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CASSAVA AS A FOOD RESOURCE IN BRAZIL

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I. Cassava as a Traditional Subsistence Crop

Cassava is a shrubby perennial plant that is cultivated in the tropics primarily for its edible roots. It goes by several names, including manioc, tapioca, mandioca, and yuca (1, p. 1). It is a member of the spurge family (Euphorbiaceae), along with the rubber tree and castor bean. Several specific names have been used to designate cassava, including *Manihot utilissima*, *M. palmata*, *M. dulcis*, and *M. aipi*, but the present designation is *M. esculenta*. The plant grows to be five to twelve feet tall under cultivation and may reach heights of up to eighteen feet in abandoned fields. The edible roots for which it is cultivated form just beneath the soil surface, radiating outward from the central stem. They develop a swollen shape as starch reserves are formed and may attain a length of one to two feet, a diameter of two to six inches, and a weight of well over a kilogram. Commonly, five to ten of these enlarged roots form on each plant.

Although it is basically a tropical crop, cassava has been grown to a minor extent outside the limits of the tropics, in such locations as Florida and northern Argentina (2, p. 15). The plant is easily killed by frost, so it must be grown where the frost-free period is long enough to produce a crop. The earliest varieties take at least six months to reach a harvestable stage and most varieties need at least 10-12 months' growth, so cassava production takes place mainly in entirely frost-free areas. It will grow where annual rainfall is as low as 20 inches or as high as 200 inches. One of its most prized qualities is its ability to withstand drought, making it valuable in regions of irregular rainfall distribution. Although it grows best on soils that are light-textured, deep, and fertile, it can be cultivated successfully on soils so impoverished that no other crop will grow (2, pp. 15-16).

Cassava originated in tropical America. Archeological evidence suggests that it has been cultivated for at least 7000 years. The site of its earliest domestication as a crop plant has been the subject of some controversy. Some evidence suggests that there were actually two centers of origin, one in southern Mexico and Guatemala, and the other in northern South America (3, pp. 352-360).

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* In slightly modified form, this paper was first submitted as a part of the requirements for Agricultural Economics 660: Food, Population, and Employment, Fall Term 1975/76.

Because of its outstanding ability to produce an economic yield on impoverished soils and because it is not a highly preferred food, cassava production is usually relegated to the poorest land, with better soils reserved for other crops. It is often grown by small farmers who practice the system of shifting cultivation, where land is cleared of bush or forest vegetation, cultivated for a few years until its fertility is exhausted, and abandoned to revert back to its original state until a degree of fertility has been restored. In this system, cassava is often grown as the last crop in the rotation, when fertility levels are too low to permit economic yields of other crops. It may be grown either in pure culture or interplanted with corn, beans, cotton, or other crops.

The cassava plant produces viable seeds, but farmers use stem cuttings rather than seeds as the means of propagation. These cuttings are six- to twelve-inch sections of the main stem, containing at least two nodes. At planting time they are thrust into the ground for about half their length, usually at an angle to the soil surface. Some farmers insert two or three cuttings together; more often, single cuttings are used. Plants are commonly spaced three to five feet apart. Land preparation, ideally, involves a deep, thorough cultivation, but in practice is usually rather cursory. If poor drainage is likely to be a problem, the soil is arranged into mounds or ridges on which the cuttings are planted. Otherwise it is left flat. After planting, the plot is usually weeded two or three times as it is becoming well established. It receives little further attention. Plants that are diseased may occasionally be removed and manure may be applied if it is available. Chemical fertilizers or pesticides are not used.

Harvesting may begin as soon as the roots are suitable for consumption, but it can be spread over a long period without danger of losing the crop. Many varieties will continue to grow for as long as four years, the roots becoming more fibrous and less palatable but remaining edible (2, p. 22). If the soil is apt to become waterlogged, the roots should be harvested quite soon after they are mature to avoid the danger of rot. Otherwise, there is no requirement to harvest the plot quickly. Roots can be harvested when they are needed, when prices are high, or when other tasks are not urgent. Once they are removed from the ground, however, they begin to rot within about two days (2, p. 23). They must be processed or consumed rapidly or they will spoil.

The harvesting operation is one of the most laborious tasks in the production of cassava, since the roots must be dug up and removed from the ground by hand. If they are not needed for food and prices in the market are too low to warrant the cost of harvesting, they may simply be left in the field, serving both as a famine reserve and as the first step in the reversion of the land to bush vegetation (2, p. 187).

Cassava varieties are divided into two main groups--sweet and bitter. Sweet varieties are generally short-season types, maturing in six to ten months and deteriorating if left in the ground too much longer than this. Bitter varieties usually require more time to mature and may be left in the ground for as long as three or four years without deterioration. Sweet varieties are usually consumed as a vegetable or secondary staple, with relatively little processing, while bitter varieties are given more elaborate processing and function as a primary staple in the diet (4, p. 173). There is a correlation, though not precise, between the sweetness and bitterness of cassava varieties and the amount of toxic hydrocyanic acid (HCN) they contain. Sweet varieties, in general, are characterized by low levels of HCN, most of which is confined to the outer layers of the roots. Bitter varieties contain higher levels of HCN and it is distributed more evenly throughout the root (4, p. 177).

The processing and preparation of cassava for human consumption has three objectives: 1) to make it palatable, 2) to make it safe to eat, i.e., to reduce the HCN content to a safe level, and 3) to convert it into a form in which it can be stored for later use.

William O. Jones, in his comprehensive study of cassava in Africa, states that (2, pp. 29-30):

> All modern methods for processing manioc roots derive from Indian methods, and the ancient processes are still employed in many parts of the tropics. In fact, some of the tapioca of commerce is prepared by methods very little improved over those used in South America before the arrival of the Europeans. The Indian then removed the prussic acid /HCN/ by leaching, rotting, and heating, or by various combinations of these processes, and produced four principal kinds of food products: meal, flour, starch, and a stock for sauces and soups.

Probably the most common form in which cassava is utilized is a coarse meal known as *farinha de mandioca* in Brazil. It is prepared by peeling and washing the roots, grating them into a pulpy mass, squeezing this to express the juices, and toasting the resulting pulp over the fire. The meal can be stored for several months and can be eaten dry or mixed with water to form a paste or porridge. A variation of this process involves prior soaking and fermenting of the roots in water for several days, producing a product known as *gari* in Africa or *farinha d'agua* in Brazil.

Flour is made from cassava roots by drying them in the sun or over a fire and pounding them into a powder. It can be used to make a type of bread or cake. Cassava is high in starch, which may be extracted by stirring grated, pressed cassava in water and allowing it to settle. The damp starch may be sifted and roasted to convert it to tapioca. The juice that is squeezed from the roots in making meal can be boiled down to form a stock for sauces or soups.

Cassava leaves may be used for consumption. An early report by Nieuhoff in 1813 described their preparation in Brazil (5, p. 860). The leaves were bruised and crushed in a wooden mortar and eaten like spinach with oil or butter. Jones (2, p. 31) states that while cassava leaves are not an important food in modern South America, they have become of considerable importance in parts of Africa. He cites instances in which daily consumption of leaves is as high as 500 grams (2, p. 141). Some minor uses for cassava include beer, which is brewed from a cassava-cereal mixture, and cassava seeds, which are occasionally eaten (2, p. 111).

II. The Appeal of Cassava as a World Food Crop

The statistics on world production of cassava are, at best, rough estimates of actual production. Being grown mainly as a subsistence crop in developing countries, cassava does not lend itself to accurate reporting. The practice of harvesting a given plot of cassava over a period of years or simply leaving it in the ground as a famine reserve makes it very hard to correlate the area occupied by the crop with the amount actually harvested annually. The extensive use of intercropping by subsistence farmers complicates the task of gathering production data. The Food and Agriculture Organization of the United Nations (FAO), which publishes world production estimates based on reports from member nations, notes in its 1973 Production Yearbook that, while the figures given are meant to relate to fresh root production, they may in some cases represent cassava meal instead (6, p. 442). This discrepancy would bias the reported production downward by a factor of approximately 2.5.

In spite of considerable uncertainty regarding the actual magnitude of cassava production, it is clear that cassava's impact has been great in places far removed from its origin in tropical America. Table 1, which lists the average annual production of major staple crops in the period 1972-74, gives some indication of the relative position of cassava in world food production. Figure 1 shows where most of the world's cassava is grown. Over 43 percent of the world's cassava production takes place in Africa, followed by South America, with 32 percent of world production, and Asia, 23 percent. Brazil is by far the leading country, producing 29 million tons of an estimated world total of 103 million tons. Other major producing countries are Zaire (11 million tons), Indonesia (10 million tons), Nigeria (10 million tons), India (6 million tons), and Thailand (5 million tons).

Cassava is estimated to account for between one-half and two-thirds of tropical root and tuber production (1, p. 1), and to represent a major source of food for approximately 300 million people (7, p. 11). The importance of cassava in the diets of the inhabitants of 14 countries with high per capita intake of cassava is shown in Table 2, which indicates that in some countries of Africa, cassava accounts for more than half of the total caloric intake.

The main characteristics which make cassava an important food crop in the tropics are these: 1) its yield of food energy is very high; 2) it can be relied upon to produce food under adverse conditions which may cause other crops to fail; 3) cost of production is low and requires little capital; and 4) the roots can be stored in the ground until they are needed.

Yield

Figure 2 illustrates the superiority of cassava over other tropical staples in its ability to produce calories per hectare per year under conditions encountered in several tropical countries. Cassava's full production

TABLE 1. ANNUAL WORLD PRODUCTION, AREA, AND YIELD OF SELECTED STAPLE FOOD CROPS, 1972-74 AVERAGE*

Crops	World Area	Average Yield	World Production
	(million hectares)	(metric tons/hectare, dry weight[a/])	(million tons, dry weight)
Cereal Grains			
Wheat	220.4	1.4	314.5
Rice	134.2	2.1	276.7
Maize	112.6	2.4	268.1
Millet	68.3	0.6	40.1
Sorghum	41.6	1.0	42.7
Roots and Tubers			
Potatoes	21.9	3.1	68.2
Sweet potatoes	16.4	2.6	41.8
Cassava	11.4	3.4	39.1
Yams	1.9	2.9	5.6

* Data from Food and Agriculture Organization (FAO), Production Yearbook 1974 (Rome, 1975), Vol. 28-1, pp. 44-70.

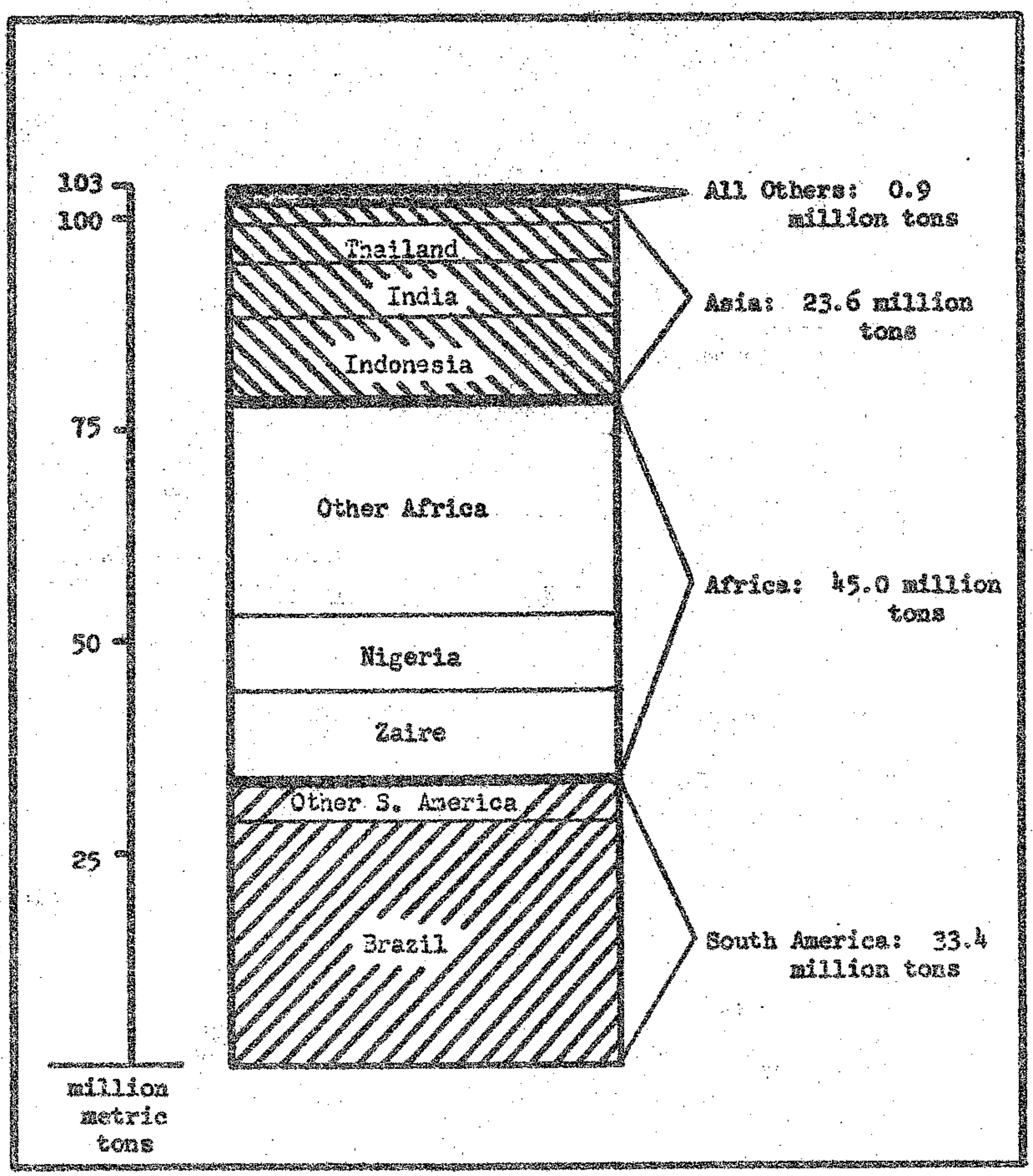
a/ Conversion from fresh to dry weights based on moisture contents in L. Nicholls, Tropical Nutrition and Dietetics (4th ed., revised by H. M. Sinclair and D. B. Jelliffe, London, 1961), pp. 396-400.

TABLE 2. COUNTRIES WITH HIGH LEVELS OF CASSAVA IN THE DIET, 1964-66*

Country	Cassava as Percent of Total Intake	Calories per day from Cassava	Population
			(millions)
Zaire	58	1193	16
Congo	55	1184	1
Central African Rep.	49	1057	1
Gabon	47	1027	1
Mozambique	43	908	7
Angola	34	659	5
Togo	26	590	2
Liberia	26	600	1
Dahomey	20	438	2
Paraguay	20	540	2
Ghana	18	380	8
Indonesia	15	269	106
Nigeria	14	306	58
Brazil	11	274	81
Weighted Average	19	374	
TOTAL			291

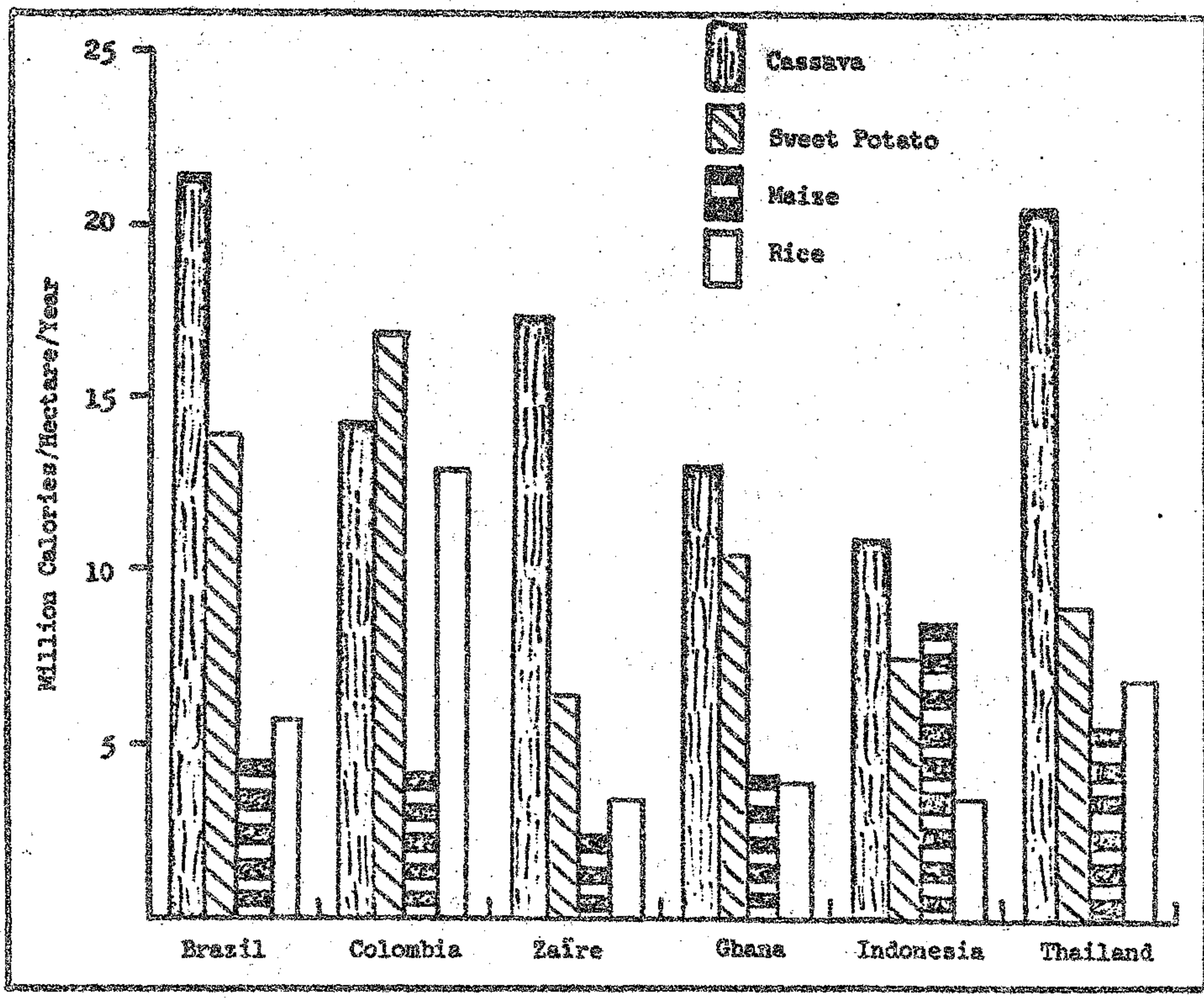
* Data from Food and Agriculture Organization (FAO), Food Balance Sheets, 1964-66 (Rome, 1971).

FIGURE 1. ANNUAL WORLD CASSAVA PRODUCTION AND MAJOR REGIONS OF PRODUCTION, 1972-74 AVERAGE*



* Data from Food and Agriculture Organization (FAO), Production Yearbook, 1974 (Rome, 1975), Vol. 28-1, pp. 67-68.

FIGURE 2. RELATIVE YIELD OF FOUR STAPLE CROPS IN SELECTED TROPICAL COUNTRIES IN 1973*



*Data from Food and Agriculture Organization (FAO), Production Yearbook, 1973 (Rome, 1974), Vol. 27, pp. 46-86; caloric values from L. Nicholls, Tropical Nutrition and Dietetics (4th ed., revised by H. M. Sinclair and D. B. Jelliffe, London, 1961), pp. 396-400.

potential is seldom actually realized since it is generally grown on poorer land than other staple food crops. A major reason for cassava's high yielding ability is a characteristic which it shares with other root crops, that of high harvest index--that is, a high proportion of the total plant weight consists of the edible portion. Of the total dry weight of root crops, up to 60-85 percent is the edible protion, as compared to only 36 percent for wheat (8, p. 263). Another slight advantage of cassava over most other crops is the fact that the plant is not propagated from a plant part which is otherwise consumed. Thus, there is no necessity to reserve a portion of the harvest for planting the next season's crop, as is the case with the cereal grains, potatoes, and yams.

Reliability

Cassava is prized for its ability to produce high yields under adverse conditions. Its ability to thrive on impoverished soils is valuable in systems of shifting cultivation because it enables the farmer to harvest one or two additional crops after the land which he has laboriously cleared would otherwise be exhausted. Where the soils have been depleted by almost continuous cultivation, cassava produces economic yields where other crops fail. The ability of the plant to recover from drought makes it an "insurance crop" in areas where rainfall distribution is uncertain. Cassava is relatively free of devastating disease and insect problems--it may be damaged but is seldom completely destroyed. Its freedom from damage by the migratory African locust has contributed to its wide use in Africa (2, p. 23).

Cost of Production

The cost of cassava production is variable, depending on the conditions under which it is grown, cost of labor, and intensity of cultivation. The main costs under traditional systems are family labor and land. The opportunity cost of the labor is usually low and the opportunity cost of the land may be close to zero, since cassava may be the only crop that will thrive on it. Bruce F. Johnston, in his study of the food economies of West Africa, compiled a cost-of-production hierarchy in which only plantains had a lower cost of production than cassava in terms of cost per pound and per 1000 calories (9, p. 144). Table 3 compares the productivity of several African crops in terms of their yield of FAO "wheat equivalents" per hectare and per man-hour. Cassava has the advantage over the other African crops both in terms of productivity per unit of area and per unit of labor.

Storage in the Ground

The farmer gains flexibility in his use of the crop by being able to store it simply by leaving it growing in the field. The labor of harvesting is great, but it can be spread over a long time. The harvest can be completed when other tasks are not pressing. The unharvested plot is a source of food if other crops fail and a source of cash if prices rise in the market. This practice of storing cassava as the standing crop in the field cannot be followed if soils are poorly drained.

TABLE 3. RELATIVE RETURNS TO LABOR OF SELECTED AFRICAN CROPS*

Crop	Labor Input	Yield in Kilograms of Wheat Equivalent	
	(man-hours/hectare)	(kg./hectare)	(kg./man-hour)
Cassava	1870	3285	1.75
Sweet Potato	1160	1824	1.58
Maize	900	1340	1.49
Millet	500	650	1.30

* Data from C. Clark and M. Haswell, Economics of Subsistence Agriculture (London, 1964), p. 81.

It should also be noted that it occupies land which could be used for production unless it would otherwise lie idle. But if cassava is the last crop in the sequence of rotation before the land is to be abandoned, this may well be the case.

Disadvantages of Cassava

The most commonly voiced criticism of cassava is that its protein content is low, making it a poor food from a nutritional standpoint. Table 4 compares the composition of commonly consumed staple food crops and shows that cassava is indeed low in protein, although it compares favorably with the cereal crops in vitamin and mineral content. Cassava, eaten as the sole source of food, does not constitute a desirable diet, but neither do most other foods.

The presence of HCN in cassava must be considered one of its disadvantages, although it has been widely consumed for centuries with relatively few problems of toxicity. The techniques that have evolved for preparing cassava are essentially effective in making it safe to eat, but instances of acute poisoning from eating cassava are not unknown, and chronic toxicity from long-term, heavy consumption of cassava is sometimes manifested in the form of goiter or certain neurological disorders (10, pp. 28-34). This problem could become increasingly significant if cassava is more widely consumed and could be a barrier to the development of new markets for cassava.

The rapid post-harvest deterioration of cassava has probably been a serious constraint to its transition from subsistence to commercial production, making it difficult to market fresh roots at any distance from their point of production. The poor storage qualities of the crop are very inconvenient for industrial processing, since it is not feasible to maintain a few days' supply of raw material for the processing plant. Cassava, when left in the ground for long periods, gradually loses quality

TABLE 4. COMPOSITION OF SELECTED CROPS PER 100 CALORIES EDIBLE PORTION*

Crop	Protein	Calcium	Iron	Vit. A	Thiamine	Riboflavin	Ascorbic Acid
	(g.)	(mg.)	(mg.)	(I.U.)	(mg.)	(mg.)	(mg.)
Wheat	3.2	5.8	0.73	±0	0.087	0.023	0
Sorghum	2.9	9.0	1.26	±0	0.140	0.034	0
Maize	2.8	3.3	0.69	30–170	0.096	0.036	0
Rice	2.0	1.4	0.28	±0	0.017	0.008	0
Yam	1.9	9.6	1.10	0–190	0.096	0.029	9
Colocasia	1.8	22.1	0.90	±0	0.090	0.027	45
Sweet Potato	0.35–2.5	21.9	0.90	0–3500	0.090	0.035	26
Banana	0.8	5.5	0.39	80	0.039	0.039	16
Cassava	0.5	16.3	0.65	±0	0.460	0.019	20

* Data from C. A. de Vries, J. D. Ferwerda, and M. Flach, "Choice of Food Crops in Relation to Actual and Potential Production in the Tropics," Neth. J. Agric. Sci., Vol. 15, p. 247 (1967).

and increases in disease susceptibility, as well as occupying considerable land area. If the means of processing the crop rapidly into a more easily stored form are readily available, this problem is less serious.

Cassava's role among low-income populations is that of the cheapest starchy staple available. It is not a highly preferred item in the diet and its consumption tends to decline as incomes rise (11, p. 158). Out of enthusiasm for the impressive agronomic qualities of the crop, this fact has sometimes been forgotten.

III. Cassava Production and Utilization in Brazil

With an area of approximately 3.3 million square miles, Brazil (Figure 3) is the world's fifth largest country, ranking just behind the United States of America in size. Its population in 1973 was estimated to be 101 million, with an annual growth rate of 2.8 percent (6, p. 15). Urbanization of the Brazilian population is taking place at a rapid rate, as shown in Figure 4. From 1940 to 1970, while the rural population increased by 46 percent, the urban population grew by 310 percent, accounting for 75 percent of the nation's total population increase during the three decades. Brazil's population is now 56 percent urban.

Brazil's Major Economic Regions[1/]

Brazil was officially divided into the five regions shown in Figure 3 (North, Central-West, Northeast, Southeast, and South) in 1969. A brief description of these five regions follows, emphasizing population, climate, and actual and potential agricultural activities. The maps in Figure 5 illustrate the major natural features, agricultural activities, and population distribution of the country.

North

The North is the largest and most sparsely populated of Brazil's major regions, comprising 42 percent of Brazil's area but only about 4 percent of its population. It is composed mainly of the Brazilian Amazon, the world's largest rain forest, and its population is concentrated mainly along the Amazon and its tributaries. The climate is characterized by high rainfall and a lack of seasonal variation in temperature. There is a short winter dry season in the eastern part of the region, while the western areas experience high rainfall throughout the year. The major economic activities of the area are extraction of forest commodities (rubber, Brazil nuts, oil plants, and wood), cattle raising of an extensive nature, and subsistence farming. Most soils of the North are subject to rapid loss of fertility when cultivated, and

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1/ Description of Brazil's regions is based mainly on R. M. Paiva, S. Schattan, and C. F. Trench de Freitas, Brazil's Agricultural Sector: Economic Behavior, Problems, and Possibilities (São Paulo, 1973), pp. 277-408.

FIGURE 3. BRAZIL'S REGIONS, STATES, AND MAJOR CITIES

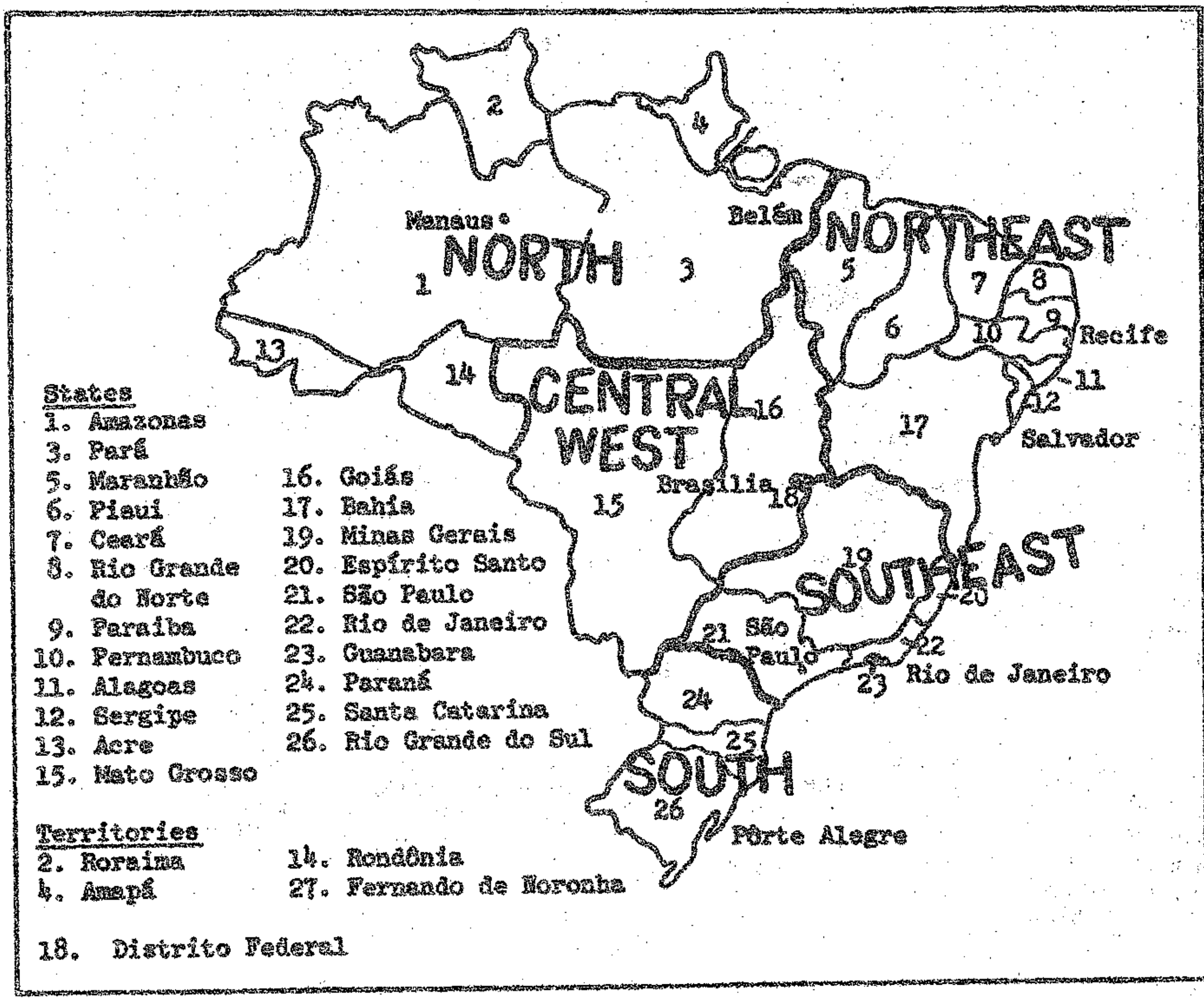
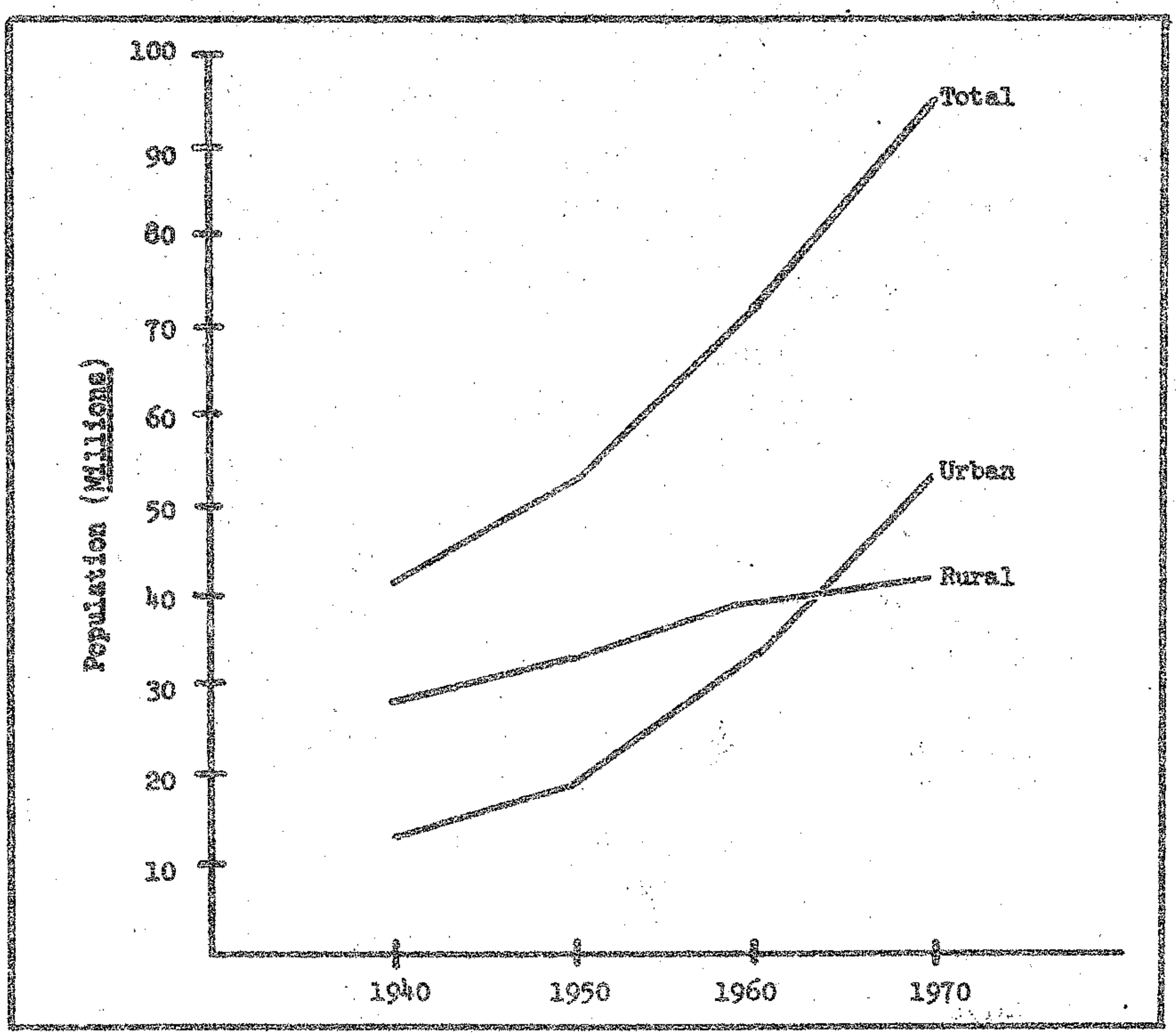
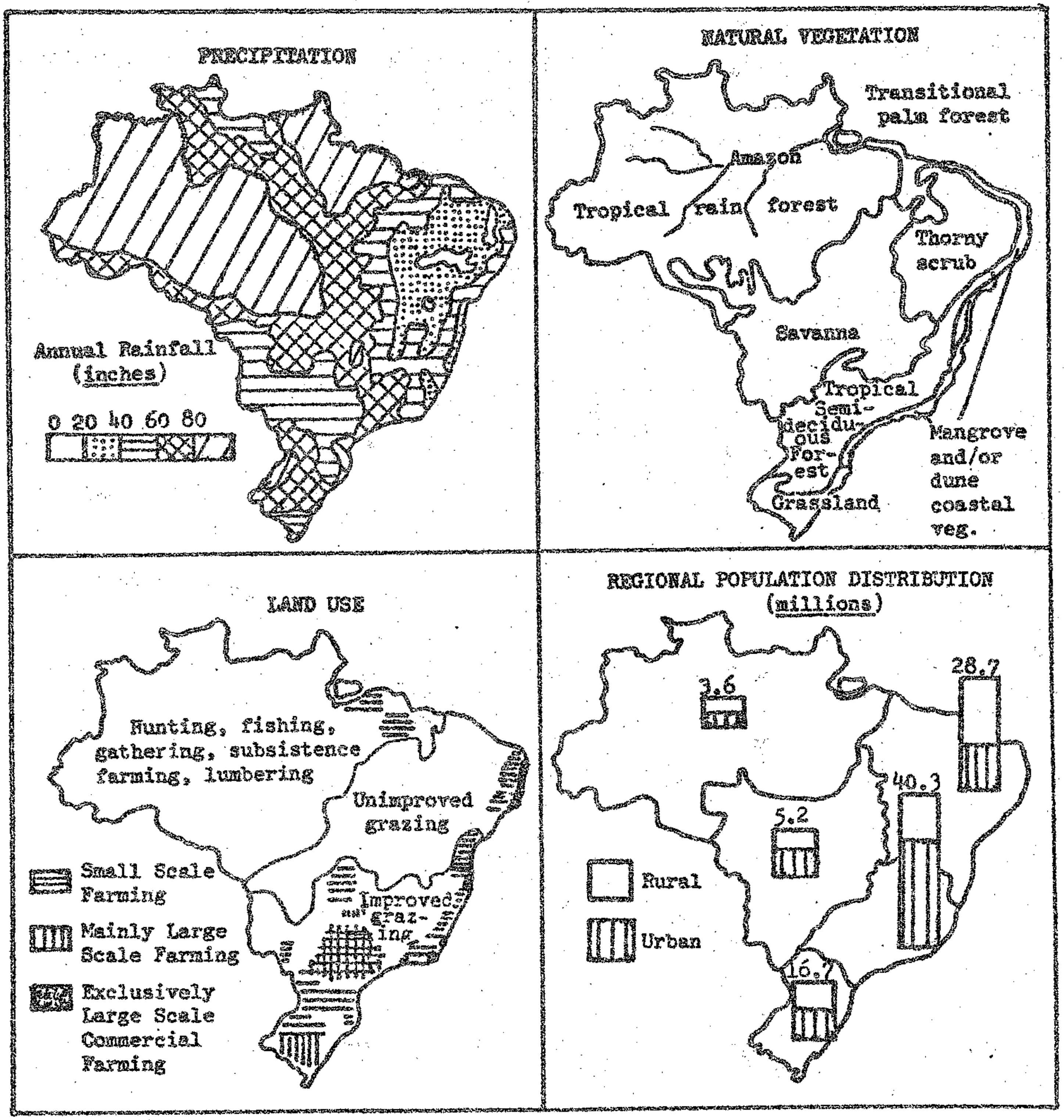


FIGURE 4. BRAZIL'S POPULATION GROWTH AND URBANIZATION, 1940-70*



* Source: R. M. Paiva, S. Schattan, and C. F. Trench de Freitas, Brazil's Agricultural Sector: Economic Behavior, Problems, and Possibilities (São Paulo, 1973), p. 287.

FIGURE 5. BRAZIL: MAJOR FEATURES*



*Rainfall, natural vegetation, and land use adapted from U.S. Central Intelligence Agency Map of Brazil; regional population distribution, from R. M. Paiva, S. Schattan, and C. F. Trench de Freitas, Brazil's Agricultural Sector: Economic Behavior, Problems, and Possibilities (São Paulo, 1973), p. 287.

the extent of land well suited to agriculture, using presently available technology, is small. The North's crop production, both total and per capita, ranks lowest among Brazil's regions, and takes place mainly in the area near Belém. Exploitation of this region's resources to a greater extent will depend on the capital and technology needed for successful cultivation of its soils, and the infrastructure necessary for marketing and transporting its potential products.

Central-West

This region is also sparsely settled and little developed, with 22 percent of Brazil's area but only about five percent of its population and three percent of its income. The region has two clearly defined seasons, with the dry season lasting four to six months. The most widespread natural vegetational type is the cerrado or savanna, with some areas of tropical forest as well. The most important agricultural activity is cattle raising, although lack of feed during the dry season seriously limits the productivity of this enterprise. Large portions of this region have a climate favorable for agriculture, but fertile soils are relatively rare. Most of the region's fertile land and most of the farms are located in the southern part which is favored not only in climate and topography, but also with relatively easy access to consumer centers such as São Paulo. In 1960 the nation's capital, Brasilia, was established in this region. New roads from the capital to Belém and Acre have led to fairly rapid development of parts of the region.

Northeast

The Northeast comprises 18 percent of Brazil's total area. It is the least wealthy region, with 30 percent of the country's population but only 14 percent of its income. Family food budget surveys in the early 1960s indicated that the proportion of the population receiving inadequate diets was substantially higher in the Northeast than in the Southeast or South (Table 5). A coastal belt on the eastern edge of this region receives adequate and regular rainfall, but precipitation decreases towards the interior. A large central area of the Northeast is subject to semi-arid conditions and occasional disastrous droughts, which have caused large-scale migrations out of the area. The coastal region supports production of many crops, particularly sugar cane and cocoa in large plantations. The interior is characterized by cattle raising and production of short-cycle food crops, usually using relatively primitive methods. The semi-arid regions of the Northeast are plagued by high population density, periodic drought, and relatively poor prospects for improved agricultural production.

Southeast

This is the most highly developed and populous of Brazil's major regions. It comprises only about 11 percent of the country's area, but has 43 percent of the population and generates 62 percent of its income. The Southeast's population is 73 percent urbanized, compared to 56 percent for Brazil as a whole. Agriculture is highly diversified in the

TABLE 5. ESTIMATED PROPORTION OF BRAZIL'S POPULATION WITH DAILY PER CAPITA INTAKE OF LESS THAN 2450 CALORIES*

(percent)

Region	Total	Urban	Rural
BRAZIL	38.5	53.7	31.1
Northeast	75.4	75.8	75.5
East	37.6	52.5	31.6
South	28.8	44.0	2.8

* Data from Getulio Vargas Foundation, Food Consumption in Brazil--Family Budget Surveys in the Early 1960's (Rio de Janeiro, 1970), p. 15.

Southeast, with both highly sophisticated and traditional agricultural enterprises. The climate features a dry season ranging from one or two months to five or more months in areas bordering the dry Northeast. The coastal belt features dense, humid Amazon-like forests, while a savanna-like vegetation prevails toward the western border. In the southern part of the region, considerable seasonal variation in temperature occurs, and frost is an occasional hazard to coffee plantations at higher altitudes. Much of the eastern part of this region was the site of Brazil's first intensive coffee production and the natural fertility of the soils in this area has largely been exhausted. The most promising areas for production increases are southeastern Minas Gerais and the state of São Paulo.

South

Although the South is the smallest of Brazil's five regions, it is larger than any western European country. It is the home of approximately 18 percent of the country's population and comprises about 7 percent of its total area. The population of the South is mostly of European origin. Agriculture is very diversified, featuring both modern and traditional farming methods. In the southern part of this region, low winter temperatures restrict the production of some tropical crops and occasional severe frosts occur in Paraná. There is no prolonged dry period in most of the South, although short periods of drought occur in summer. The climate and fertile soils of the South favor the production of many temperate crops, such as wheat, soybeans, and potatoes, as well as coffee, corn, beans, and rice. Extensive grasslands support herds of well-bred cattle and sheep. Northern Paraná possesses highly fertile soils and is Brazil's most famed agricultural area. The region's prospects for increased production are thought to be excellent, due to adequate topography, fertile soils, vast new areas in the west, and a favorable climate except for occasional frosts in Paraná.

Land Distribution

The distribution of farmland in Brazil is not equitable (Figure 6). Very small holdings account for 32 percent of all farms but only one percent of area being farmed, whereas large holdings account for three percent of all farms and 53 percent of area farmed.

Cassava Production

Estimated cassava production in Brazil rose from 13.5 million tons in 1953 to 33 million tons in 1973, with most of the increase being due to increased area of production rather than to higher yields. The area devoted to cassava production doubled during the two decades, while yields rose by only about 15 percent. The average yield of cassava in Brazil of 15 tons per hectare compares favorably with world average yields of approximately 10 tons per hectare (12, p. 133; 6, pp. 83-84).

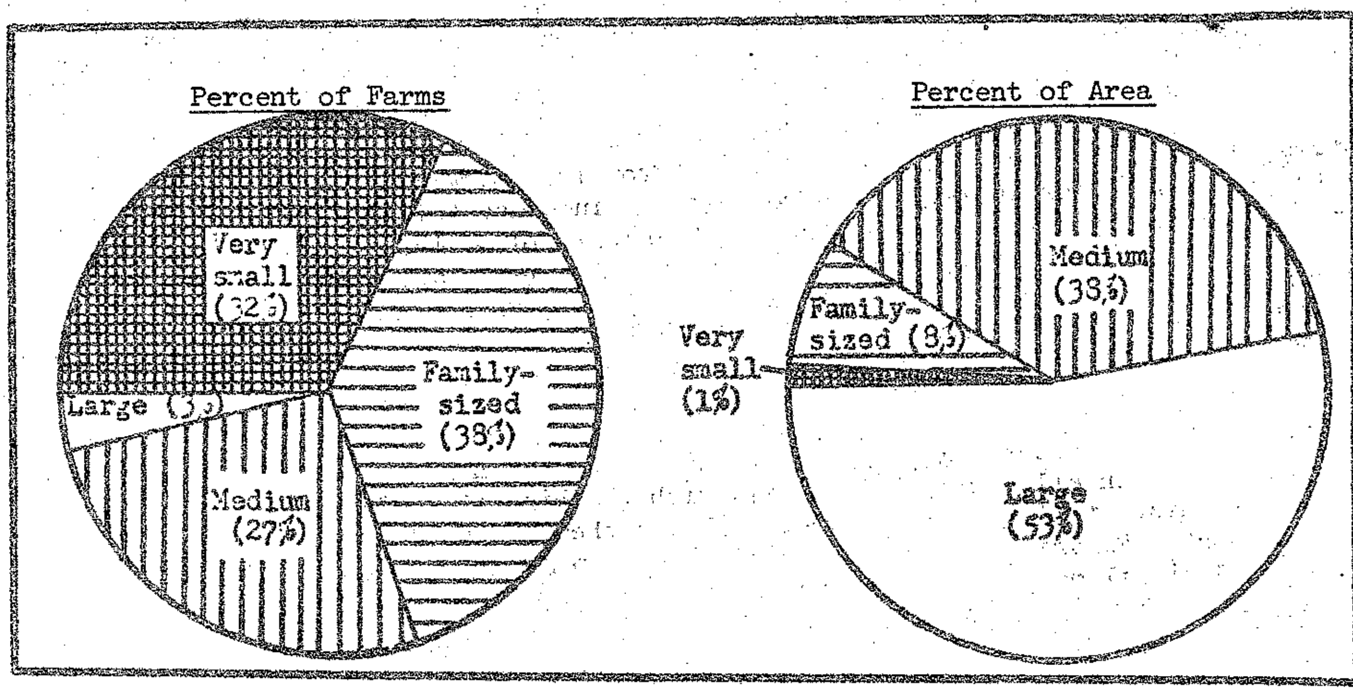
Cassava ranks sixth in acreage and eighth in gross income of the crops in Brazilian agriculture (13, p. 61). Significant amounts of cassava are produced in all regions of Brazil, with the highest production in the Northeast, followed by the South, the Southeast, the Central-West, and the North (Figure 7). Most production takes place on small farms using traditional methods, but there is some relatively commercialized production in the Southeast and South, largely for the starch market or for livestock feed (14).

Although cassava's ability to produce an economic yield under adverse conditions has been stressed, it is subject to attack by a number of insects and diseases which prevent it from realizing its full yield potential. Among the important diseases are angular leaf spot, brown leaf spot, leaf and stem rust spot, common mosaic, cassava root rot, and bacterial wilt, the last mentioned of these causing very serious losses wherever it occurs. Among the insects known to cause damage to cassava in Brazil are stem borers, weevil borers, hornworms, ants, leaf cutters, and spider mites (13, pp. 62-63).

Cassava in the Diet

Although cassava is estimated to account for approximately 11 percent of all calories consumed by Brazilians, there are pronounced differences in the amount consumed by various segments of the population. From Figure 8, which depicts consumption of fresh cassava and cassava flour by rural and urban consumers, three points can be made: 1) Much more cassava is eaten by rural than urban consumers. 2) The decline in consumption with rising income is less pronounced than might be expected. 3) It appears that an increase in consumption of fresh cassava occurs as incomes rise in urban areas. There are important regional differences in cassava consumption. Figure 9 shows that consumption of cassava is much higher in the Northeast than the rest of Brazil and that almost all casaava consumed in the Northeast is in the form of flour. The South, on the other hand, is characterized by relatively little cassava consumption, and by a preference for fresh roots over flour.

FIGURE 6. RELATIVE IMPORTANCE OF VERY SMALL, FAMILY-SIZED, MEDIUM, AND LARGE FARMS[a/] IN BRAZIL, 1960*

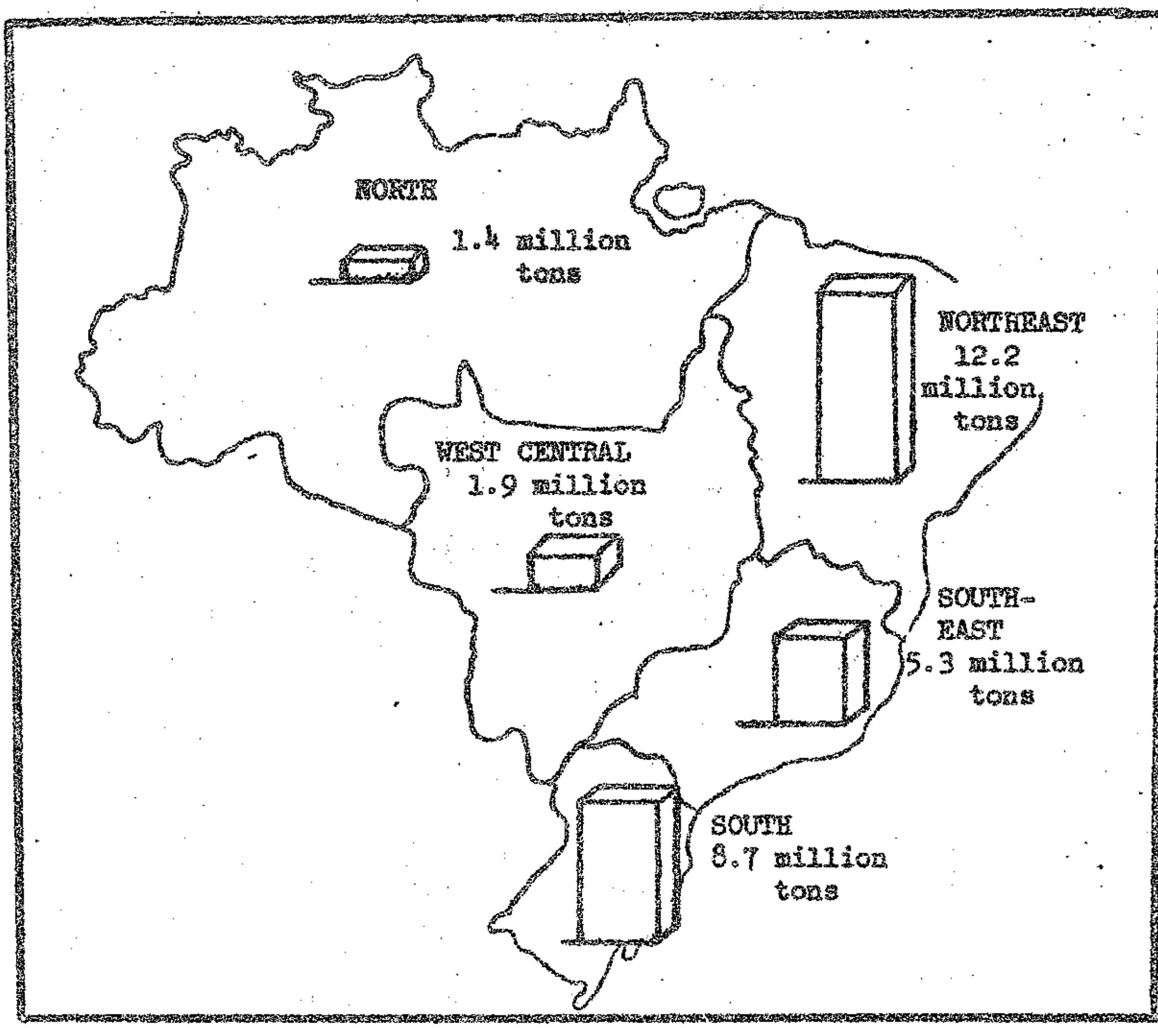


* Source: Inter-American Committee for Agricultural Development, Land Tenure Conditions and Socio-Economic Development of the Agricultural Sector: Brazil (Washington, D.C., 1966), p. 98.

a/ Very small: farms of a size inadequate to give full-year employment to two people; family sized: farms which provide full employment for two to four people; medium: farms which provide full employment for 4-12 people; large: farms which provide full employment for more than 12 people.

The contrast in relative consumption of cassava among income groups is more striking when expressed in terms of calories derived from cassava as a percentage of total calories consumed. In this respect, cassava declines in importance from 17 percent of total calories for lowest income groups to less than eight percent for the highest income groups. Among the poorest segment of the rural population in the Northeast, cassava accounts for 36 percent of calories consumed, whereas high-income urban consumers in the South derive less than one percent of their calories from cassava. The family food budget surveys on which these figures are based estimated that per capita daily intake of calories varied from 1551 in the lowest income groups to over 3800 among the most wealthy consumers. If these findings are correct, it would appear that as incomes rise, consumers increase their expenditures on other foods without significantly decreasing their cassava consumption (15, pp. 16-18, 75-77).

FIGURE 7. BRAZIL'S REGIONAL CASSAVA PRODUCTION, 1970*

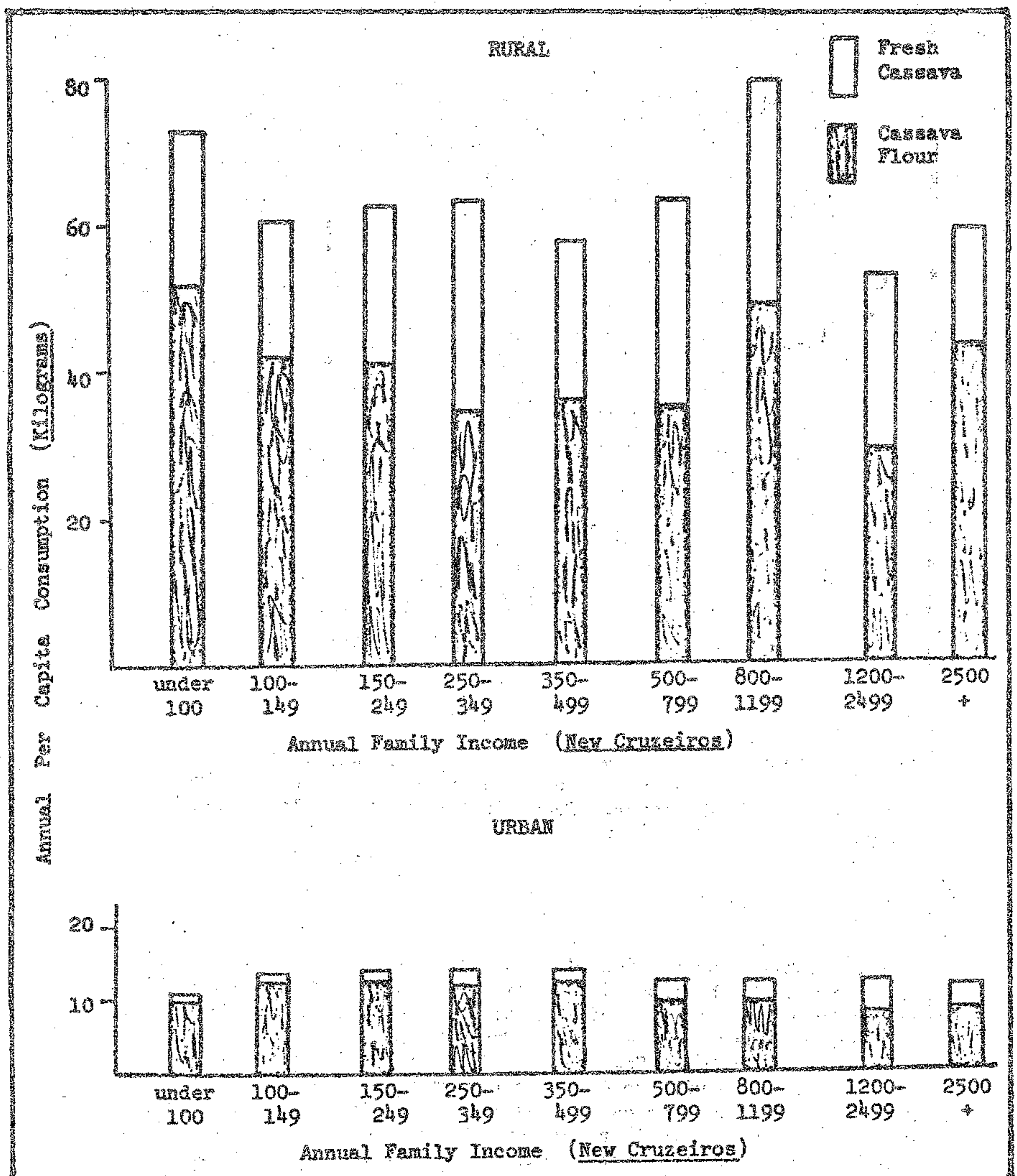


*Source: R. M. Paiva, S. Schattan, and C. F. Trench de Freitas, Brazil's Agricultural Sector: Economic Behavior, Problems, and Possibilities (São Paulo, 1973), p. 292.

Other Uses

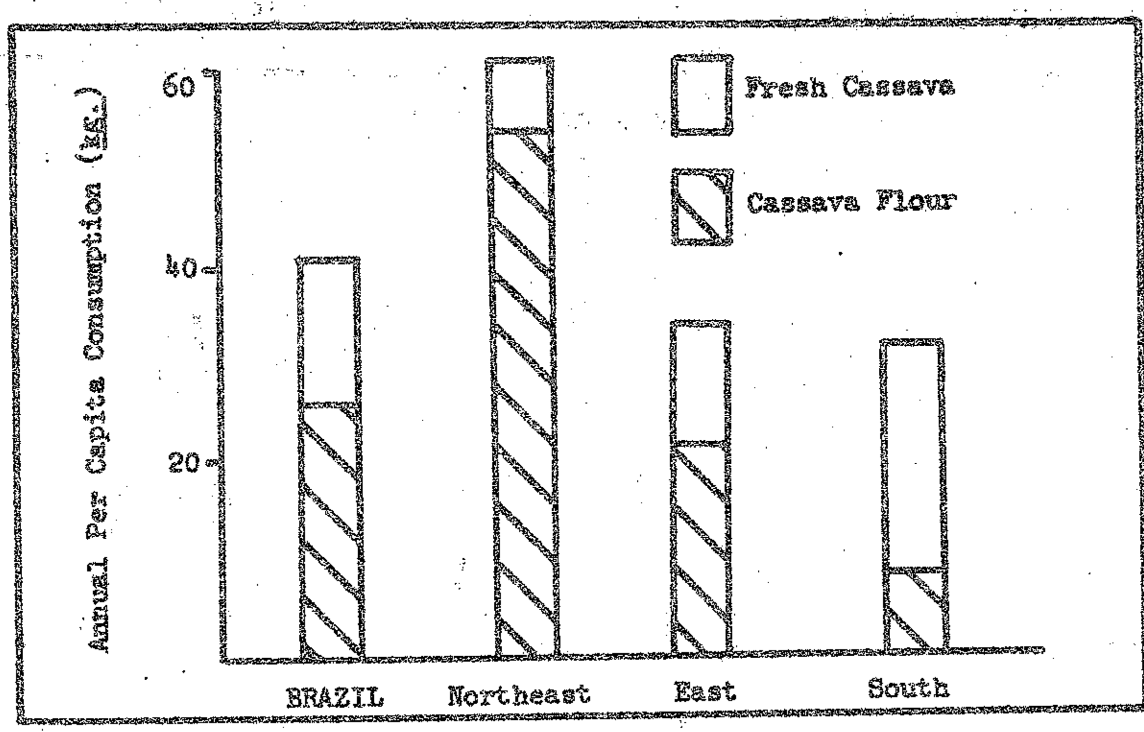
A significant proportion of Brazil's cassava crop is fed to livestock. Truman P. Phillips, in his extensive study of cassava utilization and potential markets, cites estimates which indicate that as high as 47 percent or even 63 percent of Brazil's production is used for this purpose (1, pp. 85-86). Some cassava is utilized in starch production, but it must compete with several other sources of starch, particularly maize, and the market for cassava as starch has not expanded in recent years (1, p. 86). A small proportion of the crop is exported, mainly to the United States and Western Europe, but Brazil's performance as a cassava exporter has been very erratic (Figure 10) despite a rising worldwide demand for cassava products. This may be due to Brazil's

FIGURE 8. PER CAPITA CASSAVA CONSUMPTION BY INCOME CLASS IN RURAL AND URBAN AREAS OF BRAZIL, EARLY 1960s*



* Source: Getulio Vargas Foundation, Food Consumption in Brazil--Family Budget Surveys in the Early 1960's (Rio de Janeiro, 1970), pp. 198-209.

FIGURE 9. REGIONAL PER CAPITA ANNUAL CONSUMPTION OF FRESH CASSAVA AND CASSAVA FLOUR IN BRAZIL, 1960*



* Source: Getulio Vargas Foundation, Food Consumption in Brazil--Family Budget Surveys in the Early 1960's (Rio de Janeiro, 1970), pp. 198-209.

inability to provide a dependable supply of cassava products at competitive prices on the world market. Domestic prices for cassava products are frequently higher than export prices and are less demanding in quality requirements (1, p. 90).

IV. Potential for Increased Cassava Production in Brazil

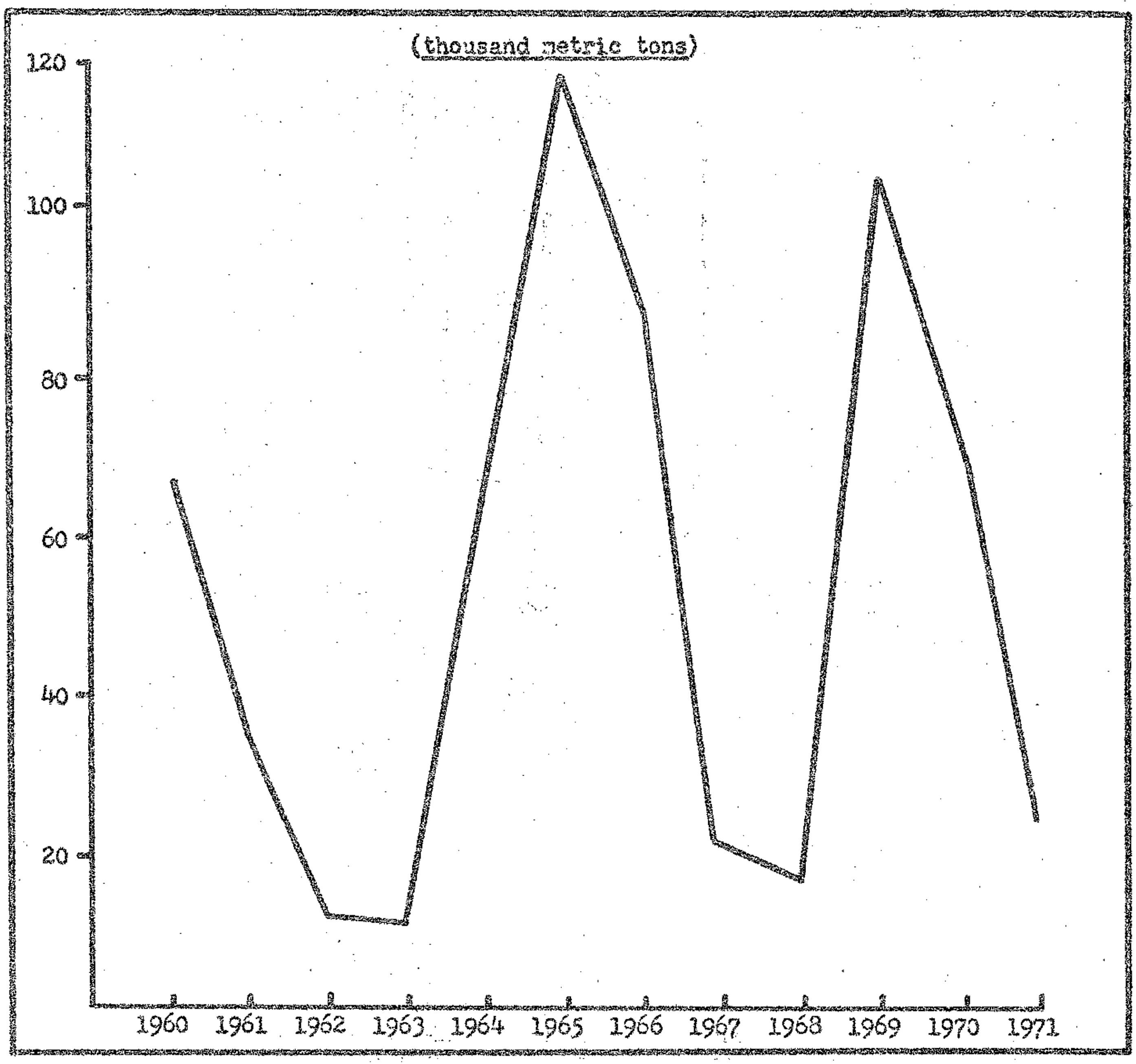
Increased Area

The area used for cassava production doubled in the two decades from 1953-73, rising from 1.1 million to 2.2 million hectares (6, pp. 83-84; 12, p. 133). This trend is likely to continue as new land is brought into production. The ability of cassava to thrive on poor soils can be exploited on new land of marginal quality as well as long-cultivated land of low fertility.

Increased Yield

Despite its outstanding ability as a reliable producer of food calories under marginal conditions, cassava has been somewhat neglected by researchers until recent years. Far more attention has been paid to crops

FIGURE 10. BRAZIL'S EXPORTS OF CASSAVA PRODUCTS, 1960-71*



*Source: Truman P. Phillips, Cassava Utilization and Potential Markets, (IDRC-020e, Ottowa, 1974), p. 86.

either grown in the developed countries or grown for export to the developed countries than to the staple food crops of the tropics. Figure 11, a comparison of actual and potential yields of some major staple food crops, emphasizes the extent to which cassava's potential has yet to be realized, as well as the tremendous gains that can be made through research. Great progress can be made not only by improving the way the crop is grown but also by changing the plant itself through selective breeding. Cassava research has been stepped up in the past decade. Research on all aspects of cassava production is now being carried out at several tropical research facilities. Major emphasis is being placed on cassava at the International Center for Tropical Agriculture (CIAT) in Colombia, the International Institute for Tropical Agriculture (IITA) in Nigeria, the University of Bahia in Brazil, and the Central Tuber Crops Research Institute in India.

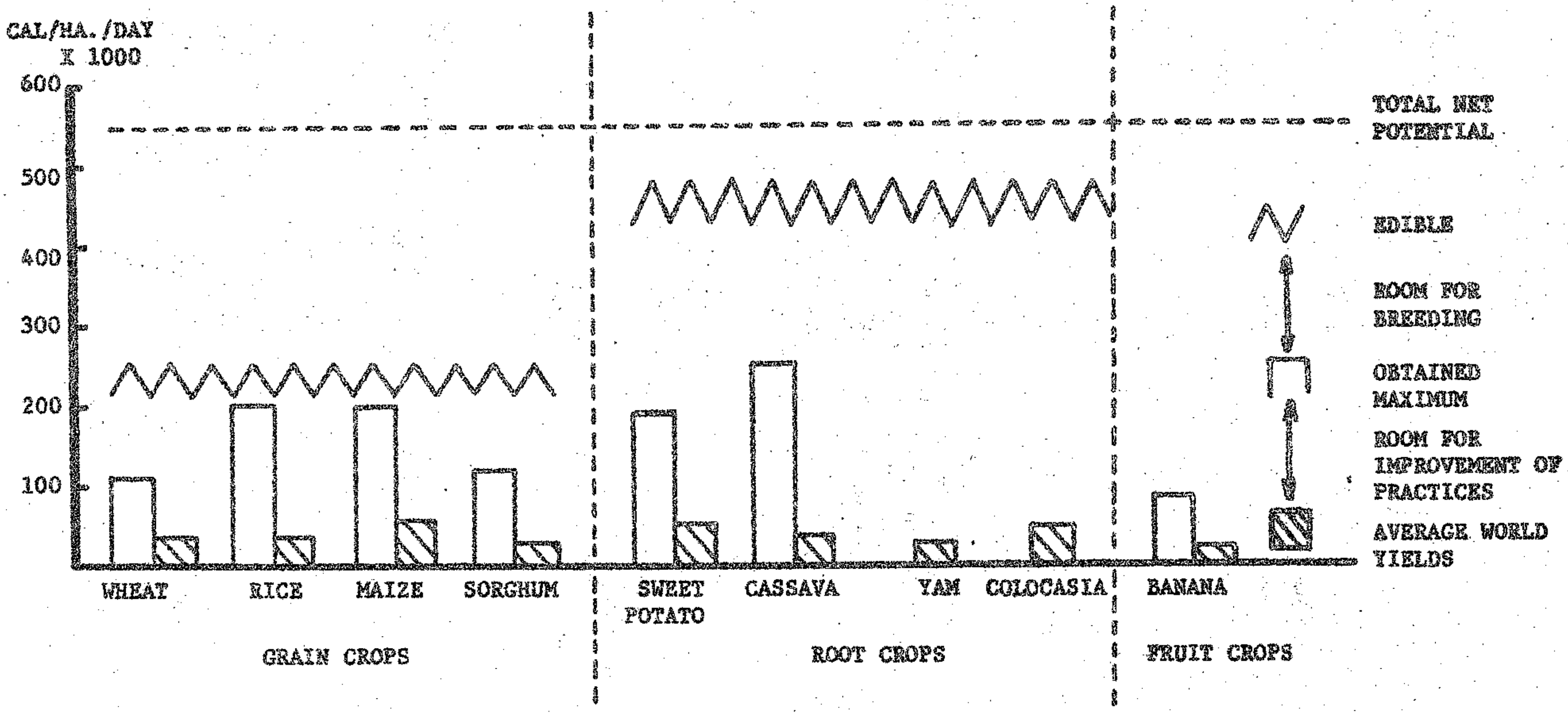
Production Practices

Studies of cultural practices in cassava production indicate there is room for improvement over traditional practices in many instances. One example of this is the potential for yield increases through higher plant populations. A CIAT study of the effect of plant population on yield (Figure 12) indicated that the plant spacing commonly used by farmers, giving a population of approximately 10,000 plants per hectare, may be too low for optimal yields. The yield of marketable roots in the CIAT test was somewhat higher when a population of 20,000 plants per hectare was used. When the population was increased to 40,000 plants total yield increased, but the effects of crowding resulted in a high percentage of roots too small for marketing. Undoubtedly the optimal plant population will be found to vary according to other production practices and variety grown, but agronomic research is needed to clarify the relationships. Increases in yield can also be expected with the mechanization of land preparation, the use of chemical fertilizers, and the application of insecticides. These inputs will be used to a very limited extent in the subsistence farming sector, but are being used to an increasing degree on commercial farms.

Disease-free Planting Material

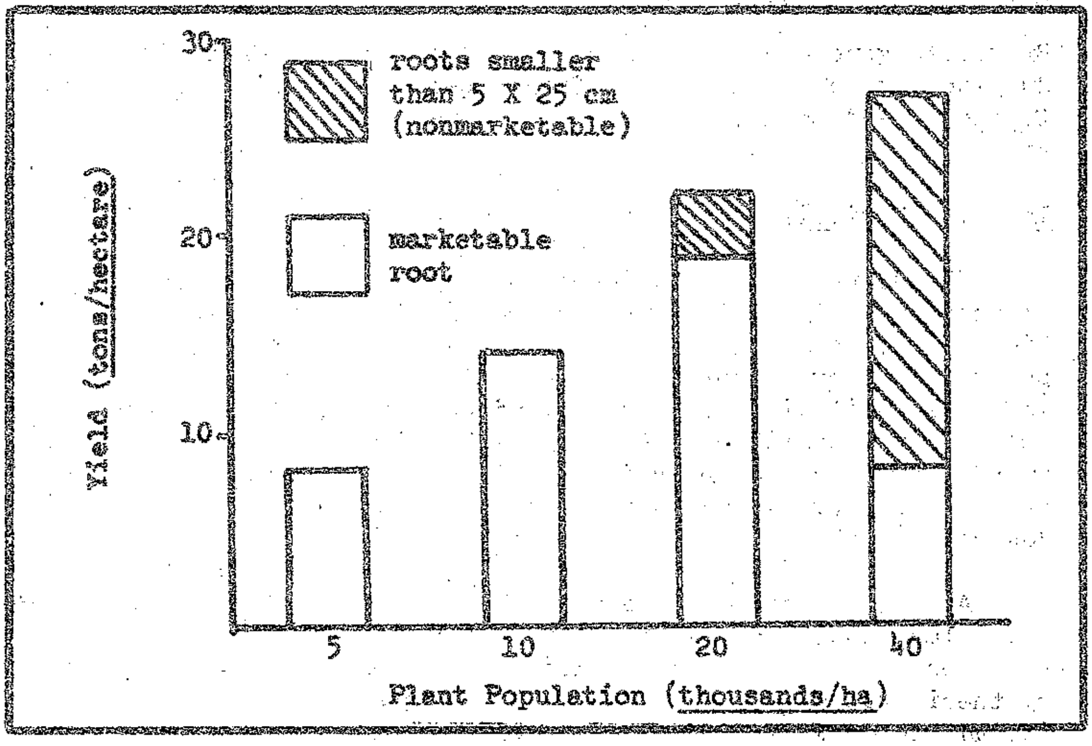
In crops that are propagated with vegetative plant parts, such as tuber pieces or stem cuttings, a major production problem is the difficulty of maintaining disease-free planting material. In cassava, certain viruses and bacteria can be transmitted through the stem cuttings, thus perpetuating and spreading the diseases they cause. One of the worst of these is cassava bacterial blight, which causes such serious losses that land has sometimes been taken out of cassava production because of it. To break into the cycle of transmission, CIAT has developed a scheme designed to insure the production, multiplication, and dissemination of disease-free planting material. This system, coupled with the eradication of the pathogen from infested fields, could significantly reduce losses from this disease (16, p. 83). Programs like this are very difficult to implement among subsistence farmers and would require that the

FIGURE 11. AVERAGE WORLD YIELDS, MAXIMUM OBTAINED YIELDS IN SELECTED TROPICAL EXPERIMENT STATIONS, AND ESTIMATED POTENTIAL YIELDS TO BE REACHED THROUGH BREEDING AND RESEARCH*



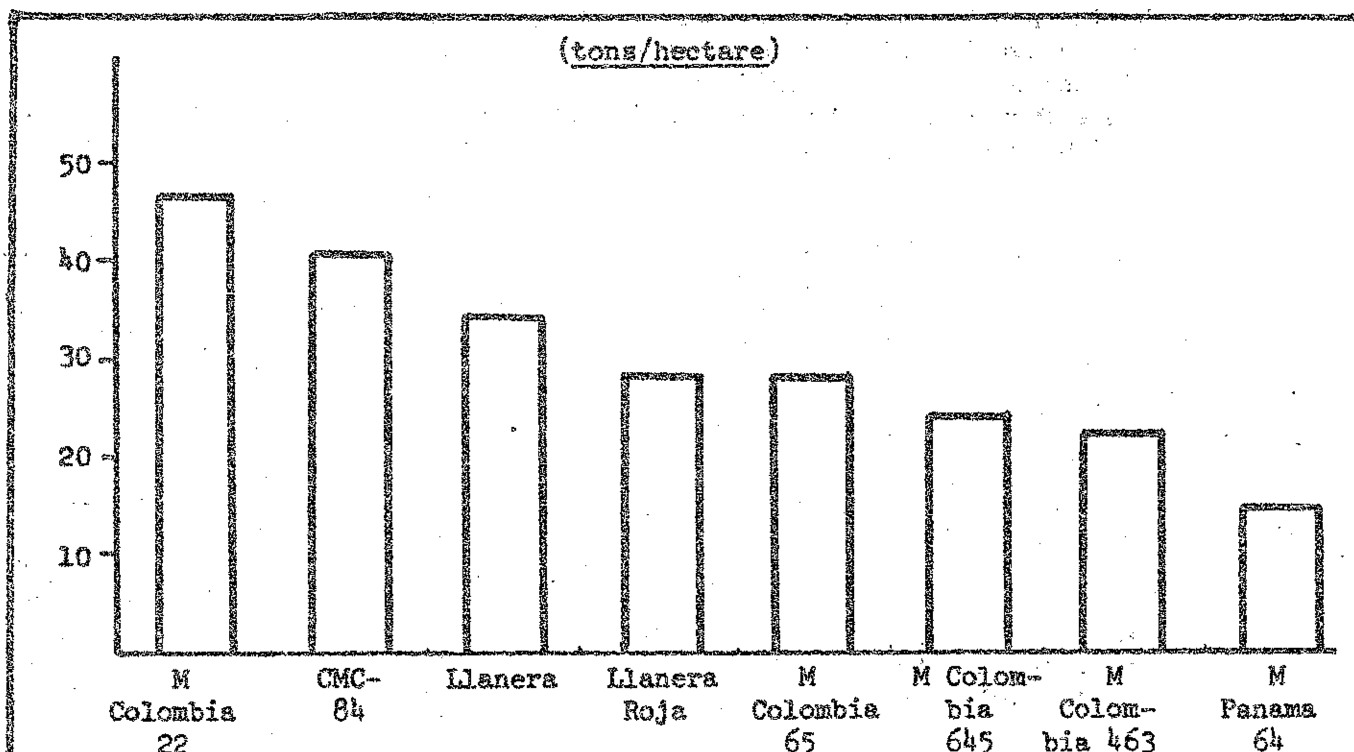
*Source: C. A. deVries, J. D. Ferwerda, and F. Flach, "Choice of Food Crops in Relation to Actual and Potential Production in the Tropics," Neth. J. Agric. Sci., Vol. 15, p. 246, 1967.

FIGURE 12. EFFECT OF PLANT POPULATION ON TOTAL AND MARKETABLE YIELD AT LA ZAPATA, VALLE, COLOMBIA, 1973*



*Source: Centro Internacional de Agricultura Tropical (CIAT), CIAT Annual Report, 1974 (Cali, Colombia, 1974), p. 88.

FIGURE 13. YIELD PERFORMANCE OF SEVERAL CASSAVA VARIETIES AT CALI, COLOMBIA, 1973*



* Source: Centro Internacional de Agricultura Tropical (CIAT), CIAT Annual Report, 1974 (Cali, Colombia, 1974), p. 90.

Brazilian government take more than its usual interest in cassava production, but could have significant benefits if given the necessary financial and technical support accompanied by the necessary extension efforts.

Improved Varieties

The scope for increasing cassava yields through plant breeding seems tremendous. Figure 13 compares the yield performances of several varieties tested at Cali, Colombia. One variety in the test produced 46 tons per hectare, over four times the world average yield, on relatively infertile soil with the use of limited inputs. In the cassava germplasm collections assembled at CIAT and IITA, variability has been identified in almost all characteristics examined. This variability gives breeders the opportunity to manipulate genetically diverse material into more desirable combinations.

An "ideal" cassava plant has been envisioned by cassava researchers. This plant would have a structure designed to photosynthesize at maximum efficiency and an enhanced ability to translocate the products of photosynthesis rapidly to the roots. The components of this "ideal" plant include an optimal ratio of leaf area to ground area, a long life for individual leaves, and at least nine swollen roots.

Although cassava is prized for its relative freedom from devastating pests and diseases, it is subject to sufficient pest and disease damage to keep its yields significantly below potential levels. A major thrust of breeding programs is to identify resistance to the major insects and diseases affecting cassava and to incorporate it into new varieties. Resistance to most cassava pests and diseases has been identified either in cassava itself or related species with which cassava can be crossed. The use of resistant varieties will have special importance to subsistence farmers who often do not have the means to obtain and utilize control measures that require purchased inputs.

V. Prospects for Improving Storage and Utilization of Cassava in Brazil

Considering the huge production potential of Brazil and the likelihood of raising cassava yields through breeding and research, it appears that the future role of cassava as a food resource of Brazil may be defined and limited by storage and utilization rather than production problems. A significant expansion in its role could be envisioned if the crop could be stored and processed easily and consumed in more nutritious, safe, and preferred forms. The projections for 1980 made by Phillips (1, p. 90) indicate that Brazilian demand for human food will then be about 14 million tons. Projections of 1980 production range from 40 million to over 50 million tons. One of the best ways to take advantage of this production is to feed more cassava to livestock, and ways to accomplish this should be explored. Lastly, the prospects for increasing the volume of cassava exports should be considered.

Storage

The flexibility of the system for marketing and processing cassava tends to be limited by the extremely short storage life of fresh roots. For the subsistence farmer who can simply leave the plants growing and harvest roots as they are needed, this limitation is of little consequence, except for the gradual loss of quality and the otherwise unnecessary occupation of land by the standing crop. As attempts are made to commercialize the crop, the necessity of transporting the roots to distant markets and maintaining their quality until they are sold makes short storage life a serious constraint in marketing fresh roots. Storage problems are also inconvenient for any system involving central processing, for it is not feasible to maintain even a few days' supply of roots at the processing plant. The storage life of cassava roots may be increased from the present three to five days to as long as one to three months by using a structure similar to the European potato clamp, in which a pile of 300-500 kilograms of roots is surrounded by a layer of straw and covered with soil in a 10-15 centimeter layer. If the process is successful, which depends to some extent on the external environment, the roots undergo a "curing" process, giving them a much longer shelf life than fresh roots. Another method of prolonging cassava's storage life is to pack roots in boxes with rice hulls, sawdust, or similar material surrounding them (17, pp. 45-47). The wide ranging genetic variability in the cassava germplasm collections lends itself to solving some of cassava's post-harvest deterioration problems through plant breeding.

Utilization

As Human Food

The expanded use of cassava as human food can be enhanced by solving problems related to nutritional quality, toxicity, and preference by consumers. The most severe criticisms of cassava have often been directed at its low protein content, and a number of possible remedies for this shortcoming have been attempted or suggested:

1) The use of cassava leaves. Cassava leaves contain 4-7.5 percent protein on a fresh-weight basis and are eaten quite widely in some countries, but not in Brazil (2, p. 10, 31). In rat feeding trials, cassava leaf meal from sweet varieties was found to be a good supplement to a cereal-based diet at levels of up to 6 percent of the total diet (18, pp. 61-65).

2) Protein-enriched cassava flour. Feasibility tests have been made in Brazil to assess consumer acceptance of cassava flour fortified with protein from various sources. Roasted flour enriched with soybean protein was readily accepted by the consumers who sampled it (1, pp. 84-85) and more extensive trials are being conducted. It seems questionable, however, whether a product of this kind will significantly improve the protein intake of the poorest segment of the population, since it requires central processing and will necessarily be more expensive than nonfortified flour.

3) Cassava as an ingredient in composite bread flours. Cassava flour in a composite mixture based on wheat flour can be used in proportions of up to about 20 percent without having drastic effects on the baking quality of the mixture. By law, all bread sold in Brazil must contain a small percentage (one to three percent) of cassava flour (1, p. 22). This is a good import-substitution policy, but is not likely to change the situation of the poorest segment of the population.

4) Cassava as a substrate for producing fungal protein. The production of a fairly high-protein product based on the fermentation of cassava by a fungus, supplemented by an inorganic nitrogen source, has been accomplished experimentally, but the efficiency of conversion was low and the incidence of contamination by undesirable micro-organisms was high. The prospects of obtaining from this process a product of acceptable texture, taste, and price, using village-level technology, are considered poor (19, pp. 179-194).

5) Breeding for higher protein content. Early efforts in Indonesia to breed cassava varieties with relatively high protein content were unsuccessful (20, pp. 107-112). Recently, some cassava varieties with higher than average protein levels have been identified. The variety "Llanera" has two to three times the average protein content (21, p. 31). However, the protein in cassava tends to be poorly balanced and to have low digestability (1, pp. 127-128).

Each of the proposals for solving the protein-deficiency problem of cassava suffers some limitation in terms of quality, cost, or acceptability. The prospects for molding cassava into a food which, eaten alone, satisfies all nutrient requirements, are poor as they are for most other food crops. This does not detract from its value as a supplier of energy.

The presence of HCN in cassava is considered a potential barrier to its expanded utilization and was the subject of an interdisciplinary workshop held in London in 1973 (7). More research is needed to establish safe levels of HCN for human consumption and to evaluate existing and potential methods of HCN removal. Environmental effects have a large but poorly understood effect on the HCN content of given varieties, making toxicity ratings more difficult to obtain. Although no cassava varieties with zero levels of HCN have been identified, it does appear feasible and practical to breed for low levels of HCN. A potential drawback of this approach is the possibility of increased susceptibility to insects or diseases in less toxic varieties. HCN level is not believed to be a factor in insect resistance, but its effect on disease resistance remains unknown (22, pp. 38-39).

As Domestic Livestock Feed

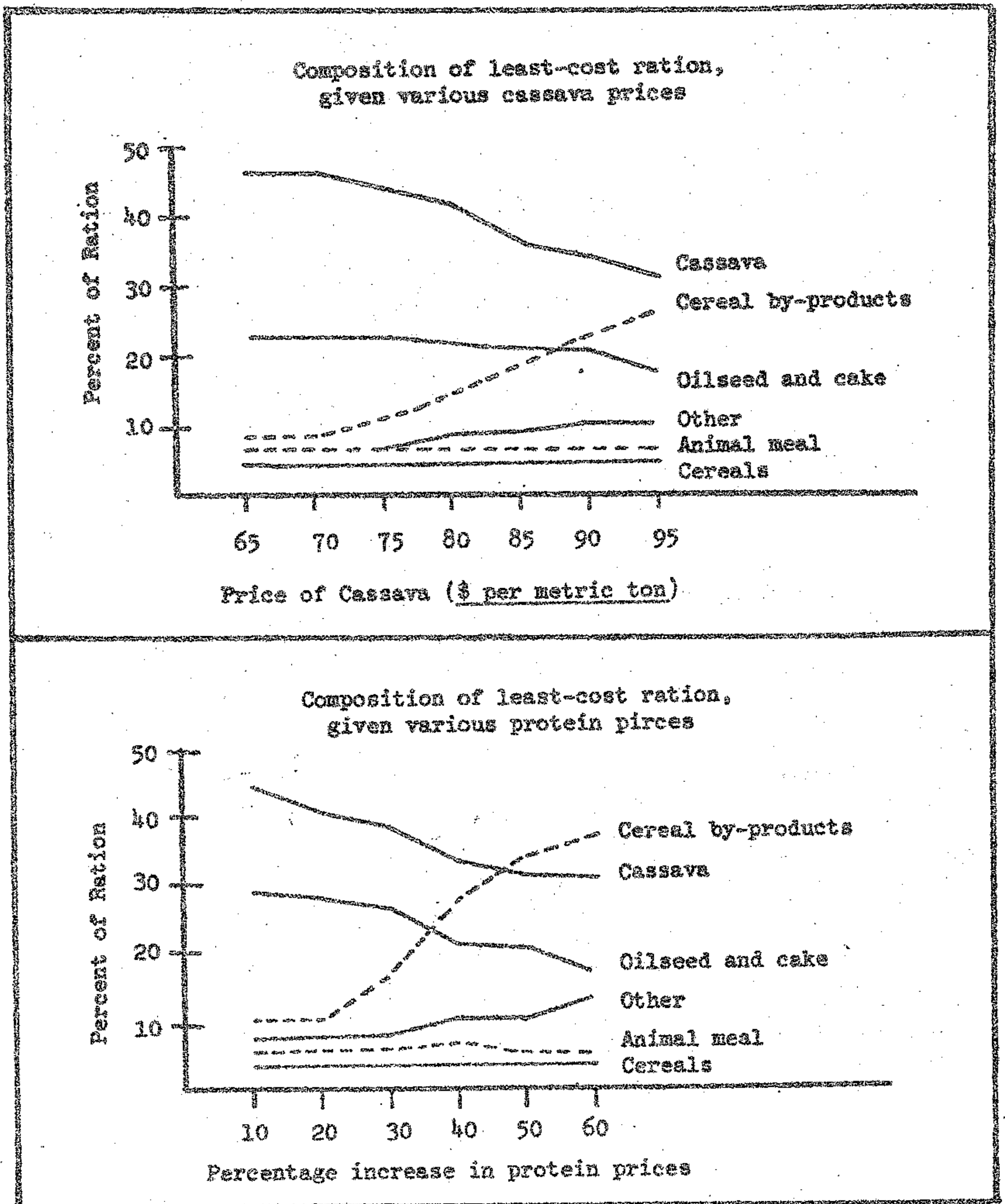
Meat production in Brazil nearly doubled from 1948-52 to 1971 (1, p. 86). Exports of beef have climbed from 29,000 tons in 1961 to 115,000 tons in 1971 (23, p. 194). Brazil's cattle population in 1970 was estimated at 78-98 million head, or about the same number as the human population. Despite the size of the cattle herd, the annual per capita meat output was only 18 kilograms, reflecting the generally low level of technology employed in beef production. A primary reason for the low productivity of the cattle herds is the seasonal weight loss that occurs during the winter months. The Brazilian government is anxious to increase meat production to satisfy rising domestic demands and also to increase exports to a foreign market that is expected to expand (23, pp. 183-197).

A significant and increasing proportion of Brazil's cassava crop is presently being fed to livestock, usually in the form of fresh roots or as the whole plant which has been put through a hammer mill (13, p. 61). This use should continue to increase at least as rapidly as livestock production increases. In the production of beef with relatively extensive methods, there is a place for increased feeding of cassava as a relatively cheap supplement to seasonally inadequate pastures. In hog production and more intensive beef production enterprises which have developed in the South and Southeast, cassava can be used to advantage as an energy-supplying component of compound feeds.

In compounded feeds, cassava plus a protein supplement can be used in place of cereal grains. The percentage of cassava that can be used economically depends on the relative prices of cassava, protein supplement, and cereal grains, and on the needs of the class of livestock being fed. The use of cassava tends to be most attractive economically for feeding animals that do not have a high protein requirement, such as pigs being fattened (24, p. 11). The effects of changing cassava and protein prices on the composition of a least-cost pig ration in the Netherlands are shown in Figure 14. In swine-feeding experiments at CIAT, rations containing up to 60 percent cassava were used. At this level, the performance of the animals declined unless the diet was well supplemented with methionine, an amino acid in which cassava is particularly deficient. It was suggested that the use of cassava in pig rations becomes economical when the cost of an 85 percent cassava meal:15 percent soya meal mixture is cheaper than the cost of corn. CIAT is also experimenting with swine feeds based on cassava silage plus a protein supplement. Preliminary results indicate that this may constitute a desirable ration. To eliminate the need for a protein supplement in cassava-based rations, the fungal fermentation processes originally aimed at human food technology are being examined more closely. The problem of contamination by undesirable organisms in the fermentation process may have been solved by the use of a species of Aspergillus which grows at temperatures of about 50°C., too warm for most contaminants. This process, developed in 1973 and now being tested on a pilot-plant scale at CIAT, has promise of producing a 15 percent protein livestock feed at low cost, using village-level technology (25, pp. 11-13).

Cassava may also be used in cattle feeds, but usually at a lower level than in swine rations. In the Netherlands, it is fed mainly to mature cattle at a maximum rate of 10-20 percent in the diet (26, p. 20-21). Cassava is also fed to poultry and rabbits as a component of compound feeds (1, pp. 52-53).

FIGURE 14. EFFECT OF CHANGING PRICES FOR CASSAVA OR PROTEIN SUPPLEMENT ON THE COMPOSITION OF LEAST-COST PIG RATIONS IN THE NETHERLANDS*



* Source: Truman P. Phillips, _Cassava Utilization and Potential Markets_ (IDRC-020e, Ottowa, 1974), pp. 50-66.

The development of a compound feeding industry which utilizes cassava is most likely to occur where livestock production and cassava production are relatively sophisticated and commercialized and where there is a large market for livestock products. These conditions are most prevalent in the South and Southeast.

As Livestock Feed for Export

Until quite recently, very little cassava was used in developed countries as livestock feed. The extensive use of cassava in compounded feeds began in Europe in the early 1960s when the Common Agricultural Policy of the European Economic Community (EEC) was implemented. The EEC price policy has maintained the price of cereal grains at levels of from 48-77 percent higher than the world market price (7, p. 20). This, coupled with relatively liberal policies toward the entry of protein supplements and cassava products, made it profitable for feed compounders to import large amounts of cassava, particularly into the cereal importing countries of Germany, the Netherlands, and Belgium. EEC imports of cassava have risen rapidly, reaching 1.9 million tons in 1973 (1, p. 43). The bulk of these imports originate in Thailand, whose exports rose from .4 million tons in 1962 to over 1.4 million tons in 1973, earning some $75 million in foreign exchange (27, pp. 52-53).

Cassava in Thailand is grown exclusively as a cash crop. Human consumption is negligible, although it is used to a certain extent for domestic industrial purposes. It is sold by farmers to operators of small processing plants in which it is cut into irregularly shaped chips and spread over large concrete floors for drying. It is then sold to the operator of a somewhat larger plant, where it is pressed into pellets through a process of extrusion under pressure through holes in a metal die. The resulting pellets are about 1 centimeter in diameter and 2 centimeters long. There are approximately 90 pelleting factories and about 500 chipping and drying factories in the country. Of the pelleting factories, approximately 25 percent use machinery of European construction and are operated by German exporters, with the remainder being locally operated. Pellets produced by the European machines are considered better in quality and receive a higher price than "native" pellets (28, pp. 31-36). 36). The major complaints lodged against the Thai products are that their starch content is too low, they are adulterated with sand and other foreign material, and they are often contaminated with bacteria and molds (29, p. 121). Still, the European buyers continue to purchase more of them each year.

Prices paid to farmers for fresh roots have been kept low, never more than $20 per ton, and usually closer to $10-12 per ton. The price of pelleted cassava at dockside in Thailand has ranged from $35-40 per ton in 1970 to as high as $75-80 per ton in 1973. When shipping costs of approximately $14-19 per ton are added, the cost of the pellets delivered to European ports has been in the range of $60-95 per ton (1, pp. 102-105; 30, p. 125; 31, pp. 3-7).

Future demand for cassava in the EEC will depend on several factors: 1) world cereal grain prices, 2) future policy toward importation of cereal grains, cassava, and protein supplements, 3) further expansion of demand for livestock products, 4) expansion of the compound feeding industry, and 5) willingness of feed compounders to use more cassava in the feed formula when it is economically practical for them to do so--this may depend on the ability of exporters to supply a high quality product on a dependable basis. Phillips has made projections indicating that the demand for cassava in the EEC in 1980 should lie between 3.5 and 9 million tons, an increase of from two to six times the 1970 levels. He speculates that the current high feed grain prices may lead to the use of cassava in other developed countries. Japan, for example, would find it profitable to import up to one million tons of cassava annually if import barriers against it were removed. It may be economically attractive to import cassava into certain areas of North America which happen to have good port facilities and are distant from domestic grain production. Another potential market for cassava as livestock feed is Eastern Europe, where feed grains are deficient and livestock production is being emphasized (32, pp. 16-18).

The ability of Thailand to continue to dominate a greatly expanded world market for cassava is somewhat doubtful. Thai processors and exporters expect to be able to provide about two million tons of processed cassava by 1980 (1, p. 99). If EEC demand reaches projected levels, this market alone will offer significant opportunities for other cassava producing countries to increase their exports. It has been estimated that in order to enter the world market, the exporter must be able to provide pellets at an end-user price of $90-95 per ton, which, given the 2.5:1 ratio of fresh roots to finished product, requires that production and processing costs not exceed $16-22 per ton of fresh roots (1, p. 63).

With such enormous production potential, there is little question of Brazil's ability to produce enough cassava to capture a large share of the future world market. Phillips' projections of Brazil's 1980 production indicate a surplus of 16-27 million tons after demands for human food and domestic livestock feed are satisfied. Converted into pellets, this surplus would yield about 7-11 million tons (1, p. 90).

Of crucial importance to establishing an expanded export market will be the ability of Brazilian exporters to provide a dependable supply of high-quality product at a competitive price. The erratic pattern of Brazilian exports of cassava products during the 1960s, when the EEC market for cassava was steadily increasing in volume, would suggest that the present marketing system is unable to respond effectively to world demand (Figure 10). From 1964-71, Brazil has exported cassava in the form of chips to Western European countries each year, mainly from the port of Santos, near São Paulo. The amount exported has ranged from 3,000 to 41,000 tons per year, and prices have ranged from $42-57 per ton (1, pp. 87-90). These prices are competitive with cassava products from Thailand, but the amount supplied at these prices has not been steady. The importance of cassava in the diet of Brazilians results in competition between domestic demand and export opportunities, and it will be difficult to establish and maintain foreign markets unless the cassava produced for export can be somewhat insulated from wide fluctuations in domestic prices. This could conceiveably be accomplished through such means as 1) production on the basis of contracts among growers, processors, and exporters, 2) production and processing on cooperatives having agreements with exporters, 3) production and processing on large plantations, or 4) government support of exports.

For shipping and handling in international trade, pellets are the preferred form, although chips are satisfactory for the domestic trade in livestock feed. Chipping and drying may be accomplished on a small scale with only a few hundred dollars in capital investment, but pelletizing operations are more heavily capitalized. An economic study by the Tropical Products Institute arrived at estimates of approximately $225,000 and $350,000 as the total costs of plants capable of producing 4900 tons per shift per year and 9800 tons per shift per year, respectively (33, pp. 26-27).

The best prospects for developing a large industry based on cassava exports as livestock feed seem to lie in the South and Southeast, where cassava is grown on a commercial scale, where it is less important as a human food than in the Northeast, and where fairly well developed port facilities exist. The expansion of the industry in the Northeast would face more difficulties in terms of infrastructural needs as well as more competition with the market for human food. An active role by government, however, could substantially enhance prospects for the Northeast.

Another Potential Market

Before drawing any conclusions about cassava's future role as a food resource in Brazil, one potentially important nonfood use should be considered. There is considerable interest in the widescale production of cassava for the purpose of ethyl alcohol production. Brazil has been particularly hard-hit by high oil prices in recent years since most of its oil is imported. Cassava starch can be fermented to produce ethyl alcohol. This was done on a commercial basis before World War II; since then, sugar has been the primary raw material for this purpose. To stretch its supply of gasoline Brazil is now blending it with 15 percent alcohol for certain industrial uses, such as steel smelting, and an automobile engine designed for the combustion of alcohol is being designed (34, p. 417). The renewed interest in cassava as a source of alcohol stems from the urgent need to substitute for petroleum products, the reluctance to cut into the foreign exchange earnings of sugar exports, and a desire to develop the Northeast, where there is much cassava and much poverty. A factory with a capacity of 20,000 liters of alcohol per day has been authorized in Minas Gerais and a second large plant is planned in Bahia, in the Northeast (35, pp. 112-114).

VI. Conclusion

There is great potential for expanding cassava production in Brazil, both by expanding the area of production and by increasing yields. The problems involving storage and utilization of cassava will probably continue to limit its future role to an extent at least as great as those involving production capability. Cassava will continue to be an important food crop of Brazil. Perhaps the most promising area in which cassava utilization can be expanded is in the production of compounded domestic livestock feed. Exports of cassava for livestock feed may also be expanded significantly, but the conditions governing the size of this market are subject to change and Brazil's ability to supply the world market is subject to competition with the domestic market. If the large scale use of cassava for the production of alcohol as a gasoline substitute becomes a reality, cassava's role as a food resource will be substantially altered. In any case, the tremendous production potential of this crop is likely to be exploited to an increasing extent as Brazil strives to feed its growing population and develop its economy.

Citations

1 T. P. Phillips, Cassava Utilization and Potential Markets (IDRC-020e, Ottowa, 1974).

2 W. O. Jones, Manioc in Africa (Stanford, Calif., 1959).

3 Barbara S. Renvoize, "The Area of Origin of Manihot esculenta as a Crop Plant--A Review of the Evidence," Economic Botany, Vol. 26, 1972.

4 J. W. Purseglove, Tropical Crops: Dicotyledons, Vol. 1 (London, 1968).

5 John Nieuhoff, "Voyages and Travels into Brazil," in John Pinkerton, ed., A General Collection of the Best and Most Interesting Voyages in All Parts of the World, Vol. 15 (London, 1813).

6 FAO, Statist. Div., Production Yearbook, 1973 (Vol. 27, Rome).

7 Barry Nestel, "Current Utilization and Future Potential for Cassava," in Barry Nestel and Reginald MacIntyre, eds., Chronic Cassava Toxicity (IDRC-010e, Ottowa, 1973).

88 D. G. Coursey and P. H. Haynes, "Root Crops and Their Potential as Food Crops in the Tropics," World Crops, July-August, 1970.

9 B. F. Johnston, The Staple Food Economies of Western Tropical Africa (Stanford, Calif., 1958).

10 D. G. Coursey, "Cassava as Food: Toxicity and Technology," in Barry Nestel and Reginald MacIntyre, eds., Chronic Cassava Toxicity (IDRC-010e, Ottowa, 1973).

11 T. T. Poleman, "The Food Economies of Urban Middle Africa: The Case of Ghana," Food Research Institute Studies, Vol. II, No. 2, May 1961.

12 FAO, Statist. Div., World Crop Statistics--Area, Production, and Yield, 1948-64 (Rome, 1966).

13 Elton Santos, personal communication.

14 E. S. Normanha, "General Aspects of Cassava Root Production in Brazil," in Proc. 2nd Int. Symp. on Trop. Root and Tuber Crops, D. L. Plucknett, ed., (Honolulu, 1970).

15 Getulio Vargas Foundation, Food Consumption in Brazil--Family Budget Surveys in the Early 1960's (São Paulo, 1970).

16 Centro Internacional de Agricultura Tropical (CIAT), CIAT Annual Report, 1973 (Cali, Colombia).

17 R. H. Booth and D. G. Coursey, "Storage of Cassava Roots and Related Post-Harvest Problems," in E. V. Araullo, B. Nestel, and M. Campbell, eds., Cassava Processing and Storage (IDRC-031e, Ottowa, 1974).

18 J. Adrian and F. Peyrot, "Possible Use of the Cassava Leaf (Manihot utilissima) in Human Nutrition," Pl. Fds. Hum. Nutr., Vol. 2 (1971).

19 T. E. Trevelyan, "The Enrichment of Cassava with Protein by Moist-Solids Fermentation," Trop. Sci., Vol. 16 (1974).

20 G. G. Bolhuis, "A Survey of Some Attempts to Breed Cassava-Varieties with a High Content of Protein in the Roots," Euphytica, Vol. 2 (1953).

21 C. H. Hendershott, et al., Literature Review and Research Recommendations on Cassava, AID Contract csd/2497, Univ. Georgia (Athens, Ga., 1972).

22 J. H. Cock, "Cyanide Toxicity in Relation to the Cassava Research Program of CIAT in Colombia," in B. Nestel and R. MacIntyre, eds., Chronic Cassava Toxicity (IDRC-010e, Ottowa, 1973).

23 R. M. Paiva, S. Schattan, and C. F. Trench de Freitas, Brazil's Agricultural Sector: Economic Behavior, Problems, and Possibilities (São Paulo, 1973).

24 D. G. Coursey and D. Halliday, "Cassava as Animal Feed," Outlook Agric., Vol. 8 (1974).

25 B. Nestel, Current Trends in Cassava Research (IDRC-036e, Ottowa, 1974).

26 UNCTAD-GATT, The Markets for Manioc as a Rawmaterial for Compound Animal Feedingstuffs (Geneva, 1968).

27 Deja Tulananda, "Problems of the Thai Tapioca Trade," in E. V. Araullo, B. Nestel, and M. Campbell, eds., Cassava Processing and Storage (IDRC-031e, Ottowa, 1974).

28 P. J. Mathot, "Production and Export Control in Thailand and the Marketing in Europe of Tapioca Pellets," in E. V. Araullo, B. Nestel, and M. Campbell, eds., Cassava Processing and Storage (IDRC-031e, Ottowa, 1974).

29 N. C. Thanh, "Technology of Cassava Chips and Pellets Processing in Thailand," in E. V. Araullo, B. Nestel, and M. Campbell, eds., Cassava Processing and Storage (IDRC-031e, Ottowa, 1974).

30 A. Hone, "Tapioca: A Case Study of India with Particular Reference to Kerala," in T. P. Phillips, Cassava Utilization and Potential Markets (IDRC-020e, Ottowa, 1974).

31 Anne R. McClelland, Developing the Potential for Cassava as a Commercial Livestock Feed in South Vietnam (USAID, Saigon, 1975).

32 T. P. Phillips, "World Market Prospects for Cassava and Its Products," in E. V. Araullo, B. Nestel, and M. Campbell, eds., Cassava Processing and Storage (IDRC-031e, Ottowa, 1974).

33 D. Edwards, The Industrial Manufacture of Cassava Products: An Economic Study (Tropical Products Institute G88, London, 1974).

34 P. H. Abelson, "Energy Alternatives for Brazil," Science, Vol. 189, August 1975.

35 Veja (Rio de Janeiro), Nov. 26, 1975.