.4 tons per hectare. The difference between the existing and the potential yield appears to be particularly large when compared with the increase of 2 tons per hectare that actually took place in the past 25 years. During that period, however, the research resources allocated to cassava were extremely limited as was the policy attention it received.

The survey also uses analysis of variance to study the difference in yield given different inputs. At the existing level of research expenditure, significantly higher yields are expected in 2000, with increments ranging from 5 tons

Figure 3—Current and potential yields of cassava on inferior soil, by input category, 1985-2000



per hectare without fertilizers and irrigation to about 9 tons per hectare with fertilizers and irrigation. With irrigation alone, the projected increase is not significant. If the resources for research were doubled, which would enable scientists to develop new varieties and improve cultural practices, the yield would increase significantly for all inputs: the increase per hectare would range from an additional 10 tons without using fertilizers and irrigation to about 13 tons using both of these inputs. The scientists indicated that yield could be increased about 5 tons per hectare even without using fertilizers or irrigation or with using fertilizers alone. However, if irrigation was used or if both fertilizers and irrigation were used, yields are not expected to increase significantly.

The gap in potential yield between using no fertilizers or irrigation and using fertilizers alone on existing varieties and those in the pipeline given the current level of research resources is significant for 2000, but similar to the corresponding gap in 1985. Further, the difference between the potential yield of cassava grown with both fertilizer and irrigation and of cassava grown with fertilizer alone is significant and expected to be more than twice as large in the year 2000 as in 1985. If research resources were doubled, however, the differences would continue to be significant and the gaps wider. The differences resulting from using irrigation alone continue to be insignificant (see Sarma, Gandhi, and Kunchai 1988 for detailed data on the analysis of variance).

These yields are projected for the inferior soils where much of cassava is grown at present. The potential yields represent what the scientists feel could be achieved in 2000 given the application of various inputs and defined resource levels. The large gap that exists between the yields on the fields of farmers and those in on-farm tests shows that the potential is large for improving the average yield by applying inputs and using the associated agronomic practices.

YIELDS UNDER OPTIMUM SOIL AND CLIMATIC CONDITIONS

The Delphi Survey also collected information on the average yields under optimum soil and climatic conditions. According to 140 responses of the scientists surveyed, the overall current yield of cassava on farmers' fields under optimum soil and climatic conditions was 14.4 tons per hectare. In general, cassava is only grown on inferior soils; the exceptions are areas like Tamil Nadu in India, where the crop is grown under favorable conditions. Similar, presumably very small, areas exist in Latin America and Sub-Saharan Africa, although their exact extent is unknown. The Delphi Survey indicates the likely yield on these soils. The average yield per hectare of cassava grown on optimum soils is 17.6 tons in Latin America, 13.1 tons in Asia, and 12.6 tons in Sub-Saharan Africa. Without fertilizers or irrigation, the yield of 12.3 tons per hectare was about two-thirds of that with fertilizers. As with inferior soils, the gap existing between the yield achieved on farmers' fields, in on-farm trials, and in research stations was large. The main results are presented in Figure 4.

The existing varieties of cassava grown on optimum soils could yield an average of 23.7 tons per hectare in 2000, ranging from 19.3 tons without fertilizers and irrigation to 32.1 tons with both. Farmers' fields without irrigation but with fertilizers yielded 25.5 tons per hectare, about 6.2 tons higher than on fields with neither fertilizers nor irrigation.

Doubling the resources devoted to research could produce improved varieties and increase the average yield on farmers' fields to 29.5 tons per hectare. Farmers in Tamil Nadu State in India already produce such yields. By using irrigation and fertilizers, farmers could increase their average yield to 37.6 tons per hectare, almost one-and-a-half times higher than the yield on fields without irrigation and fertilizers.

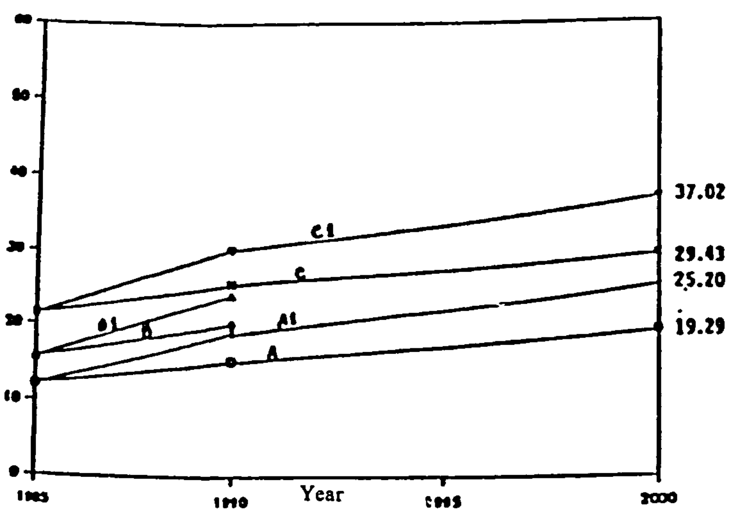
CONSTRAINTS ON YIELD

Of the 12 constraints on achieving the potential yield of cassava,[14] lack of incentives was identified as the most important. The low potential yield of existing varieties was ranked next in importance, followed by problems with marketing the output and with storage and processing. Diseases ranked fifth. Regional differences exist, however, and affect how constraints were ranked. In Asia and Latin America, constraints were ranked according to the overall pattern; in Sub-Saharan Africa, however, diseases were ranked first in

Figure 4--Current and potential yields of cassava on optimum soil, by input category, 1985-2000

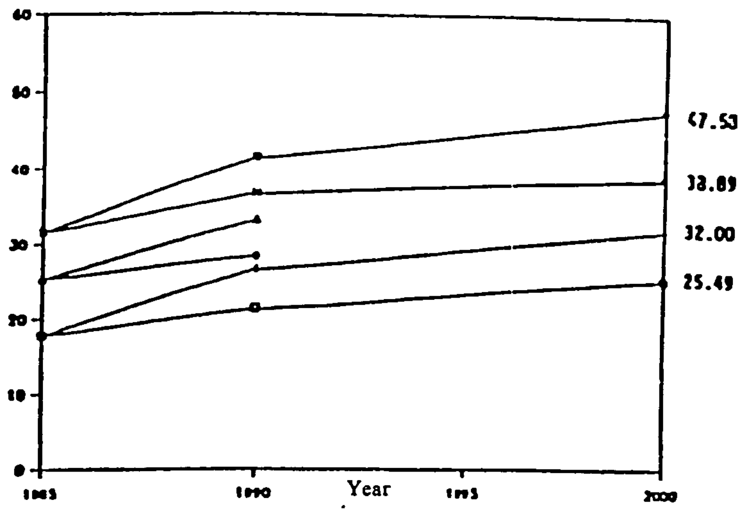
With no fertilizers or irrigation

Yield in metric tons/hectare



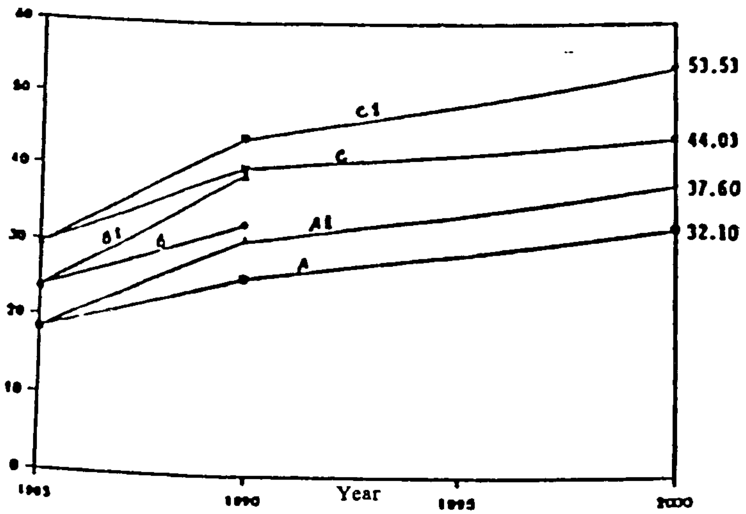
With fertilizers, without irrigation

Yield in metric tons/hectare



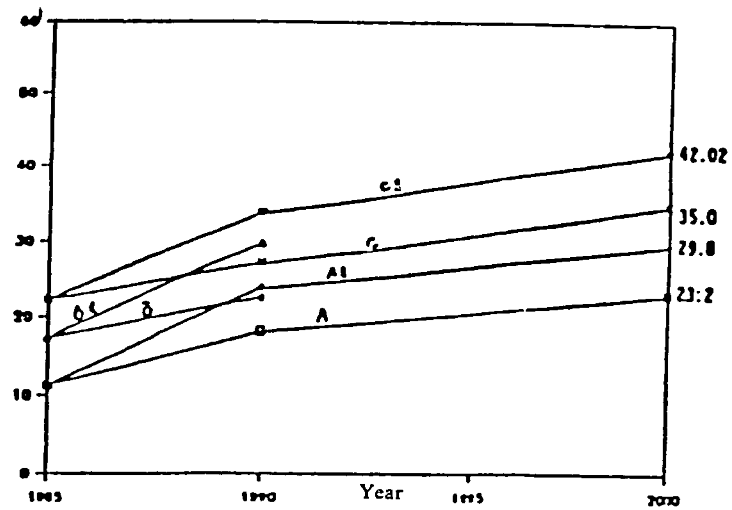
With fertilizers and irrigation

Yield in metric tons/hectare



With no fertilizers, with irrigation

Yield in metric tons/hectare



With existing varieties

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

With doubling of research resources

A1: Farmers's fields; B1: On-farm tests; C1: Research stations importance, followed by the low potential yield of existing varieties and the lack of incentives. This is as it should be. Economic and other incentives are more important in Asia and Latin America because degree of commercialization is greater in these regions than in Sub-Saharan Africa. On the other hand, diseases are a major constraint in Sub-Saharan Africa, which therefore emphasizes the need to evolve disease-resistant varieties of cassava. The Delphi Survey thus produced valuable insights into both the potential yields given various combinations of inputs and into the constraints that prevent farmers from achieving the full potential.

Cassava mosaic virus, bacterial blight, mealybugs, and green spider mites are the most important diseases and pests affecting cassava production in Sub-Saharan Africa. Cassava mosaic virus reduces yields throughout Africa, and the International Institute of Tropical Agriculture (IITA) has bred several improved varieties that are resistant to mosaic. The bacterial blight, which is common across the humid and subhumid regions of Africa, can be even more damaging than the mosaic virus. Resistance to this disease is also routinely incorporated in IITA's improved varieties. Cassava mealybugs were first reported in Sub-Saharan Africa (Zaire) in the early 1970s and rapidly spread to other parts of Central Africa. This pest can damage up to 75 percent of the total crop during severe attacks and is found in all major cassava-growing areas of Sub-Saharan Africa except Kenya, Seychelles, Madagascar, Tanzania, and Mozambique. It can be controlled by the Biological Control Program being developed by IITA. The green spider mite was also introduced to Africa in 197? and has since spread from Uganda to the entire cassava belt. It is more widespread than the mealybug, but less damaging, causing a 30 percent loss in yield (Dorosh 1987). The widespread adoption of disease-resistant varieties and implementation of integrated pest management programs are basic to improving cassava yields in Sub-Saharan Africa in the future.

POTENTIAL YIELDS AND PROFITABILITY OF CASSAVA

The case studies undertaken in Asia examined the scope for increasing cassava yields by adopting improved high-yielding varieties (HYV) and agronomic practices that would reduce the unit cost of production. The intention was to determine whether cassava could be substituted for coarse grains in livestock feed. For this purpose information was collected from secondary studies on cassava yields achieved on farmers' fields, in on-farm trials, and at research stations. Analysis of this information confirmed that by adopting HYVs and improved agronomic practices, farmers could increase their yields. Moreover, by adopting favorable policies, the government could reduce the unit cost of producing cassava and increase the net returns per hectare.

In India, HYVs of cassava have been evolved by the Central Tuber Crops Research Institute (CTCRI) and the agricultural universities of Kerala and Tamil Nadu. The CTCRI launched a Lab-to-Land program to encourage farmers to adopt its research findings. Information on the comparative yield of these HYVs and of local varieties indicated that during 1984/85 cassava farmers realized an average yield per hectare of about 26.3 tons for HYVs and 14.3 tons for local varieties. The CTCRI achieved yields of 30 tons per hectare from their HYVs. Net returns were Rs 5,110 per hectare from HYVs and Rs 2,839 per hectare from local varieties (see Table 24). In India, cassava is grown in areas where it has a comparative advantage because its agroclimatic requirements are less demanding. It does not, except in some dry areas, normally compete with food or feed crops for land, although it does compete with them on the demand side. P. S. George (1988) reports that the cost of producing HYVs makes them competitive with other raw materials used to manufacture starch and cattle feed. At low competitive rates, these varieties offer enough incentive for farmers to improve their cultivation practices and increase their yields.

In Indonesia, recently developed varieties of cassava give yields that are 30-40 percent higher than those of the older HYVs and 50-60 percent higher than those of local traditional cultivars. The new varieties had, however, not been released at the time of the study. Farmers can also increase their yield by using fertilizers. Without fertilizers, farmers' fields yielded, on average, 7.1 tons per hectare; with fertilizers, they yielded 12.0 tons. Yields in Indonesia

Table 24—Costs of production and returns, by variety of cassava, India, 1984/85

Input/Indicator	Local Varieties	High-Yielding Varieties	High-Yielding Varieties on CTCRI Farms[a]
		(Rupees/hectare)	
Input			
Planting materials	250	250	250
Labor	3,061	3,599	4,490
Farmyard manure	1,057	1,144	1,250
Fertilizers	249	1,240	1,425
Total	4,617	6,233	7,415
Indicator			
Yield (metric tons/hectare)	14.30	26.28	30.00
Gross return	7,456	11,343	13,500
Cost (Rs/kilogram)	0.32	0.24	0.25
Net return	2,839	5,110	6,085

Sources: Central Tuber Crops Research Institute, *Summary Report: Lab to Land Phase I* (Trivandrum: Central Tuber Crops Research Institute, 1987), taken from P.S. George, *Trends and Prospects for Cassava in India*, Cassava Working Paper 1 (Washington, D.C.: International Food Policy Research Institute, 1988).
[a]CTCRI is the Central Tuber Crops Research Institute.

also vary by region. Varieties in East Java yield 19.0 tons per hectare at research stations, which is 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 yields between 12.0 tons and 23.5 tons per hectare. Comparing the expected returns from traditional and improved agronomic practices shows that both yields and profitability could be increased substantially in East Java and in Lampung. In fact, the cost of producing cassava could be reduced almost 50 percent. Although variable costs would increase with improved technology, net income per hectare would be nearly six times higher than it would be with traditional methods of cultivation (Kasryno 1988; see Table 25).

In the Philippines, farm trials conducted by the Philippine Root Crops Research and Training Center of the Visayas College of Agriculture also showed the benefits that could be achieved by applying fertilizer to cassava. In these trials, villages that used fertilizer produced between 6.8 tons and 10.1 tons per hectare more than those that did not. In a fourth village, which had alluvial soil, the difference was 3.4 tons per hectare. In general, researchers felt that an additional 7 tons per hectare could be achieved by using fertilizers (see Table 26). However, farmers were not keen to apply fertilizers because of their high cost. Recently, however, the government of the Philippines liberalized its trade policies governing fertilizers, and prices have begun to decline. Using fertilizers reduced the cost per unit of output substantially, from 1,026 pesos to 433 pesos, and increased net income correspondingly (Cabanilla 1988).

In Thailand, national tests showed that the use of fertilizers raised yields per hectare from 10.6 tons to 15.6 tons, but increased production costs per hectare from 5,625 baht to 6,165 baht. The cost per ton of cassava produced declined, however, by 26 percent, and net returns increased correspondingly. The benefits of using fertilizers were even more pronounced under optimum soil and climatic conditions. The time-series and cross-sectional data available from farmers' fields and on-farm trials showed that yields increased considerably when fertilizers were applied: 3.5 tons in farmers' fields to 12.0 tons in on-farm trials (see Table 27).

Information from the early 1970s on the cost of production, output, and net returns per hectare of cassava were reported in the Cassava

Table 25—Cost analysis of production of cassava, by pattern, East Java and Lampung provinces, Indonesia, 1983-84

Indicator	Farmer's Pattern		Recommended Pattern	
	East Java	Lampung	East Java	Lampung
Total value of crop/ hectare (1,000 rupiah)	204.0	188.0	566.0	448.0
Total cost/hectare (1,000 rupiah)	142.2	140.9	207.3	184.6
Net income/hectare (1,000 rupiah)	61.8	47.1	358.7	263.4
Cost of production (rupiah/kilogram)	13.9	15.0	7.3	8.2
Yield (tons/hectare)	10.2	9.4	28.3	2.4

Source: Faisal Kasryno, *Trends and Prospects for Cassava in Indonesia*, Cassava Working Paper 3 (Washington, D.C.: International Food Policy Research Institute, 1988).

Table 26—Yields of cassava produced in farm trials, by type of fertilizer applied, in four villages, Baybay, Leyte, Philippines, 1985-86

Fertlizer Applied	Ordinary Soil			Alluvial Soil,
	Cartagnos	Kabalasan	Maganhan	Igang
(kilograms of NPK)		(kilograms/hectare)		
0-0-0	5,667	4,891	8,996	20,827
60-30-30	23,250	...	...	...
30-15-15	16,083	...	...	...
60-0-0	...	13,966	...	...
120-0-0	...	15,538	...	...
17.5-17.5-17.5	...	18,317	...	...
35-35-35	...	20,050	...	...
25-25-25	...	...	...	21,733
50-50-50	...	...	...	26,765
Yield difference[a] (tons/hectare)	6.760	7.269	10.187	3.422

Source: Philippine Rootcrop Research and Training Center, Visayas College of Agriculture, unpublished data taken from L. S. Cabanilla, *Trends and Prospects for Cassava in the Philippines*, Cassava Working Paper 2 (Washington, D.C.: International Food Policy Research Institute, 1988).

... Negligible.

[a]Difference between the average yield with fertilizers and without them.

Table 27—Costs and returns of cassava produced with and without fertilizers, by type of soil and location, Thailand, 1985

Type of Soil/ Category	Yield	Output Value	Production Cost Per Hectare	Production Cost Per Ton	Net Profit
	(metric tons/ hectare)	(bahts)	(bahts/ hectare)	(bahts/ metric ton)	(bahts/ hectare)
Inferior soil					
National average					
Without fertilizer	10.6	6,148	5,625	530.6	523
With fertilizer	15.6	9.048	6,165	395.2	2,883
Field survey					
Without fertilizer	10.2	7,038	4,459	437.2	2,579
With fertilizer	13.7	9,453	4,069	297.0	5,384
On-farm tests (average)					
Without fertilizer	9.7	6,693	6,780	699.0	87
With fertilizer	15.8	10,902	9,578	606.2	1,324
Optimum soil					
National average					
Without fertilizer	15.6	9,048	5,625	360.6	3,423
With fertilizer	23.1	13,398	6,165	266.9	7,233
Field survey					
Without fertilizer	14.8	10,212	6,450	435.8	3,672
With fertilizer	18.3	12,627	6,057	331.0	6,570
On-farm tests (average)					
Without fertilizer	19.2	13,248	6,252	326.5	6,996
With fertilizer	31.2	21,528	9,220	295.5	12,308

Source: The national averages and the data from the on-farm tests are from Thailand, Ministry of Agriculture and Cooperatives, Department of Agriculture, unpublished data; the field survey data are from Kasetsart University, *Field Survey of Cassava-based Feed Pilot Project Area* (Bangkok, 1986), taken from Chaiwat Konjing, *Trends and Prospects for Cassava in Thailand*, Cassava Working Paper 6 (Washington, D.C.: International Food Policy Research Institute, 1989).

Case Study in Nigeria, which shows that adopting better practices doubled the net returns per hectare from those realized using traditional practices. Improved practices assume that 313.8 kilograms of fertilizers (NPK 10:10:20) are applied (see Table 28).

In the case study of cassava in Zaire, Tshibaka and Lumpungu (1989) reported that cassava and plantain are potentially more profitable than rice or maize. The net benefit from cassava is 26,000 Zaire per hectare, and both cassava and plantain have high benefit-to-cost ratios (see Table 29).

In the parts of Asia and Latin America where the cassava economy is commercialized, the economics of cultivating cassava compares favorably with that of other crops. But commercialization is constrained by low income elasticities of demand for purchased cassava as food. Moreover, a variety of other constraints, such as processing, marketing, and relative prices affect other uses of cassava. These need to be overcome before the production of cassava can be developed further.

Table 28—Cost of production, output, and net returns per hectare of cassava, by type of practice, Nigeria, 1972

Indicator	Traditional Practices	Improved Practices[a]
Yield (kilogram/hectare)	5,573.90	11,272.30
Prices (naira/kilogram)	0.57	0.57
Gross value of output (naira/hectare)	3,177.10	6,425.20
Cost (naira/hectare)	287.00	405.50
Net return (naira/hectare)	2,890.10	6,019.70

Source: S. O. Adamu, *Cassava Trends and Prospects for Nigeria*, Cassava Working Paper 5 (Washington, D.C.: International Food Policy Research Institute, 1989).
[a]Assumes that 313.8 kilograms of fertilizer are applied.

Table 29—Net benefits and benefit-cost ratio of selected crops in the Zairean Basin, 1982/83

Indicator	Cassava	Rice	Maize	Plantain
Total cost of				
Production (zaires/hectare)	825	1,015	594	301
Labor (zaires/hectare)	694	774	461	263
Value of output (zaires/hectare)	27,063	5,576	11,876	9,763
Profit margin or net benefit (zaires/hectare)	26,238	4,561	11,282	9,462
Benefit-cost ratio	31.8	4.5	19.0	31.4

Source: Adapted from Tshikala Tshibaka and Kamanda Lumpungu, *Trends and Prospects for Cassava in Zaire*, Cassava Working Paper 4 (Washington, D.C.: International Food Policy Research Institute, 1989).

A question that arises is why farmers do not apply fertilizers even when they know that doing so will increase their yield. With fertilizers, cassava will produce an additional 5 tons of fresh roots per hectare, roughly 1.5 tons of cereal equivalents. If the dosage were 100-200 kilograms of nutrients per hectare, the response ratio would be 25-50 kilograms of fresh roots or 7.5-15 kilograms of cereal equivalents per kilogram of nutrients. With such a response, the profitability of using fertilizers would depend upon the price that farmers get for their cassava and the price they pay for fertilizer. Unless the relative price of cassava is not in line with that of cereals, applying fertilizers to cassava would be as profitable as applying it to cereals, if not more so. If this is so, then the factors that constrain the use of fertilizers must be examined. If cassava costs less than cereals, encouraging farmers to use fertilizers on cassava will be difficult if the relatively low price is the result of poor demand for the crop, taste preferences, or increasing incomes, for example. In this case, the obvious step would be to promote alternative uses of cassava (such as feed or industrial purposes) and thus increase its demand. Introducing better varieties or other forms of technical change alone is thus not enough, and the resulting increased production would further lower the price of cassava in the face of constrained demand.

Even in areas without demand and relative price constraints, applying fertilizers may be uncommon for other reasons. First, cassava is grown in agriculturally poor and economically backward areas where fertilizer is often not used on many crops, despite its economic viability. Second, the interrelated processes of fertilizer promotion, distribution, supply, and credit may not be adequately developed. Among the factors that encourage farmers to use fertilizers on cassava are the place of the crop in the farmers' economy and the farmers' knowledge of the benefits to be gained by applying fertilizers. Cassava ranks low in the hierarchy of crops. Thus when the development of cassava is justified on the grounds of equity, three steps must be taken: demand must be developed; an appropriate price environment must be created; and the use of fertilizers must be promoted by supporting extension, supplies, and credit support.[15]

6

Scenarios of Cassava Output and Use in 2000

In its analysis of food gaps in the developing world, IFPRI projected the supply and demand separately for each country, assuming that past trends in output and per capita income will continue. The trends of projected output were based on food staples as a group because the national trends affecting individual commodities are likely to be less stable than the trends affecting group commodities. Similarly, where the trends in individual countries vary widely, the analysis was of trends in groups of countries. This methodology was further modified by computing the trends in crop area and yield per hectare separately and then using the projected area and yield per hectare to determine the projected output. Projections of each country's demand for food used the income elasticity of demand, growth of per capita income, and projected population. Alternative estimates of demand were also made using trend estimates of the per capita consumption in the base period (that is, given zero income growth) and alternative growth rates in income. IFPRI's projections of supply and demand assume constant relative prices. Projected feed use was obtained by extrapolating semilogarithmic trend equations fitted to past annual data for each country. Finally, allowances for waste and other uses were estimated by applying past ratios to projected production. The aggregate use of cassava for food, feed, and other purposes constitutes the total domestic use. The projection methodology adopted for cassava is essentially the same.

The projections obtained by this method do not, however, represent forecasts of the likely supply and demand in 2000. They are based on the extrapolation of past trends and therefore assume that past trends will continue in the future. Further, this method does not take into account the relative importance of the subsistence and commercial segments of cassava's economy and the implications of this for developing its potential. An in-depth analysis of these factors was not possible because national and subregional information was lacking on the subsistence and commercial segments and on the marketed surplus of cassava. Similarly, data on the relative extent of on-farm and commercial use of cassava as feed are not available for most countries. These uses, and the forces influencing them, vary widely among countries within the region. Nevertheless, the projections based on IFPRI's methodology are presented here in the hope that they will help policymakers in initiating action on the policy alternatives for cassava in the years ahead.

PROJECTED PRODUCTION

The annual, national data on area and production of cassava from 1961 to 1985 were aggregated for a subregion, and the subregional yield was calculated. The semilogarithmic trend growth rates of area and yield were then computed separately for each subregion. These trends were extrapolated to 2000. The projected area and yield per hectare were then multiplied for each subregion to obtain the projected output in 2000. In Thailand, where the past growth in area was rapid, the growth of cassava area was constrained to 1.0 percent a year and yield was limited to 0.2 percent so that the growth in output would be 1.2 percent a year. In subregions where the growth rate of either area or yield per hectare was 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 1985. The area and output of each subregion were aggregated to give the total for the region and for developing countries as a whole. The resulting projections are given in Table 30.

Table 30—Projected output of cassava, by region, 1985 and 2000

Region	Area 1985	Area 2000	Yield/Hectare 1985	Yield/Hectare 2000	Output 1985	Output 2000
	(million hectares)		(metric tons)		(million metric tons)	
Asia	4.4	6.0	12.3	14.1	54.9	85.2
Sub-Saharan Africa	7.5	9.4	7.3	8.5	55.2	79.6
Latin America	2.9	3.5	11.1	11.3	32.1	39.7
Total	14.9	18.9	9.6	10.8	142.2	204.5

Source: Computed by the International Food Policy Research Institute.

Note: 1985 figures are trend values.

If past trends in area and yield per hectare continue, the total output of cassava in 2000 will be nearly 204 million tons, grown on 19 million hectares and yielding an average of 10.8 tons per hectare. Of this, 42 percent will be from Asia, 5 percentage points higher than its 1983-85 share. Sub-Saharan Africa's share would drop from 41 percent in 1983-85 to 39 percent. Latin America's share would also drop 3 percentage points. Among the subregions, the humid lowlands and coastal tropics of Sub-Saharan Africa would have the highest projected output: about 37 million tons (see Table 31).

The projected area in 2000 represents an annual growth rate of 1.6 percent between 1985 (trend value) and 2000, which is more or less the same as that between 1961-63 and 1983-85. The assumption that past trends will continue for the entire period may not be realistic, however, in light of the slow growth from 1971-73 to 1983-85. The area under cassava was particularly low in 1983, which influenced the triennial average for 1983-85. Further, by 1988, the area under cassava increased to 14.8 million hectares. The growth in area from 1961 to 1985 was positive in all subregions except the ASEAN, excluding Thailand. Here again, the area under cassava declined at a slight 0.22 percent a year. Even if the negative trend continues until 2000, the effect on the total area projected for 2000 would only be 52,000 hectares. Moreover, if Latin America would modify its current grain policies, which discourage the development of cassava, the area under cassava in Latin America might cease to decline in the future. In Asia, improving the yield of cassava could reduce the unit cost of producing it, raise its competitive position as an ingredient in livestock feed, and the area may not decline. Further, nearly 62 percent of the increased production of cassava in 2000 compared with 1985 would be due to projected increases in area, compared with 57 percent between 1961-63 and 1983-85.

Of the additional 62 million tons of cassava expected to be produced in 2000, Asia would contribute 48 percent, Sub-Saharan Africa, 39 percent, and Latin America, 12 percent. Their corresponding share of the additional 56 million tons produced between 1961-63 and 1983-85 was 52, 39, and 8 percent, respectively (see Table 32). Thus Asia's share of the projected additional output would decrease, while that of Latin America would increase. The projected increase in yield would be relatively modest: from 9.6 tons to 10.8 tons per hectare. For both periods, the increase in output would be largely the result of increases in area.

As an alternative to projecting the area and yield per hectare for subregions, the annual output of cassava in 2000 was projected for each of the 24 countries whose average production exceeded 500,000 tons in 1983-85. The annual output of the remaining 45 countries was aggregated and the aggregate output was projected. Here again, Thailand's annual growth rate in output was constrained to 1.2 percent. This method projected a total of 202

Table 31—Projected production and total domestic use of cassava in developing countries, by region and subregion, 2000

Region/ Subregion	Area	Yield	Production from Area and Yield	Domestic Use: Food	Domestic Use: Feed	Domestic Use: Other	Domestic Use: Total	Surplus or Deficit
	(millions of hectares)	(tons/ hectare)	(million metric tons)					
Asia	6.03	14.13	85.21	30.79	3.31	4.73	38.83	46.38
South Asia	0.55	29.47	16.32	9.88	0.00	1.52	11.39	4.93
China	0.54	17.83	9.68	2.24	1.92	0.39	4.54	5.14
Indochina and the Pacific Islands	1.37	6.66	9.14	4.22	0.77	0.49	5.48	3.66
Thailand	2.01	14.98	30.07[a]	0.86	0.00	0.00	0.86	29.21
ASEAN countries (excluding Thailand)	1.56	12.84	19.99	13.60	0.62	2.33	16.55	3.44
Sub-Saharan Africa	9.36	8.50	79.57	70.99	1.48	13.49	85.95	−6.39
Semi-arid tropics	0.16	4.72	0.75	1.11	0.06	0.06	1.24	−0.49
Humid lowlands and coastal tropics	4.70	7.78	36.56	34.27	0.75	6.48	41.50	−4.94
Equatorial wet tropics	3.27	6.88	22.49	20.93	0.20	4.06	25.18	−2.69
Modified tropics	1.23	16.06	19.77	14.68	0.46	2.89	18.03	1.74
Latin America	3.51	11.31	39.67	17.99	12.88	8.17	39.04	0.64
Seasonally dry tropics	0.36	11.64	4.24	2.32	1.41	0.62	4.35	−0.11
Subtropics	0.30	13.74	4.19	0.89	2.39	0.43	3.71	0.48
Wet tropics	0.06	11.55	0.71	0.72	0.08	0.09	0.89	−0.18
Brazil	2.56	11.44	29.28	13.17	8.83	6.83	28.83	0.45
Mexico, Central America, and the Caribbean	0.22	5.79	1.26	0.89	0.17	0.20	1.26	−0.00
Total developing countries	18.90	10.82	204.45	119.77	17.67	26.39	163.82	40.63

Source: Computed by the International Food Policy Research Institute.

[a]Based on trend projection of output constrained at 1.2 percent per year.

Table 32—Past and projected increase in the area and production of cassava, by region, 1961-2000

Region	Projected Increase in 2000 Compared with 1985		Actual Increase in 1983-85 Compared with 1961-63	
	Area	Production	Area	Production
	(million hectares)			
Asia	1.60	30.32	1.62	29.23
	(40)	(48)	(39)	(52)
Sub-Saharan Africa	1.83	24.40	1.88	22.12
	(45)	(39)	(46)	(39)
Latin America	0.61	7.62	0.62	4.69
	(15)	(12)	(15)	(8)
Total	4.04	62.34	4.12	56.04

Source: Computed by the International Food Policy Research Institute.

Note: Numbers in parentheses are percentages and may not add to 100 because of rounding.

million tons of output in 2000 (see Appendix 2, Table 42). If past trends are assumed to continue, the projected output of cassava in 2000 would range from 202 to 204 million tons, unless the long-term rate of growth in area declines or the yield per hectare increases at an accelerated rate.

PROJECTED DOMESTIC USE OF CASSAVA

Use for Food

The projected use of cassava for food in 2000 was calculated under two assumptions: that the trend in per capita income from 1961 to 1985 continues and that the income elasticity of cassava for food is zero (or at the same trend estimate of per capita consumption as in 1985). 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. Income elasticity coefficients for selected countries are given in Appendix 2, Table 43.

The use of cassava for food in 2000 was projected to be 119.8 million tons under the first method and 121.9 million tons under the second (see Tables 31 and 33). The difference between the two is small mainly because the income elasticity of the demand for cassava is low.

Sub-Saharan Africa would contribute 59 percent of the projected demand for cassava, compared with its contribution of 54 percent in 1985. Nearly 60 percent of the developing countries' projected output in 2000 would be used for food. The projected increase in the use of cassava for food from 1961 to 2000 is given in Table 34.

In Latin America, the projected increase in the use of cassava for food from 1985 to 2000 is projected to be double the increase from 1961 to 1985. The past, slow increase in food use was, as already explained, due to the agricultural policies, adopted by many of the countries of the region that favored the consumption of grains and discouraged that of cassava. The bulk of the increase in food use is expected to be in Sub-Saharan Africa. Asia's use is projected to be nearly half that of the period from 1961-63 to 1983-85.

Use for Feed

Annual time-series data on the use of cassava for feed were obtained from the FAO

Table 33—Projected use of cassava for food, by region, 2000

Region	Trend Income Growth, 2000	Zero Income Growth 2000	Zero Income Growth 1985 (Trend Value)
	(million metric tons)		
Asia	30.8	31.4	24.6
	(26)	(26)	(30)
Sub-Saharan Africa	71.0	72.0	44.3
	(59)	(59)	(54)
Latin America	18.0	18.5	13.8
	(15)	(15)	(17)
Total	119.8	121.9	82.7

Source: Computed by the International Food Policy Research Institute.

Note: Numbers in parentheses are percentages of the total and may not add to 100 because of rounding.

Table 34—Projected increase in the use of cassava for food, by region, 1961-2000

Region	Increase in 2000 over 1985 Trend Value	Increase in 1983-85 over 1961-63
	(million metric tons)	
Asia	6.24	10.50
	(17)	(35)
Sub-Saharan Africa	26.73	17.62
	(72)	(58)
Latin America	4.15	2.09
	(11)	(7)
Total	37.12	30.20

Source: Computed by the International Food Policy Research Institute.

Note: Numbers in parentheses are percentages of the total and may not add to 100 because of rounding.

Agricultural Supply/Utilization Accounts, which contain standardized commodity balances for cassava. These balances were aggregated for subregions. The projected use for feed in each subregion in 2000 was obtained by extrapolating the semilogarithmic trend equation fitted to the annual data for 1961 to 1985. These subregional projections were then aggregated to give the regional and developing world projections.

If past trends continue and the price of cassava relative to alternative sources of feed remains unchanged, the countries studied will use about 17.7 million tons of cassava as livestock feed in 2000. Of this amount, Latin America would consume 73 percent, Asia, 19 percent, and Sub-Saharan Africa, 8 percent (see Table 31).

From 1985 to 2000, Asia and Latin America will consume about 90 percent of the projected increase in feed use, shared equally. From 1961 to 1985, Latin America accounted for the bulk (57 percent) of the increase (see Table 35).

Table 35—Projected increase in the use of cassava for feed, by region, 2000

Region	Increase in 2000 over 1985 Trend Value	Increase in 1983-85 over 1961-63
	(million tons)	
Asia	1.74	0.87
	(45)	(26)
Sub-Saharan Africa	0.44	0.59
	(11)	(18)
Latin America	1.70	1.91
	(44)	(57)
Total	3.88	3.37

Source: Computed by the International Food Policy Research Institute.
Note: The numbers in parentheses are percentages and may not add to 100 because of rounding.

Other Uses

Projecting the residual category, namely, other uses including wastage, was more arbitrary. The ratio of other uses to total production in each subregion was calculated for 1983-85 and then applied to the projected output for 2000. The aggregate quantity for this category was 26.4 million tons.

THE BALANCE BETWEEN PRODUCTION AND USE

Under the assumptions made in the study, the overall balance of production and use in 2000, in broad magnitudes, would be as follows:

Projected area under cassava	18.9 million hectares
Projected yield/hectare	10.8 tons
Projected output (supply)	204 million tons
Projected food use	120 million tons
Projected feed use	18 million tons
Projected other uses	26 million tons
Total use	164 million tons

This scenario of projected output and use for the developing countries shows a net excess of supply over total use of about 40 million tons of cassava in 2000. Most of this excess would be in Asia. Led by Thailand, with 29 million tons (which includes the present level of exports), the projected supply in all subregions of Asia exceeds the estimated use. Latin America, Brazil for the most part, would also have a small amount of excess production. Sub-Saharan Africa would probably have a small net deficit. If the developing countries continue to export 20 million tons net, they will have to find additional markets for about 20 million tons of cassava. These markets could include domestic consumption for food, feed, or industrial purposes or consumption in developed or other developing countries for livestock feed.

Attention has already been drawn to the limitations of projecting output and use. These projections show, however, that demand will constrain the future development of cassava. If the use of cassava does not improve and if additional markets are not found, supply will eventually grow more slowly to match use, and the gap, as such, will not occur.

A qualitative assessment follows of the prospects for cassava. This assessment is based on the views expressed at the workshop on past trends and prospects for cassava in the Third World that was held in Washington, D.C., in August 1987.

PROSPECTS FOR CASSAVA IN 2000

There are conflicting views about the prospects for cassava in Sub-Saharan Africa. One view is that as per capita income increases, the demand for cassava decreases, and coarse grains eventually replace it in human diets. After a review of the declining importance of cassava in world food production, De Bruijn and Fresco (1989, 21-34) conclude that in Sub-Saharan Africa, "where ecological and market conditions are most favorable, maize rather than cassava will likely be the preferred crop." The other view is that "production will expand substantially to meet demand from low-income rural and urban groups, both of which will grow rapidly during the next 16 years. Given the projected gap between food supplies and needs in Africa by 2000, cassava consumption is likely to expand to groups not now eating cassava but whose incomes are declining due to armed conflict, drought, and economic dislocation" (Welsch 1986). This trend will be assisted by improvements in the technology of processing and storing cassava.

In Asia, the demand for cassava within Thailand depends on export demand. Recently, exports from Thailand to countries outside the European Community, particularly Japan, the Republic of Korea, Taiwan, and the U.S.S.R began to increase. These exports reached 8.25 million tons in product weight of chips and pellets in 1988 (27 percent more than in 1987). The increase was stimulated by the bonus quota system, in which every sale to countries outside the European Community entitled traders to export an amount to the European Community in addition to their stock-based share (FAO 1989). Outside Thailand, Asian countries could expand the domestic use of cassava for livestock feed by adopting new technology, and thus reducing the unit costs, if the price of cassava and of protein substitutes were competitive with maize and if marketing arrangements were improved. The prospects for the domestic use of cassava as food other than snacks are not bright. Low-income cassava growers may, however, continue to consume the roots produced on their own farms, especially when rice is relatively expensive. In the Philippines, the government is encouraging farmers to produce cassava starch.

In Latin America, especially Brazil, the use of cassava for food and feed is tending to decline. Lynam (1989b) feels that the recent economic climate could, however, encourage governments to include cassava in their agricultural policies. These economic developments include major realignments in foreign exchange, the reduction or elimination of subsidies, and renewed emphasis on increasing domestic production and reducing imports. Furthermore, cassava is competitive with feedgrains in several countries (not including Venezuela) under existing grain policies. If low-cost technologies for drying and storing cassava were developed and the current grain policies, which are operating against cassava, were modified, the possibility of reversing past trends in Latin America would be good.

7

Conclusions and Policy Implications

The growth in production of cassava between the early 1960s and the mid-1980s was associated with different components of use in the three regions. In Asia, it was exports, mainly from Thailand, and food use; in Sub-Saharan Africa it was predominantly food use, both for the rural and the urban poor; and in Latin America the use was for food and feed in the domestic economy. The prospects for 2000 in each of these regions must be assessed in this context.

The output and use projected for 2000 and discussed in the previous chapter show that if past trends in area and yield per hectare continue into the future, supply response will not be a serious problem. Even if the total area under cassava grows at 1 percent a year instead of 1.6 percent, the aggregate output will be around 187 million tons. The Delphi Survey indicated that by applying fertilizers, farmers could attain higher yields even with existing varieties of cassava. If the average yield improved to 12 tons per hectare, even if area remained at the trend level in 1985 (14.8 million hectares), an output of 178 million tons could be attained. If the pest and disease problems in Sub-Saharan Africa were controlled by the wide adoption of disease-resistant varieties and integrated pest management practices, farmers could attain higher average yields even without using fertilizers. The reasons such trends should be encouraged are compelling.

In the marginal lands of Asia and Latin America where cassava is grown, the priority given to developing cassava is justified by considerations of equity. In these areas, either no other crop can be grown or the net returns from cassava are higher than those from alternative crops, even given the existing yield and price. Improving yields would help farmers meet their need for food, and, if they are producing for the market, increase their income. In these areas, the cultivation of cassava must not be discouraged for want of demand, particularly when no other crop can be grown. Steps should thus be taken to explore and develop alternative uses of cassava in convenience foods, livestock feed, or other industrial purposes.

CONTRIBUTION TO FOOD SECURITY AND RURAL WELFARE

Cassava is particularly important to Sub-Saharan Africa because it is a major food staple in the region. Cassava probably cushioned the region from the effects of its very poor production of food during the past two decades, when the production of food grew at the slow rate of 1.7 percent a year while population grew at about 3 percent. In the humid forest area, cassava has a comparative advantage over other cereal grains. In the savannah and drier areas where cereals can be grown profitably, however, the question of the priority that should be assigned to cassava and other cereal grains, mainly maize or sorghum, will eventually arise. In assigning priority, not only the net returns but also the labor costs should be kept in mind since the cultivation and on-farm processing of cassava are labor intensive. Even in these areas, the immediate importance of cassava for food security should be recognized.

The developed countries are battling the problems of food surplus, while the developing countries are tackling the problems of food deficit. This is particularly true in Sub-Saharan Africa, where the problem of food is likely to become more acute in the coming years. One reason that the developing countries are unable to absorb the food surpluses of the developed countries is that they lack purchasing power. For individuals, too, the problems of hunger and malnutrition are closely related to the lack of income and employment opportunities. Cassava can play a role in providing employment and income to the poor in developing countries and also in helping to reduce the food deficits of the developing world.

Thus, the two principal objectives of developing cassava are to contribute to food security and to improve the welfare of the poorest sections of the population. Because of cassava's inherent characteristics, its development can be used as a catalyst for growth in rural areas. For this objective to be achieved, however, efforts to increase production should be matched by efforts to research and develop postharvest technology and marketing. Such a focus could allow small producers to benefit from cassava's biological efficiency.

USE AS LIVESTOCK FEED

As incomes increase in developing countries, the population will consume more livestock products. As mentioned in Chapter 5, this change will create a derived demand for feed that can use cassava or surplus grains in world markets. With improvements in yield per hectare, dried cassava can be competitive with maize, sorghum, and other coarse grains as an ingredient in feed. Developing cassava would reduce the pressure on feedgrains, which also form an important element in the diet of developing countries.

POLICY ISSUES

Asia

Attention has already been drawn to the regional peculiarities in the use of cassava in Asia, Sub-Saharan Africa, and Latin America. Easing the constraints on the development of cassava in different regions requires specific policy measures. Indonesia has, for example, poor infrastructure, which constrains efforts to market cassava to be used in manufacturing feed and to be exported; the area under cassava has been declining; and the little expansion that has taken place occurred in areas with poor communications and high transportation costs (Kasryno 1988). The situation in the Philippines resembles that in Indonesia, but cassava is less important to the country's food security. The main policy objective in the Philippines is to raise the income of low-income farmers, but, as in Indonesia, the constraint of poor infrastructure is overwhelming (Cabanilla 1988).

The case studies have shown that potential demand exists in Asia for cassava as an ingredient in feed and as a raw material for industry. To expand its use in feed, cassava should be supplemented by protein sources; to enlarge its use in industry, more attention should be paid to the quality of the product and the technology of production. In both cases, infrastructure must be developed to move the raw material from the producing areas to the manufacturing centers. Cassava markets are often fragmented over space and are not integrated with the industrial markets for feed. Integrating the market for these two commodities is needed so that the price responsiveness of the compound feed industry is transmitted to the cassava industry and vice versa. Measures that encourage processors to adopt improved technology also help to improve quality.

Sub-Saharan Africa

Considerable progress has been made in improving the varieties of cassava and in eliminating a range of constraints relating to pests and diseases in Africa. Unfortunately, the impact of these improvements on the average yield remains limited because extension services and planting materials are inadequate. More attention must be given to developing improved and more efficient systems of producing cassava in various cropping patterns, including rotations. Similar technologies must be developed if soil management and pest and disease control are to be improved.

African countries should give greater priority to developing postharvest technologies, especially for processing and various aspects of storing, drying, packaging, and marketing. If postharvest technologies can be found and implemented that increase the use of cassava, countries in Sub-Saharan Africa will be able to meet the demand created by the increasing urbanization and affluence of certain segments of the population.

This research in postharvest technology should be linked with the development of plants and commercialization of products. Ways to reduce and use waste in cassava processing require study, as does the possibility of substituting cassava flour for different proportions of cereals in foodstuffs such as bread and other food preparations.

The effect of cassava-based diets on nutrition has been studied in Africa. More studies are needed, however, on the nutritional effect of different commodity mixes and products at varying levels of cassava dependency in different geographical and socioeconomic strata.

Because of the drought-tolerant nature of the crop, yields of cassava are relatively more stable than those of other crops, which in turn stabilizes production and income. This is particularly important for the low-income groups. Employment in the processing of cassava also diversifies the sources of income at the village level. As women are employed in cultivating and processing cassava, the income they earn benefits the nutrition of their family.

Latin America

In Latin America, cassava is produced by small-scale farmers within an agricultural sector that is characterized by a skewed distribution of land. Thus any income generated by the development of cassava will have to be directed to the small-farm sector. As in other regions, any measures to increase production should be synchronized with steps to expand its use. In order to achieve this, alternative growth markets, such as livestock feed, must be developed for cassava.

Cassava farmers in Latin America face large and uncertain variations in price induced by either the fragmented nature of fresh cassava markets or the inelastic demand of *farinha* markets. This uncertainty constrains the development of capacity for processing cassava chips to be used in feed mixes. Stabilizing prices and assuring a market would encourage farmers to expand production and further stabilize prices in traditional food markets. Cementing the linkages between the use of cassava for food and feed and between the market for cassava pellets and feedgrains calls for coordinating the investment in processing capacity, the formation of market channels to millers, and the expansion of output, particularly by improving production technologies.

Studies carried out by the Centro Internacional de Agricultura Tropical indicate that most cassava-producing countries in Latin America can produce cassava at costs that compare favorably with the cost of producing maize or sorghum. Most of these countries have, however, no policies that deal directly with cassava. Many of the policies dealing with other crops or goals have a direct, negative impact on cassava. Of particular importance are subsidies and import and exchange rate policies that favor cereal grains at the expense of cassava. The impact of these policies needs to be carefully analyzed and policies that adversely affect cassava should be revised.

All Regions

Cassava is a small-farm crop that requires postharvest processing. Government interventions particularly those that diversify the end uses and marketing of cassava products, are needed if cassava is to be an effective instrument for development. Governments also should facilitate the participation of the private sector in developing cassava-processing industries and extend agricultural extension and credit services to cassava cultivation. In the area of research, 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.

The international agricultural research centers, national agricultural research institutes, and universities should pool their resources, coordinate their activities, and give greater priority to the postharvest phase. They should also share information on food processing and the range of opportunities for using cassava.

LESSONS FROM THE DELPHI SURVEY

The results of the Delphi Survey also confirm some of the policy conclusions of this paper. The wide gaps between the average yield of cassava on farmers' fields and that achieved in on-farm tests and research stations given different inputs indicate that greater efforts are needed to expand extension services and to provide input supplies and incentives to enable farmers to adopt the improved cultural practices designed to raise yields. The use of fertilizers alone could raise cassava yields at least 5 tons per hectare, and efforts should be made to propagate their use and thus increase the output and income of farmers. Doubling the resources for research on improved varieties and associated agronomic practices would improve the yield of cassava significantly in areas where the demand for cassava exists. Improving yields would reduce the unit costs of production and increase net profits per hectare. Resources are particularly needed for improving yields on farms with inferior soil and low use of inputs. The constraint posed by the low yield potential of existing varieties can be overcome by allocating adequate research resources to improving the varieties of cassava so that they achieve higher yields and are more resistant to pests and diseases. This is particularly important in Sub-Saharan Africa. Integrated pest management also reduces losses. National research centers should devote more attention to applied research in areas where cassava has a comparative advantage.

The respondents to the Delphi Survey reported that the lack of incentives to grow cassava, both financial, such as remunerative prices, and others, was the most important constraint. Government intervention to ensure that farmers have incentives to grow cassava may be justified in areas where considerations of equity are a priority. The other incentives include the provision of input supplies, credit, and extension. The results of the survey also confirm that national and international centers should give higher priority to research on postharvest technology and product development in order to solve the problems of marketing, storing, and processing cassava.

MORE STUDIES

General policy issues such as nutritional interventions, price policies, and self-sufficiency in food production should be continuously reviewed. Other problems that need to be addressed include investments in the postharvest phase of producing, marketing, and distributing cassava products and the increasing relevance of legislation and measures that ensure quality control. In addition, other major policy issues relate to the research and development of cassava and of competing crops. These relate to supply, demand, labor use, infrastructure, and resource allocation. In order for cassava to contribute to food security and help alleviate poverty, these problems must be studied in depth and appropriate policy solutions found.

Another more recent and pressing problem in many of the developing countries of Sub-Saharan Africa and Latin America is the burden of the national debt, which has led several countries to consider restricting imports of various commodities. The role that increasing the production and consumption of cassava could play in meeting part of the domestic need for food and feed thus requires careful consideration.

IMPROVED DATA

Attention has been drawn to the deficiencies in the availability of data on cassava. The need to improve both the reliability and timeliness of the statistics on area and production of cassava is urgent. Data on on-farm consumption, both for food and for feed, and on marketed quantities are also needed. National governments should take serious steps to organize, in consultation with FAO, the crop surveys needed to achieve this. Some countries might have to undertake special studies for designing appropriate methods of collecting data.

Reliable data on the use of cassava for food, feed, and industrial purposes, and on the amount of wastage need to be collected in all three regions through periodic sample surveys or other means. Information on the adoption of improved varieties and technologies, rural and urban consumption, and nutrition are needed for planning and implementing programs to develop cassava. Monitoring the development programs is also essential so that the relevant policies are properly designed and implemented. Increased priority should therefore be given to collecting statistics on cassava and its products, particularly in countries where the crop has a large potential.

SUSTAINABLE PRODUCTION

Concern has been expressed about the effect that cultivating cassava could have on soil degradation and erosion. Many trials have shown that cassava does extract significant amounts of nutrients from the soil, but that with the exception of potassium it does not extract more than many other crops (Cock 1985). The nutrients so lost can be returned to the soil by applying manures and fertilizers. The practice of returning cassava leaves and stalks to the soil also replenishes part of the fertility lost. Soil erosion may occur if, after the harvest, rains wash the loose top soil away; this should be avoided. The aim of cassava research and development should be to achieve sustainable production in the long run.

CONCLUSIONS

The potential for increasing the yield per hectare as well as the total output of cassava in the developing world is considerable. This is of particular importance for food security in Sub-Saharan Africa where cassava is a major food staple. Developing cassava can be an engine of growth in the economically backward areas where it is usually grown. It can increase employment opportunities and thus help to improve the income of the poor, if technical and marketing problems are overcome first. Cassava also has a potentially large role to play in livestock feed, industrial raw material, and foreign exchange earnings in several developing countries.

Apart from research on evolving HYVs, breeding disease-resistant varieties, and developing appropriate associated agronomic practices, researchers should pay greater attention to postharvest technology and product development, which support the future scope for expanding the use of cassava. Other policy measures needed include (1) providing incentives to farmers such as remunerative prices, credit, and extension services; (2) reexamining commodity policies that militate against cassava (in other words, removing the bias against cassava, if any, in macroeconomic policies on subsidies, trade, and exchange rates); (3) integrating the markets of cassava for food and feed and these markets with those of other commodities; and (4) examining the scope for increasing the demand for cassava as a convenience food and diversifying its end uses.

Appendix 1
Subregions of Cassava-Growing Countries

Region/Subregion	Countries
Asia	
South Asia	Burma, India, Sri Lanka
China	China
Indochina and the Pacific Islands	Fiji, Kampuchea, Laos, Papua New Guinea, Vietnam
Thailand	Thailand
ASEAN countries (excluding Thailand)	Indonesia, Malaysia, the Philippines, Singapore
Sub-Saharan Africa	
Semi-arid tropics	Burkina Faso, Chad, the Gambia, Mali, Niger, Senegal, Somalia, Sudan
Humid lowlands and coastal tropics	Angola, Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea, Liberia, Madagascar, Mozambique, Mauritius, 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, Suriname
Brazil	Brazil
Mexico, Central America, and the Caribbean	Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago

Appendix 2
Supplementary Tables

Table 36—Estimated area under cassava in selected developing countries, 1976-85

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
					(hectares)					
Angola	120,000	120,000	120,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000
Burkina Faso	5,000	5,000	4,500	4,000	3,500	3,100	3,100	3,450	3,408	6,300
Burundi	39,000	39,000	40,000	39,000	39,000	39,000	40,000	40,000	45,000	45,000
Cameroon	507,746	515,130	545,416	553,270	401,954	397,140	383,140	390,000	400,000	410,000
Chad	47,000	48,000	49,000	50,000	55,000	60,000	65,000	65,000	65,000	67,000
Costa Rica	2,033	2,800	3,000	4,500	5,000	5,000	5,477	4,521	5,000	5,000
Gabon	40,000	40,000	40,000	40,000	41,000	40,000	41,000	42,000	42,000	42,000
Gambia, The	3,000	2,700	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Haiti	56,000	57,000	57,980	62,861	63,000	63,000	64,000	65,000	65,000	65,000
Kenya	74,000	79,000	80,000	80,000	80,500	42,000	75,000	84,000	46,000	50,000
Liberia	76,000	79,000	82,000	82,000	85,000	87,000	87,000	87,000	87,000	87,000
Malawi	41,000	42,000	43,000	44,000	45,000	45,000	45,000	23,000	40,000	35,000
Mali	5,500	6,000	6,500	6,500	7,000	7,200	7,500	8,000	8,500	8,000
Mozambique	550,000	600,000	600,000	602,000	600,000	600,000	600,000	500,000	550,000	570,000
Panama	4,500	4,500	4,700	4,700	4,800	4,800	4,800	4,800	4,900	4,900
Papua New Guinea	8,000	8,200	8,400	8,600	8,800	9,000	9,200	9,400	9,500	9,700
Reunion	410	410	420	430	430	430	430	440	450	460
Somalia	2,700	2,700	2,700	2,800	2,900	3,000	3,100	3,200	3,300	3,400
Tanzania	550,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000	450,000
Zambia	53,000	53,000	53,000	55,000	55,000	58,500	60,000	60,000	61,000	61,000
Total	2,184,889	2,154,440	2,192,616	2,221,661	2,079,884	2,046,170	2,075,747	1,971,811	2,018,058	2,051,760

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

Table 37—Estimated production of cassava in selected developing countries, 1976-85

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
					(hectares)					
Angola	1,739,999	1,760,001	1,700,000	1,800,000	1,850,002	1,900,000	1,950,002	1,950,002	1,950,002	1,950,002
Burkina Faso	26,499	27,001	27,499	28,001	28,499	28,519	28,519	31,739	31,357	32,000
Burundi	444,999	450,002	500,000	395,199	400,000	451,002	443,999	443,999	510,999	520,001
Cameroon	809,999	800,000	632,241	642,930	625,080	638,290	518,652	600,000	650,002	670,000
Chad	163,000	170,000	174,999	179,999	209,999	225,001	239,999	250,002	279,999	290,001
Costa Rica	13,451	14,104	13,870	14,520	18,077	19,054	20,958	21,100	20,566	14,533
Gabon	250,002	215,998	229,000	238,999	250,002	237,000	250,002	260,001	244,999	250,002
Gambia, The	9,501	8,999	5,999	5,999	5,999	5,999	5,999	5,999	5,999	5,999
Haiti	239,999	250,002	260,911	253,849	250,002	252,001	260,001	265,000	265,000	270,000
Kenya	605,000	609,999	620,001	630,000	635,000	500,000	390,001	839,999	230,000	450,002
Liberia	274,999	285,001	295,000	300,000	300,000	314,999	320,001	320,001	320,001	320,001
Malawi	267,000	272,999	279,999	268,001	292,001	295,000	296,000	143,685	258,694	209,323
Mali	44,999	50,002	55,001	56,001	60,001	62,000	65,000	70,000	74,999	72,999
Mozambique	2,700,000	2,800,000	2,900,000	3,000,000	3,100,000	3,200,000	3,250,002	3,150,002	3,150,002	3,250,002
Panama	40,303	39,897	39,501	39,821	33,944	34,436	34,931	33,868	34,356	34,851
Papua New Guinea	86,001	88,001	90,001	92,001	94,001	96,000	98,000	100,000	101,000	103,000
Reunion	4,000	4,099	4,201	4,300	4,300	4,399	4,399	4,501	4,501	4,600
Somalia	30,000	31,000	30,000	31,000	32,000	33,000	34,000	35,000	36,000	37,000
Tanzania	5,500,000	5,111,312	4,824,001	5,146,002	5,630,799	6,000,000	5,000,000	5,400,000	5,600,000	5,500,000
Zambia	169,000	171,999	174,999	177,999	179,999	190,001	200,000	209,999	209,999	209,999
Total	13,418,751	13,160,416	12,857,225	13,314,622	13,999,703	14,486,701	13,410,465	14,134,898	13,978,474	14,194,314

Source: Food and Agriculture Organization of the United Nations, "Production Yearbook Tape, 1986," FAO, Rome, 1988.

Table 38—Countries whose average output of cassava exceeds 500,000 metric tons of fresh roots, 1983-85

Country	Average Production	Country	Average Production
	(million metric tons)		(million metric tons)
Angola	1.95	Madagascar	2.06
Brazil	22.14	Mozambique	3.18
Benin	0.66	Nigeria	11.75
Cameroon	0.64	Paraguay	2.64
Central African Republic	0.90	Philippines	1.35
China	3.80	Sri Lanka	0.66
Colombia	1.44	Tanzania	5.50
Congo	0.60	Thailand	19.41
Côte d'Ivoire	1.31	Uganda	3.30
India	5.60	Vietnam	2.87
Indonesia	13.44	Zaire	15.05
Kenya	0.51	Total[a]	130.27

Source: Food and Agriculture Organization of the United Nations, "Production Yearboook Tape, 1986," FAO, Rome, 1988.

[a]Total includes other developing countries.

Table 39—Current yields on farmers' fields, in on-farm trials, and at research stations, by region and type of soil

Location/Region	Inferior Soil		Optimum Soil	
	Yield	Number of Observations	Yield	Number of Observations
	(tons/hectare)		(tons/hectare)	
Farmers' fields				
Asia	9.43	64	13.13	51
Sub-Saharan Africa	7.22	45	12.64	43
Latin America	11.15	59	17.58	46
All countries	9.44	163	14.44	140
On-farm trials				
Asia	13.86	53	21.33	49
Sub-Saharan Africa	11.71	40	17.75	40
Latin America	16.29	49	23.53	38
All countries	14.10	142	20.19	127
Research stations				
Asia	18.42	67	23.39	64
Sub-Saharan Africa	17.46	52	23.59	49
Latin America	21.60	50	30.35	40
All countries	19.07	169	25.91	153

Source: Computed by the International Food Policy Research Institute.

Table 40—Potential yields of existing and improved varieties of cassava on farmers' fields, by type of soil and region, 2000

Variety/Region	Inferior Soil Yield	Inferior Soil Number of Observations	Optimum Soil Yield	Optimum Soil Number of Observations
	(tons/ hectare)		(tons/ hectare	
Existing varieties				
Asia	15.06	55	22.49	53
Sub-Saharan Africa	13.63	53	20.38	51
Latin America	19.36	57	28.30	50
Improved varieties				
Asia	19.98	51	27.36	47
Sub-Saharan Africa	20.57	48	28.31	46
Latin America	23.04	56	33.33	49

Source: Computed by the International Food Policy Research Institute.

Table 41—Potential yields of existing and improved varieties of cassava on farmers' fields and at research stations, by type of soil, 2000

Variety/Location	Inferior Soil Yield	Inferior Soil Number of Observations	Optimum Soil Yield	Optimum Soil Number of Observations
	(tons/ hectare)		(tons/ hectare	
Existing varieties				
Farmers's fields	16.29	168	23.68	154
Research stations	22.45	156	35.21	157
Improved varieties				
Farmers' fields	21.12	158	29.45	145
Research stations	32.58	152	43.10	151

Source: Computed by the International Food Policy Research Institute.

Table 42—Projected production of cassava by the 24 major producers, 1985 and 2000

Major Producers of Cassava[a]	1985 Trend Value	2000 Projection Value	Average Annual Growth Rate, 1985-2000
	(million metric tons)		(percent)
Brazil	24.99	25.08	0.02
Thailand	25.14	30.07	1.20[b]
Zaire	14.68	20.67	2.31
Indonesia	13.43	15.33	0.89
Nigeria	12.22	16.41	1.98
India	7.72	14.90	4.48
Tanzania	6.08	9.90	3.30
China	4.23	9.68	5.67
Uganda	3.40	7.27	5.20
Mozambique	3.35	4.67	2.25
Ghana	2.44	3.91	3.20
Vietnam	3.18	7.69	6.06
Paraguay	2.49	4.32	3.74
Madagascar	1.97	3.24	3.35
Angola	2.03	2.67	1.85
Colombia	2.28	4.39	4.47
Philippines	1.85	5.04	6.92
Côte d'Ivoire	1.40	3.09	5.41
Central African Republic	0.87	0.98	0.79
Sri Lanka	0.72	1.24	3.69
Benin	0.76	1.21	3.15
Cameroon	0.67	0.67[c]	0.00
Congo	0.63	0.78	1.44
Kenya	0.53	0.57	0.48
Subtotal	137.06	193.74	2.33
Total for 45 other developing countries	7.10	8.42	1.15
Total for all developing countries	144.16	202.17	2.28

Source: Computed by the International Food Policy Research Institute.

[a]Countries producing an average of more than 500,000 metric tons of fresh roots equivalents in 1983-85.
[b]Growth constrained to 1.2 percent per year.
[c]1985 trend value is repeated because past growth was negative.

Table 43—Income elasticity of demand for cassava in selected countries, 1985-2000

Country	1985	1990	1995	2000
Angola	0.24	0.18	0.12	0.07
Brazil	−0.21	−0.22	−0.23	−0.24
China[a]	0.00	0.00	0.00	0.00
Colombia[a]	0.10	0.10	0.10	0.10
Ghana	0.20	0.20	0.19	0.19
India	0.00	0.00	0.00	0.00
Indonesia	0.33	−0.35	−0.38	−0.41
Madagascar	−0.10	−0.10	−0.10	−0.10
Mozambique	0.27	0.17	0.08	0.00
Nigeria	−0.10	−0.11	−0.11	−0.11
Paraguay[a]	−0.46	−0.51	−0.57	−0.64
Philippines	−0.21	−0.21	−0.22	−0.23
Tanzania	−0.20	−0.38	−0.54	−0.72
Thailand	−0.21	−0.22	−0.23	−0.24
Uganda	0.19	0.15	0.10	0.05
Vietnam	0.20	0.20	0.19	0.19
Zaire[a]	0.19	0.15	0.10	0.05

Source: Food and Agriculture Organization of the United Nations, "Parameters of Demand Functions," fifth run, FAO, Rome, 1978.

[a]Since the FAO data do not show the elasticity for these countries, the data for neighboring countries were used.

Table 44—Per capita and total consumption of cassava for food, by agroclimatic region, 1985 and 2000

Agroclimatic Region	Trend Value in 1985 Per Capita	Trend Value in 1985 Total	Total in 2000[a]
	(kilograms/ year)	(1,000 metric tons)	(1,000 metric tons)
Asia	10.97	24,554	31,395
South Asia	9.57	7,778	9,852
China	1.76	1,866	2,211
Indochina and the Pacific Islands	40.64	3,060	4,098
Thailand	13.65	702	894
ASEAN countries (excluding Thailand)	46.64	11,149	14,340
Sub-Saharan Africa	120.18	44,257	71,996
Semi-arid tropics	12.03	715	1,080
Humid lowlands and coastal tropics	117.16	21,221	34,468
Equatorial wet tropics	374.42	13,256	20,871
Modified tropics	98.22	9,064	15,576
Latin America	36.14	13,842	18,531
Seasonally dry tropics	30.84	1,709	2,302
Subtropics	19.85	680	974
Wet tropics	18.73	495	725
Brazil	76.00	10,303	13,641
Mexico, Central America, and the Caribbean	4.99	656	889
All producing countries	27.65	82,653	121,922
All nonproducing countries	0.18	25	31
Average/total	26.46	82,678	121,953

Notes: Parts may not add to total due to rounding. Cassava is in fresh root equivalents.

[a]Given zero income growth.

Notes

1. Cassava is known by different names in different parts of the world: *mandioca* or *yuca* in Latin America; manioc in Sub-Saharan Africa; and tapioca in India, Malaysia, and Sri Lanka. Cassava was probably originally the name of thin cakes made of manioc flour, and tapioca, the name of cooked manioc flour (Jones 1959).

2. Hereafter, tons refer to metric tons. The conversion factor (0.303) is the same as that used by IFPRI in its Food Gap Analysis. Using a conversion factor based on rice or maize equivalents would have been more appropriate, but would not have been comparable with other IFPRI data series on cassava.

3. Converted on the basis of caloric content.

4. The output increased to 138.2 million tons in 1986; the data given in Table 1 refer to the average for 1983-85, the latest period for which data on domestic use were available for all the study countries at the time of this analysis.

5. Whereas in Kerala producers keep about 70 percent for domestic consumption, in Tamil Nadu, they keep only 25 percent (1981 data).

6. For example, cassava is *gaplek* (dried cassava chips) in Indonesia; *gari* (dry, granular food made from fermented cassava) in Nigeria; and *farinha* (roasted cassava flour) in Brazil.

7. The own-price elasticity for fresh cassava in urban markets was positive perhaps because wealthier consumers pay a higher unit price for quality differences or because retail markups vary by market (Dixon 1982).

8. Raw cassava contains the glycosides linamarin and lotaustralin, which are converted to hydrocyanic or prussic acid, a poison, when they come in contact with linamarase, an enzyme that is released when the cells of cassava roots are ruptured. (Cock 1985, 26).

9. Also, as the yield of cassava improves, so could that of maize. Therefore, attention must be paid to ascertaining the relative returns to improving the technologies of cassava and maize.

10. In Ecuador, cassava flour and starch are used in pellets fed to pond-raised shrimp, and cassava growers are expanding production to meet this booming market.

11. For a fuller review of the results of the Delphi Survey, see Sarma, Gandhi, and Kunchai (1989). The Delphi method was devised in experiments conducted at the Rand Corporation "in order 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."

12. The questionnaires were sent to about 400 scientists in the disciplines of plant breeding, agronomy, plant physiology, agricultural extension, and social sciences in 57 countries. Of these, 153 responded, and 123 of those responses were usable; the rest did not furnish complete information.

13. The responses contained information on more than one category of input.

14. The 12 constraints identified in the questionnaire are (1) low potential yield of existing varieties, (2) poor fertilizer response, (3) lack of fertilizer, (4) inadequate moisture, (5) pests, (6) diseases, (7) insufficient labor, (8) inadequate extension, (9) marketing problems, (10) storage and processing problems, (11) lack of incentives (including input supplies, credit, processing, storage, transportation, marketing, and, especially important, prices), and (12) others (such as mixed cropping).

15. The authors are grateful to Gunvant Desai for developing the arguments in this section.

References

Adamu, S. O. 1989. *Trends and prospects for cassava in Nigeria*. Working Paper on Cassava 5. Washington, D.C.: International Food Policy Research Institute.

Cabanilla, Liborio S. 1988. *Trends and prospects for cassava in the Philippines*. Working Paper on Cassava 2. Washington, D.C.: International Food Policy Research Institute.

Cock, James H. 1985. *Cassava: New potential for a neglected crop*. Boulder, Colo., U.S.A.: Westview Press,

De Bruijn, G. H., and L. O. Fresco. 1989. The Importance of cassava in world food production. *Netherlands Journal of Agricultural Science* 37: 21-34.

Dixon, John A. 1982. *Food consumption patterns and related demand parameters in Indonesia: A review of available evidence*. Working Paper 6, Rice Policies in Southeast Asia Project. Washington, D.C.: International Food Policy Research Institute.

_____. 1984. Consumption. In *Cassava economy of Java*, ed. Walter P. Falcon, William O. Jones, and Scott R. Pearson. Stanford, Calif., U.S.A.: Stanford University Press.

Dorosh, Paul. 1987. Economics of cassava in Africa: An overview. Paper presented at the workshop on Trends and Prospects for Cassava in the Third World, International Food Policy Research Institute, August 10-12, Washington, D.C. Mimeo.

Falcon, Walter P., William O. Jones, and Scott R. Pearson, eds. 1984. *The cassava economy of Java*. Stanford, Calif., U.S.A.: Stanford University Press.

FAO (Food and Agriculture Organization of the United Nations). 1978. Parameters of demand functions, fifth run. Rome. Computer printout.

_____. 1986. Agricultural supply/utilization accounts tape, 1984. Rome.

_____. 1987. Standardized commodity balances for cassava. Rome. Computer printout.

_____. 1988. Production yearbook tape, 1986. Rome.

_____. 1989. *Commodity review and outlook, 1989*. Rome: FAO.

George, P. S. 1988. *Trends and prospects for cassava in India*. Working Paper on Cassava 1. Washington, D.C.: International Food Policy Research Institute.

Ikpi, Anthony, T. Gebremeskel, Natalie E. Hahn, H. Ezumah, and J. A. Ekpere. 1986. *Cassava—A crop for household food security: A 1986 situation analysis for Oyo Local Government Area, Nigeria*. Ibadan, Nigeria: International Institute of Tropical Agriculture.

India, Department of Statistics. 1985. *The national sample survey: Thirty-second round, 1977/78*. New Delhi: Controller of Publications.

Jones, William O. 1959. *Manioc in Africa*. Stanford, Calif., U.S.A.: Stanford University Press,

Kasetsart University. 1986. Field survey of cassava-based feed pilot project area. Bangkok.

Kasryno, Faisal. 1988. *Trends and prospects for cassava in Indonesia*. Working Paper on Cassava 3. Washington, D.C.: International Food Policy Research Institute.

Konjing, Chaiwat. 1989. *Trends and prospects for cassava in Thailand*. Working Paper on Cassava 6. Washington, D.C.: International Food Policy Research Institute.

Lynam, John K. 1984. Cassava. Centro Internacional de Agricultura Tropical. Cali, Colombia. Mimeo.

_____. 1989a. The evaluation of cassava consumption in Latin America. In *Summary proceedings of a workshop on trends and prospects for cassava in the Third World*, ed. J. S. Sarma. Washington, D.C.: International Food Policy Research Institute.

_____. 1989b. The meat of the matter: Cassava's potential as a feed source in tropical Latin America. In *Summary proceedings of a workshop on trends and prospects for cassava in the Third World*, ed. J. S. Sarma. Washington, D.C.: International Food Policy Research Institute.

Phillips, Truman P. 1973. Cassava utilization and potential markets. International Development Research Centre, Ottawa, Canada.

_____. 1988. Cassava research and development: Policy issues. International Food Policy Research Institute, Washington, D.C. Mimeo.

Sanint, Luis. 1986. Colombia: Potential demand for cassava. Centro Internacional de Agricultura Tropical, Cali, Colombia. Mimeo.

Sarma, J. S. 1984. Basic agricultural statistics in West Africa—Some issues for consideration. *IFPRI Report* 6 (September).

_____. 1986. *Cereal feed use in the Third World: Past trends and projections to 2000*. Research Report 57. Washington, D.C.: International Food Policy Research Institute.

Sarma, J. S., and Darunee Kunchai. 1989. Analysis of trends and prospects for cassava in the Third World. In *Summary proceedings of a workshop on trends and prospects for cassava in the Third World*. ed. J. S. Sarma. Washington, D.C.: International Food Policy Research Institute.

Sarma, J. S., Vasant Gandhi, and Darunee Kunchai. 1989. Delphi Survey for the assessment of potential yields of cassava in the Third World. In *Summary proceedings of a workshop on trends and prospects for cassava in the Third World*, ed. J. S. Sarma. Washington, D.C.: International Food Policy Research Institute.

Tshibaka, Tshikala, and Kamanda Lumpungu. 1989. Trends and prospectsfor cassava in Zaire. Working Paper on Cassava 4. Washington, D.C.: International Food Policy Research Institute.

Welsch, Delane E. 1986. Prospects for cassava in the world economy in the year 2000. In *Cassava in Asia, its potential and research development needs: Proceedings of a regional workshop held in Bangkok, Thailand, 1984*. Bogor, Indonesia: Coarse Grains, Pulses, Roots and Tubers Centre.