ASIAN DEMAND STUDIES

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Asian Demand Study:
Status Report

The economics study of cassava in Asia focuses on detailing the current status of the crop in the principal producing countries. The study relies almost exclusively on secondary data sources. The only primary data collection involved a cost survey of chipping and pelleting factories in Thailand. Depending on existing data sources has often left areas where further detail would have been valuable. This is particularly true for production issues. Nevertheless, Asian countries have well developed data systems, and the economic issues facing cassava could be explored at a sufficient level of detail to give a reasonable outline of a feasible strategy for the crop in the region.

The study is essentially complete in terms of its major findings. A few sections of the study still remains to be completed. The introductory chapter is still being written. It is an historical chapter and has depended on some major bibliographic research which is still underway, especially on early Spanish or Portuguese dissemination of the crop in Asia. The rest of the study is essentially written except the animal feed sections in the Malaysia and China chapters, and the conclusions section to the Philippines, Malaysia, China, and world trade chapters. Finally, time has not permitted the development and typing of all the tables and figures.

In terms of the scope of the study the only significant gaps in a complete regional study are analyses of the cassava sector in Vietnam and Sri Lanka. Sri Lanka is the smallest producer in the region with distinct policies that negatively affect cassava and Vietnam, while a larger producer than Malaysia or the Philippines was not accessible. Leaving out these two countries does not greatly diminish the conclusions of this regional analysis.

The Cassava Economy of Asia:
Adapting to Economic Change

INDIA = KERALA AND TAMIL NADU

It is almost an aphorism that India is a vast, diverse "sub-continent", where over three-quarters of the 684 million people (1981 Census) live in the rural sector subject to the vagaries of the annual monsoons. As might be expected a major concern of agricultural policy has been the capacity of India to feed itself and this has resulted in a commitment to attaining self-sufficiency in food grain production. This goal was achieved in the mid-1970's, essentially by focusing on development of the more productive agricultural regions (Sarma, 1982).

Self-sufficiency, while implying a termination in imports, is nevertheless a relative concept because it implies that demand is defined by production availability rather than by consumption needs. The central government has attempted to overcome this problem by intervening in grain marketing to manage demand. The government operates a public food distribution system at subsidize prices to ensure that a certain minimum level of universal distribution for food grains is achieved independent of income levels.

As Sarma has noted, "This (self-sufficiency) strategy, which was confined to certain crops and areas with assured irrigation, also resulted in the widening of interpersonal and interregional disparities.... The social justice objective, in terms of reducing unemployment or underemployment and alleviating poverty in rural areas, remained largely unfulfilled" (p. 24). The cassava-growing areas in the south of India have been such a region which has remained largely outside the area of impact of the "green revolution" technology. Although cassava is very much a regional crop in India, this is true of most other crops except rice. Analyzing cassava in southern India thus provides some insight into rectifying the disparities between regions in India.

PRODUCTION

Production Trends and Distribution:

Cassava is very much a regional crop in India, although given the size and diversity of the country, this could be said of most any crop. Cassava production is concentrated in the south of India in the state of Kerala and the western part of Tamil Nadu. These two states make up 97% of cassava production in India (Table 1). On a country wide basis cassava makes only a small contribution to total calorie supplies, with production being more or less equivalent to some of the minor coarse grains, such as barly or the small millets. However, in the south of the country cassava ranks second to rice as the major calorie producing crop. Given the range of temperature and rainfall conditions in India, this type of regional specialization in crop production would be expected for non-irrigated crops.

According to the official data series, area planted to cassava in India increased slowly from the mid-sixties to the mid-seventies, reaching a peak area of 392 thousand hectares in 1975-76 (Table 1). Since then cassava area has declined quite markedly, reaching a level of 310 thousand hectares in 1981-82. The trends in area are due principally to changes in cassava plantings in Kerala. Cassava has been widely planted in Kerala since at least the turn of the century. In the 55-year period from 1920 to 1975 cassava area expanded at a relatively slow and uneven rate of 1.3% per annum (Table 2). Since 1975 cassava area has declined rapidly to the same level as the early sixties. On the other hand, area planted to cassava in Tamil Nadu has remained relatively constant at around 50 thousand hectares since the late 1960's.

Production trends are more difficult to evaluate since the basis on which yield has been estimated has been changed twice. In 1963 yield levels in Kerala were revised sharply upward from a trend of 7 t/ha to a rising yield trend starting at 12 t/ha. In 1979 a crop cutting survey was instituted in Kerala and Tamil Nadu and what had been a rising trend in yields in Kerala was revised downward. In Tamil Nadu, on the other hand, yield estimates were dramatically increased. Given these revisions in yield estimates, production trends, which follow from the area and yield estimates, are somewhat meaningless. What can be said with some degree of confidence is that production in Kerala has declined markedly since 1975 at an annual rate of about 5% per annum. Cassava production in Tamil Nadu in the same period has shown a slight increase. The dominant question that arises is the reason behind the declining area and production of cassava Kerala.

Cassava production systems:

Kerala: Kerala is one of the most populous rural areas in the tropics. Population densities in some districts exceed 1000 people per square kilometer. About 81% of the population reside in the rural area according to the 1981 census, while a little less than half of the work force are directly involved in agriculture. However, a more accurate reflection of the population pressure is that while average farm size is only 0.49 of a hectare, only one third of the work force in the agricultural sector have access to land. Moreover, over 70% of the population who do own land have less than half a hectare (Table 3).

As a consequence of this population pressure, land use is very intensive. Excluding forest reserves and non-agricultural uses, 87% of available land is cultivated. The cropping intensity index in Kerala in 1977/78 was 132 percent, well above the average for India as a whole. However, this figure is more remarkable when it is considered that two-thirds of cultivated area is under permanent tree crops. Thus, for area under annual crops the cropping intensity index is 192 percent; that is, a substantial portion of the land under annual crops is double or triple cropped.

Cassava is the most important annual crop in Kerala after rice, making up 38% of the net area sown to annual crops. Two factors explain why cassava has achieved such importance in such an intensive agricultural system. First, the non-irrigated upland areas are characterized by lateritic soils which are low in inherent soil fertility, especially phosphorus, and are quite acidic. Cassava in comparison to most other annual crops, is well adapted to such soils, even with relatively minimal amounts of fertilizer. Second, cassava gives very high carbohydrate yields under these conditions. With average yields around 15 t/ha only triple cropping of rice under irrigation gives higher dry weight yields in the state.

While rice is grown on the irrigated bottomland, cassava is grown on the sloping upland areas. On these upland soils cassava competes primarily with tree crops for land and it is the general concensus that cassava is being displaced by higher value tree crops. However, for the principal tree crops increased plantings of rubber and cashew nut are more then offset by declining area of coconut and black pepper (Table 4). The crop or crops that are displacing cassava remain as unclear from the aggregate data but the strongest hypothesis still remains some combination of tree crops.

Cassava production systems in Kerala are relatively simple, compared to countries such as Indonesia. This is partly due to the constraints on potential intercrops imposed by soil conditions. Annual rainfall in the state averages about 3000 mm, and varies from about 2000 mm in the south to 3800 mm in the north. There is a long dry period from December to March when little rain at all is received. The rains start in April-May when 60-65% of the cassava crop is sown (Hone, 1973). The monsoons arrive in full force in June-July. From 35-40% of the crop is planted in September-October when the rains have fallen off but before the start of the dry season in December.

Land preparation is done completely by hand and any green vegetation in the plot is concentrated in the soil below where the cassava stems are to be sown. The stakes are sown vertically at populations of 10 to 12 thousand per hectare. In such intensive systems weed control is fairly meticulous and when farmyard manure or wood ash is available it is incorporated in the same form as the green manure.

Some chemical fertilizer is certainly used on cassava in Kerala, although there is conflicting data to suggest just how extensive this use is. Certainly potassium fertilizer consumption is a much higher percentage of total fertilizer consumption in Kerala than in India as a whole (33.3%

of consumption as compared to 11.4% in the whole country). Cassava has a higher potassium requirement than grain crops. A National Council of Applied Economic Research survey in 1975/76 found that 83% of cassava area in Kerala was fertilized but that only 19 kg/ha of nutrients were applied to the area fertilized. Desai (1982) has found this survey to substantially overestimate aggregate fertilizer consumption in Kerala. He provides estimates for India as a whole, suggesting that in 1976/77, 38.2% of cassava area was fertilized at a rate of 33 kg/ha. The limited data available thus suggests that there is some fertilization of cassava but at very low rates of application.

The cassava is harvested at about 10 months, with the bulk of the crop being harvested in the dry period from December to February. The percentage of the crop that is sold off the farm is open to some question. A relatively dated report (Tapioca Market Expansion Board, 1972) estimates that about 40% of production enters market channels (Table 5). This would appear a bit low considering that cassava is such a pervasive consumption item in Kerala, that about two-thirds of households in Kerala do not grow cassava, and that household consumption surveys show higher consumption levels for purchased cassava than own production (Table 6). The perversity of the latter is due to the positive relation between income and land ownership in Kerala and the shift from cassava to rice at higher incomes. 40% is then probably a minimum estimate of marketed surplus of cassava in Kerala.

The most common practice is for farmers to sell the standing cassava crop to purchase agents for a lump sum payment. The agents do not necessarily harvest straight away but must harvest before the start of the rains. Farmers, as well, gradually harvest the crop themselves, selling in small lots by the roadside or in local markets. When marketing of the fresh root is problematic, particularly in the north of Kerala, the roots are peeled, sliced and dried as chips during the principal harvest period in the dry season. Wholesale merchants and weekly markets serve as assembly points for roots and chips.

Tamil Nadu: The other major cassava producing zone is in the western part of Tamil Nadu where production is principally concentrated in Salem District. Production systems for cassava are considerably different from those in Kerala and this arises from a change in the limiting production constraint from soil factors in Kerala to moisture availability in Tamil Nadu. Rainfall in the major production area of Salem District averages 820 mm per year. This average, however, masks a very high variation, with annual rainfall in the last ten years ranging from 550 mm to 1250 mm. There is a five-month dry season from January to May when rainfall averages no more than 14 mm in the whole period. This limited rainfall is in many cases supplemented by irrigation.

Farm size for cassava farmers in Tamil Nadu are somewhat larger than that in Kerala. A sample of 70 cassava farmers in Salem District found an average farm size of 2.6 hectares, with an average area sown to cassava of .75 ha (Uthamalingam, 1980). The larger farm size reflects in part the much drier conditions in Tamil Nadu and the relative scarcity of irrigation water. Cassava is grown almost strictly as a cash crop in these cropping systems and competes for land principally with cotton, and to a lesser extent, rice and sugar cane.

Cassava's role in these cropping systems is defined by its access to a ready market (the industrial starch market) and cassava's efficiency in water use. Over 85% of the irrigation water is provided by wells and the farmer must plan his cropping pattern around expected rainfall and available water stored in the wells. When irrigation water is in short supply, farmers turn from rice and sugarcane to cassava or cotton, depending on output prices.

According to the sample of 70 farms in Salem District, 90% of the farms grew cassava under irrigation. The crop cutting survey in all of Tamil Nadu found that 72% of the plots were grown under irrigation. The irrigated crop is planted at the end of the rains in January. Up to four or five irrigations are needed for establishment. Frequency of irrigation afterwards depends on water availability in the wells and the arrival of premonsoon showers in June. On average 20 irrigations are given at an interval of 15 to 20 days.

The rainfed crop is sown at the start of the southwest monsoon in August. The crop is assured of no more than five months of rainfall before the start of the dry season in January, which is followed by the pre-monsoon showers in June-July. A rained crop is often grown on as little as 500 mm of rainfall. The irrigated crop is usually harvested after 8 to 10 months while the rainfed crop requires 12 months before it can be harvested.

Land preparation relies on bullocks and for the irrigated crop the land is ploughed four or five times before forming either beds and channels or ridges and furrows. Plant population is approximately 10,000/ha. Stakes are sown vertically and normally six or seven weedings are done during the course of the crop year.

Fertilization or manuring is a common practice for cassava in Tamil Nadu, especially for the irrigated crop. The crop-cutting survey found that 74% of the cassava plots were either fertilized or manured, using either animal manure or a vegetable compost. The farmer survey in Salem found an average application of 18.5 t/ha of farmyard manure or 15.1 t/ha of compost. Manuring is often combined with application of compound fertilizer. Moreover, cassava is usually planted in rotation with other crops and will often take advantage of residual fertility from fertilizer application on prior crops. However, where cassava is grown in successive years in the same plot, there is a marked tendency for yield to drop. A typical trend is 35 t/ha in the first year, 24 t/ha in the second and 17 t/ha in the third (Tapioca Experiment Station, Salem District, private communication).

In contrast to Kerala most of the cassava is harvested and marketed by farmers; only a small percentage is sold standing in the lot. In the Salem farm sample 87% of the cassava was marketed directly by farmers. The reason for this is the very decentralized nature of the cassava starch processing industry. The industry consists of upwards of 500 relatively small-scale plants distributed throughout the district. Coordination of harvesting by the farmer and processing of the fresh roots at the factory are easily managed without the need of middlemen or large expenditures on transport.

Yields:

By world standards cassava yields in India are high. Yields in the 1980-81 crop year averaged 16.8 t/ha in Kerala and 28.9 t/ha in Tamil Nadu. With the generally intensive level of cultural practices used in Kerala and Tamil Nadu, this high yield is not surprising. The difference in yields between Kerala and Tamil Nadu is due essentially to the poorer soils in Kerala and the use of irrigation and associated higher input levels in Tamil Nadu.

The author is unaware of any farm-level data on distribution of cassava yields in Kerala and therefore of any estimates of yield variance across farms in the state. The district-level data suggest a slight tendency for yields to be higher in the southern and central parts of the state, and lower in the north. Thus, the 1980-81 crop estimates suggest average yields of 15 t/ha in the four southern districts and of 11 t/ha in Kozhikode and 12 t/ha in Malappuram in the north. This limited data suggest little variation in yields across the state but has little implication for across farm variation.

In Tamil Nadu a crop cutting survey in 7 districts in the state found a significant variation in farm-level yields (Table 7). The yield distribution was skewed toward the lower side of the mean and as well exhibited a very extended upper tail; that is, a more or less typical distribution for farm-level cassava yields, apart from the very high mean. Over 15% of the plots had yields of over 37 t/ha with a maximum yield of 84.2 t/ha.

Tamil Nadu provides a perfect example of the yield potential of cassava when grown under very favorable production conditions. Part of the reason why national cassava yields in other parts of Asia never approach such levels is that cassava is usually grown under more marginal agro-climatic conditions. Yet even within a highly productive region such as Tamil Nadu, over a quarter of the farmers are getting less than 15 t/ha. Such typical yield distributions lie at the heart of production research: what factors explain the difference in yields at the low and high end of the distribution and to what extent are these factors a function of farmer management or a function of more or less uncontrollable biological and edaphic factors facing the farmer? The question is critical since it begs the issue of the substantial yield gap for cassava between experiment station and farm-level yields and how closely experimental yields translate into farm-level yields.

Costs of production and labor utilization:

In such densely populated rural areas and in such intensive production systems as exist in southern India, the expectation is that relative to other cassava production areas wage rates will be low, labor input per hectare will be high, inputs that substitute for land will be applied at high levels, and labor costs will be a lower portion of total costs. The available data suggest per hectare labor inputs of 265 days for irrigated systems in Tamil Nadu, 139 days for rainfed systems in Tamil Nadu

(Uthanalingam, 1980) and 200 to 220 days for production systems in Kerala (Kerala State Planning Board, private communication).

The breakdown of labor activities for Tamil Nadu shows that weeding is the principal labor requirement, and makes up 60% of total labor demand, with inputs in rainfed systems requiring about half that in irrigated systems (Table 8). Labor for harvesting forms the next major component in both systems followed by land preparation. Although there is no breakdown for Kerala, labor input per activity probably lies somewhere between the irrigated and rainfed systems of Tamil Nadu, with the exception that labor for land preparation in Kerala is much higher.

Labor input in cassava systems in India is lower than that in Indonesia but significantly higher than labor input in Thailand, Malaysia and the Philippines. This result is expected given the relative differences in the land-labor ratios in the cassava growing regions of the different countries. Moreover, labor costs are a lower proportion of total production costs in India as compared to the latter three countries. In Tamil Nadu labor makes up only 35% of variable production costs and less than 20% of total costs. This is due to the large expenditures on fertilizer and land rental.

A comparison of production costs between Kerala and Tamil Nadu (Table 9) shows that per ton costs are higher in Kerala than Tamil Nadu. The difference is due in large part to differences in yield levels, particularly when it is considered that rainfed systems in Tamil Nadu are of only marginal importance. Moreover, when average yields reported for the state are used in place of the study's sample yields, the difference becomes even more marked. Nevertheless, the flow of cassava is from Kerala to Tamil Nadu and not vice versa. This is due to the very seasonal nature of cassava supply in Tamil Nadu and the fact that opportunity cost of irrigated land when there is sufficient water is much higher than is reflected in average rental rates.

Technology Development:

Not only is there very limited potential for expanding area in cassava in southern India, but competition from other crops has actually resulted in declining area planted to cassava in Kerala. There is an obvious demand for technology that would lead to increases in cassava yields. The question arises, since the production systems are so intensive and cultural practices are of such a high level, whether there is a significant yield gap to exploit?

This issue is at the heart of the work of the Central Tuber Crops Research Institute (CTCRI) in Kerala. Under the Indian Council of Agricultural Research the institute assumes principal responsibility for research on cassava in India. Most of their work is focused on conditions in Kerala where research has been carried out since 1963. Independent research on cassava is carried out in Tamil Nadu at the Tamil Nadu Agricultural University in Corimbatore and the Tapioca Experiment Station, established in 1971 in Salem District as part of Horticultural Department of Tamil Nadu. This division in activities allows research to focus on the very different production systems of Kerala and Tamil Nadu. Moreover, India has had the longest period of continuous research on cassava in Asia.

The search for yield increasing technology in Kerala has focused on essentially four principal factors: (a) improved, high-yielding varieties, (b) soil fertility management, (c) control of African cassava mosaic virus, and (d) intercropping systems. The two principal constraints on increased productivity are perceived to be soil factors and the virus disease. Given the high level of cultural practices in the state, overcoming these two constraints would probably not lead in themselves to much higher yield levels. Major increases in per hectare productivity would have to combine as well improved varieties and intercropping, with the problem in the later being the identification of an adapted legume crop.

During the early years of CTCRI when a germplasm bank was being assembled, one selection from Malaysia, M-4, was released and found wide acceptability with farmers. This variety has since set the standard and developing hybrids to replace M-4 has been a difficult task. Only five hybrids have been released since the inception of the institute: H-165, H-97, and H-226 in 1970 and H-2304 and H-1687 in 1977. A fertility trial carried out at the experimental station arguably gives some indication of potential yield gain with these varieties (Table 10). Average yields of M-4 at intermediate fertilizer levels are at about the state average of 15 t/ha indicating little gain to be achieved by agronomic practices. The hybrid H-2304 yielded 24 t/ha at intermediate fertilizer levels and 32 t/ha at relatively high fertilizer levels.

Because most cassava grown in Kerala is consumed as a boiled root, quality characteristics are very important. This has probably been one of the principal factors limiting the wider adoption of the hybrids. These quality characteristics include HCN content, short cooking time (due to limited fuel resources of households), softness with cooking (apparently related to the ratio of anylose to amylopectin), good consistency (high starch content), and to a more minor extent, whiteness of the flesh (H-1687, for example, is yellowish due to a high carotene content). M-4 is recognized to have good culinary quality and for these properties to be stable across locations and through the growing season. The result is usually a price discount for roots from the hybrids; for example, farm prices of 0.90 rupees/kg for M-4 versus 0.75 rupees/kg for H-1687 (field notes, 1982). Thus, a 25% yield advantage is almost canceled by a 20% price discount.

Besides higher yielding ability and root quality characteristics, the other major breeding objective is field tolerance to cassava mosaic virus. M-4, though brought from Malaysia where the disease does not exist, has relatively high field tolerance as do almost all the released hybrids. Tolerance does not imply immunity with this disease and tolerant varieties must be combined with adequate selection of clean planting material, since this is the principal means of spreading the disease. Unlike in West Africa where the disease is easily spread by the white fly vector, effective infection in India is only 2 to 5%.

The final two breeding objectives are short maturity and plant type compatible with intercropping systems. The latter is complementary to the research on intercropping systems. Most of the cassava in Kerala is grown in monoculture, due in large part to the lack of adaptation of potential commercial intercrops to the lateritic soils. The institute is having some success in promoting peanuts as a suitable intercrop with cassava. Moreover, since cassava is planted continuously for many years in the same plot, maintaining soil organic matter is difficult. Long term fertility trials have shown that applying farm yard manure with fertilizer gives a significantly higher yield than fertilizer alone and that manure appears to be necessary in maintaining yield levels over time (CTCRI, 1980 and 1982).

Increasing cassava production in southern India is dependent on increasing yields. These yield increases in turn, depend on the development of high-yielding varieties that do not sacrifice quality for yield and that are tolerant to cassava mosaic virus. The improved varieties in turn imply heavier demands on soil fertility and thus higher rates of fertilizer application. Although the research objectives are quite straight forward, after twenty years of consistent breeding effort, CTCRI has found the progress to be slow, in part because substantial effort at the beginning had to be devoted to more basic studies, since little basic research had been done on cassava upto that point in time, in part because their varietal evaluation system requires approximately ten years from cross to potential release of a new variety and, possibly, in part because the recombination of all desired characters has a low probability. The efforts upto this point in time suggest that a goal of average farm-level yields of 25 t/ha is a feasible objective. If the goal is worth pursuing depends in turn on the prospective outlook for utilization of the cassava crop.

MARKETS AND DEMAND

A synthesis of production and utilization:

The modicum of uncertainty surrounding the cassava production estimates and the paucity of data on cassava consumption in its various end uses makes the development of a consistent supply and distribution series a speculative enterprise. The exercise will be attempted by first separating Kerala and Tamil Nadu, then reviewing the available consumption data for each state, and finally integrating these estimates with the production estimates. The result will then provide the basis for an evaluation of cassava markets and demand in southern India.

Kerala: An analysis of cassava utilization must begin with an estimate of human consumption of fresh roots. Several estimates exist but as can be seen in Table 11, there is a substantial range in these estimates. Given that Kumar's sample introduces a substantial upward bias in the cassava consumption estimate - consumption is higher in the southern districts, in rural areas, and in the lower income strata -, the striking feature is the difference between the estimates from food balance sheets and those from sample surveys. The George and Kumar samples have upward biases in their estimates of per capita consumption. The National Sample Survey is probably the best structured sample and thereby estimate of consumption levels. Since fresh human consumption is considered the largest single market for cassava, the difficulty arises of how to account for the difference between the consumer sample estimate and that derived from production estimates.

Dried cassava chips are also produced in Kerala, principally in the northern districts and primarily in the period October to April. These chips go into various end uses. Dried cassava can be prepared in the home and eaten, especially when fresh cassava is not available. Cassava flour is also produced by grinding the chips. At least one factory operates in Malappuram exactly for this purpose. The flour is in turn used to produce fine noodles. Often the flour is produced in the home. Also, large starch factories also buy chips for processing, particularly for glucose production. Finally, from 1955 to 1966 cassava chips were exported. After that exports ceased until just recently and since 1977 India has again been exporting modest amounts of cassava chips.

Statistics on production and utilization of cassava chips are practically non-existent. The Tapioca Market Expansion Board provides the single estimate of household consumption of processed cassava products and estimates an annual consumption of 9.5 kg per capita of dried cassava. It can only be assumed that cassava flour is included in this figure. Cassava chip exports were initiated again in 1977 after a lull of about 10 years. Exports remain small and irregular. Imports into the European Community from India were 7,949 t in 1977, 37,182 t in 1978, 26,799 t in 1979 and 11,915 t in 1980. Chips purchased by the starch factories are assumed to be included in starch production figures.

This leaves only potential exports of dried cassava to other states. Data on transport through selected checkposts for the period May 1975 to May 1976 give the following:

	Quantity (M.T.)	Value (100,000 rupees)
Tapioca chips	N.A.	78.80
Dry Tapioca	90,150	44.34

At the Kozhikode wholesale price for cassava chips in this period of 62 rupees/100 kg, the volume of tapioca chips implied is 12,710 t. On the other hand, the per ton price for dried cassava implied by the above value and volume figure is 49 rupees/t, a figure undervalued by at least a factor of ten. A selection of either the volume or value figure is arbitrary. Processing the chips into starch is possible but 90 thousand tons is a bit excessive in relation to starch production capacity in Tamil Nadu. Moreover, assembly of this volume is a bit large compared to more recent international export volumes. It is therefore assumed that 90 thousand quintals were exported to Tamil Nadu, implying a total export volume of 21,725 t.

Starch is the other major consumption form of cassava in Kerala. The industry is reckoned to run at undercapacity and to be a much more minor producer than Tamil Nadu. A listing of reported starch plants --although not necessarily a complete listing-- and their estimated annual production gives a starch production figure of approximately 57 thousand tons. An alternative unpublished estimate for 1977/78 is 110,808 t of starch (State Planning Board, private communication). The latter figure would imply a much larger industry than is commonly reckoned.

The final entry in the accounting of cassava utilization in Kerala is root export to Tamil Nadu. Most reports on the starch industry in Tamil Nadu cite imports of cassava roots from Kerala. The roots principally come from Trichur district in the north. Estimates of these exports are few. Hone (1974) presents an estimate of 400-800 thousand tons and cites a figure that licenced exports of up to 400 thousand tons are permitted. This is a remarkable volume considering that road transport is relatively scarce and expensive--transport costs add as much as 40% to root purchase price in Kerala. A transport price of 150 rupeest was cited (field notes, 1982), compared to a wholesale root price in Trichur of 519 rupees in 1981. The higher cost of root production in Kerala together with the transport cost is bound to make cassava roots from Kerala competitive only outside the principal harvest season in Tamil Nadu. Moreover, cassava production in Trichur district is one of the lowest in Kerala, producing 114 thousand tons in 1980/81. A more reasonable estimate is probably in the range of 50 to 75 thousand tons.

A synthesis of these various consumption estimates is presented in Table 12 for the year 1977. Comparing the consumption aggregate to the 1977/78 production figure, that is after the production series has been radically revised downward, reveals that about a million tons still remain unaccounted for. Wastage in an economy such as Kerala with the small distances to market and the well developing marketing services is probably small but may be assumed to be in the neighborhood of 10 to 12%. At this point there is no more justification for revising the consumption figure upward as for revising the production figure downward. Assuming that the human consumption figure is underestimated and putting the remainder in that category would imply a per capita consumption level of 103 kg/year. Compared to the other sample estimates this is not unreasonable but certainly suggests that earlier estimates of per capita consumption from food balance sheets were substantially overestimated, generally by more than 100%.

Tamil Nadu:

The market for cassava in Tamil Nadu as compared to Kerala, is dominated by demand for industrial uses as opposed to food uses. The starch and tapioca pearl industry centered in Salem District is considered to be the major end user of cassava in Tamil Nadu. There are 611 starch factories in Tamil Nadu, 497 of which are located in Salem District and the other 114 of which are located in Dharampuri, South Arcot and Coimbatore districts (Salem Starch and Sago Manufacturers's Cooperative, private communication and Uthamalingam, 1980). Utilization of cassava roots would then follow from the operational characteristics of these plants.

A sample of 30 starch and pearl factories were selected in Salem town and in outlying rural areas. The operational structure is given in Table 13. There are 228 pearl factories and 269 starch factories in Salem and assuming a distribution of 75% small-scale and 25% large-scale, leads to an average annual output per factory of 499 t. This annual average starch output thereby implies an annual production level of 248 thousand tons in Salem District and an additional 57 thousand tons in the three adjacent districts.

Uthamalingam (1980) provides alternative estimates based on the quantity shipped by railway and that purchased by the Salem Sago and Starch Merchants Association (Table 14). These are only about one-third of the above estimates. The rail shipments obviously do not include the starch consumed locally or that transported by road and therefore provides only a minimum estimate of production and an idea of variation of production from year to year. The estimate based on per factory output implies root utilization of 992 thousand tons in Salem and 228 thousand tons in the adjacent districts, assuming the relatively high conversion rate reported in Tamil Nadu of 4:1.

Most reports suggest that food usage of the cassava root is relatively minimal in Tamil Nadu. The 1973/74 National Sample Survey reports an average annual rural consumption of cereal substitutes of 4.1 kg/year for the whole state. It is probable that this figure includes only cassava but it is not certain what percentage would be root and what would be processed cassava. Since the only reported consumption in Tamil Nadu is for rural areas, it is probable that this figure only includes root consumption. This would imply a total food consumption of 125 thousand tons.

The recapitulation of the consumption, together with an assumed 10% wastage, gives a total figure of 1,514 thousand tons, which compares favorably with the production estimate of 1,682 thousands tons in 1978/79 and 1,591 thousand tons in 1979/80. A small change in the starch conversion rate could account for any difference. The production and consumption data would appear to be more or less consistent, at least since the 1977/78 crop year.

Other States: For the sake of completeness, Andhra Pradesh is the only other state with anywhere close to a significant production volume. Production in this state was 88.2 thousand tons in 1979/80 and 171.0 thousand tons in 1980/81. This volume is comparable to about 10% of the production of Salem District. Cassava is a rainfed crop in Andhra Pradesh and is principally grown in East Godavari District. The cassava root is used exclusively in a small, cassava pearl industry located in the district.

Summary: A consistent set of production and utilization estimates for the crop year 1977/78 are presented in Table 15. The disparity in the market structure between Kerala and Tamil Nadu is apparent from the difference in the weight of the fresh human consumption and starch markets in the two states. In India as a whole starch is a far larger consumption form of cassava than is apparent by only focusing on Kerala. Of the starch production a large part is in turn consumed as human food in the form of tapioca pearl. Having some idea of the different magnitudes of each market, each will now be analyzed in more detail to evaluate the potential for absorption of increased cassava production.

Cassava for Direct Human Consumption:

Cassava as a direct food source achieves substantial weight in only the food economy of Kerala State. As might be expected in rural economies where population pressure on land is high, per capita food consumption levels are low. About 70% of average incomes are spent on food, with the principal component being rice, on which 30% of total income is spent (Table 16). In the rural areas over 6% of average income is spent on just cassava. In such economies food consumption is directly dependent on income levels and as can be seen in Table 17, food calorie distribution is symmetric to income distribution. Average daily caloric intake is just over 2000 calories. Using the relatively gross standard of 2100 calories as the minimum daily requirement, Table 17 shows as much as 35% of the population in rural areas and 50% in the urban areas falling below minimum requirements. Because of the work and activity patterns of the poor in rural areas, calorie shortages can be considered to be chronic.

Cassava plays a key role in the calorie nutrition of the population of Kerala. Cassava is at least as important (National Sample Survey, 28th Round) or more important (Kumar, 1979) than rice for the low-income strata in rural areas. Rice is, however, the preferred food and consumption increases markedly with income. However, at least for the 81% of the population in the rural areas cassava consumption shows a slight increasing trend across income strata (Table 18). Even though per capita consumption levels are high, as compared to Indonesia for example, the National Sample Survey would indicate some limited capacity to increase cassava consumption in the rural areas with increases in income; although with everything else equal, most of that increase in income would go to increased rice consumption.

Because of the limited incomes in Kerala, a low-cost-per-calorie food such as cassava plays a principal role as a supplement to the higher cost rice. A principal issue is whether promoting technical change in cassava production, and the resultant lower prices, will lead to bridging the calorie deficit. In the major cassava producing district of Trivandrum cassava prices tend to be substantially lower and rice prices higher than in other districts. The survey of Kumar in Trivandrum suggests that cassava consumption levels are substantially higher and rice consumption slightly lower than the average for Kerala (Table 19). However, for the poorer income strata total calorie consumption is substantially higher than for the state average for this stratum. In areas such as the survey area where average annual consumption reaches 172 kg, there is probably not much potential for further increases in cassava consumption but changing the rice-cassava price relationship in other parts of Kerala would, on the basis of this very limited comparison, lead to increases in cassava consumption and increased calorie consumption.

Shah (undated) has argued that "attempts to increase the production of low cost, high calorie foods, with a view to bridging the calorie gap, by themselves may prove inadequate" because preferences for food qualities other than just calories bias consumption even in the low income groups to more costly foods. Food consumption patterns across income groups as described above would indeed confirm that food quality is important but as well that for the poor, where price differences are sufficiently large, cassava can constitute up to two thirds of total calorie intake.

The central government has in part incorporated the quality argument in its system of public food distribution. The foodgrain distribution system has played a major role in the food economy of Kerala since 1964, when food shortages in India led to food zoning and curtailment of private interstate trade. The system depends on a comprehensive system of ration or fair price shops, at which consumers are given quotas for foodgrains and prices are set well below open market prices. However, consumption requirements are well above the ration quota and consumers must purchase their additional requirements from the open market.

The availability of ration rice has a marked influence on rice and cassava consumption patterns. A study by George (1979) found that consumption of ration rice was relatively constant across income strata (Table 6), although this finding is based on household income. Kumar (1979) found that ration rice consumption increased with income when expressed on a per capita basis. However, whereas the higher income strata were able to complement this allotment with rice from open market purchases and at the highest income levels from own production, the lower income strata supplemented the ration rice with very high levels of cassava consumption, most of which was purchased (George, 1979). Nutrition of the poor thus depended principally on ration rice allotments and cassava purchases, as was also found by Kumar.

Wheat is also available through the ration shops but George (1979) found that "rural households consumed only a small quantity of wheat. When their rice quota was exhausted, consumers preferred to purchase cassava from the open market than wheat from the ration shops. Wheat purchases from the ration shops accounted for only about one-third of the total wheat allotment for the total sample and were the lowest in the low income household" (p.33).

Given the preference for rice, a principal determinant of the demand for cassava will be ration rice allotments. The first factor to consider is whether ration rice consumption is influenced by demand factors. Two studies (George, 1979 and Kumar, 1979) conclude that ration rice consumption is not influenced by demand factors but purely by supplies available; that is, all that is available would be consumed.

As levy procurement of rice within Kerala dropped to negligible levels, the ration system in Kerala came to rely almost completely on allotments from the Central Pool of the Food Corporation of India (FCI). Moreover, these allotments now account for over half of rice supplies in Kerala (Table 20), and whereas such allotments should introduce a certain stability in rice supplies, they are in fact, the major cause of variability in rice availability in the state. The author knows of no study which analyzes the determinants of state allocation of ration rice by the FCI, but obviously there are other criteria than just maintenance of per capita consumption levels over time. There is little choice but that cassava will continue to be a principal component of a food strategy in Kerala and in particular cassava can be used to provide a certain flexibility in the operation of the food ration system in the state.

<u>The dried chip market</u>

A peeled dry chip, similar to gaplek in Indonesia, is produced in Kerala. The market principally provides an alternative outlet for cassava during the principal harvest period from December to April, which coincides with the dry season. The chips are principally produced and assembled in the northern districts, with Calicut, Trichur and Changanachery being the principal assembly centers.

Data on the markets for cassava chips are virtually non-existent. What can be said is that this market is not as large nor as well-integrated as the gaplek market in Indonesia. Most consumers in Kerala have relatively direct access to fresh roots and most field observations would suggest a consumer preference for fresh over dried cassava. The one, and relatively dated, source on processed cassava consumption suggests very limited consumption levels, with an average annual per capita consumption of 9.5 kg of dried product. Indications are that the dried chip market for human consumption will remain very limited.

As is apparent in Indonesia a well functioning dried chip market provides an element of price stability to the fresh root market, especially where the major portion of planting and harvesting takes place at relatively restricted times of year. The chip market acts as a storage mechanism for cassava during the low season and provides a price floor during the peak harvest period. In Kerala the other major market for cassava chips is for processing into starch and glucose, especially glucose. Fresh roots produce a higher quality starch (Meuser, et.al., 1978) but chips are used in the starch industry in Kerala because they are cheaper on a starch basis and help to maintain operation outside the peak harvest season. However, if roots were available at the price and quantity desired, the starch industry would operate exclusively on roots. This particular outlet then does not provide a certain demand on which to develop an expansive dried chip market.

The other principal option in developing a dried cassava market is the export market. India exported limited quantities of cassava chips to

Europe between 1957 and 1964. The largest export level reached in this period was 72 thousand tons in the 1958-59 crop year. Exports virtually ceased until 1977 when exports to the EEC were resumed. This reopening of export shipments was brought on by a substantial price fall in dried cassava in 1977, together with a very large margin between domestic wholesale prices and import prices in Europe (Table 21). Exports have continued at relatively moderate levels since 1977 (Table 22). However, levels of 20 to 30 thousand tons result in high cost shipping and allows few of the benefits of an export price floor to develop, especially the incentives for investment in more efficient marketing and processing capacity. At this stage Kerala does not have the production base to develop an effective export market and meet domestic requirements, nor will India ever be in the position of being a large exporter of cassava products. However, a significant increase in yield levels could lead to further development of this nascent industry, which would in turn provide incentives for further market integration, the setting of a stable floor price, and in turn lower and more stable prices for fresh cassava for food.

The starch market

The market for cassava for starch production is divided between a fully integrated industry based on small-to-medium scale plants in Tamil Nadu and a relatively fragmented starch industry in Kerala consisting of two large-scale plants, 3 medium-scale and 50 small-scale plants. The principal constraint on expansion of this industry is supply of raw material to run the plants.

The industry in Kerala probably operates at no more than 50% capacity. Factories here must compete with cassava for the fresh market and during at least part of the year must offer a lower price for cassava roots than pertains on the fresh market, in order to remain competitive with production in Tamil Nadu. Thus, in 1981 a major starch factory in Kerala paid 260 rupees/t for roots, which compared to farm level prices in Tamil Nadu of between 280 to 360 rupees/t and farm gate prices for the fresh market in Kerala of 400 rupees/t (field observations, 1982). The farmer price would only cover variable production costs for the farmer and represents a price at which farmers would sell roots of low quality or where identification of other market outlets was a constraint. Further development of the starch industry in Kerala requires that prices in the fresh food and starch markets be brought closer in line. Unlike the chip export market, the cassava root market for starch is already probably large enough to set an effective price floor, should that ever be necessary. As it is, declining production trends and rising cassava prices implies that the starch industry in Kerala will remain moribund.

The cassava root market for starch in Tamil Nadu functions as a single, integrated market. The starch industry here, nevertheless, operates at between 45 to 60% capacity. Competition in Tamil Nadu does not come on the demand side with alternatives but rather from the supply side, where cassava must compete with a substantial number of crop alternatives for irrigated land. Root prices to the farmer are in turn determined principally by the sale price of starch, since roots make up approximately 80% of the total cost of starch or sago production (Table 23).

The cost and operating structure of the starch and sago industry, show in Table 23, suggests a relatively competitive, small-to-medium scale industry where annual returns on fixed investment of from 17 to 31% provide a normal return on investment, considering the general capital scarcity that characterizes the Indian economy. With further increases in farm production capacity, there is little doubt that a dropping cassava price would motivate further investment in processing capacity.

The end market for sago and starch is not well documented. The market for both apparently is centered in the more northern states. The end use of starch is principally in the textile industry, especially Bombay. Here cassava starch competes with maize starch, which is preferred over cassava starch, apparently because of the higher viscosity, and sells at a premium to cassava starch. The cassava pearl or sago, on the other hand, is used strictly in food uses and the largest market appears to be Bengal, particularly Calcuta. Uses range from a festival food to a filler for rice. Ex-factory prices of sago in 1978-79 of 1.55 rupees/kg compare favorably to rice prices of 2.2 rupees/kg. The potential consumption of starch and sago in India is not known but traders knowledgeable about the industry suggest that demand is no constraint at forseeable production levels.

Pricing and market efficiency:

Price determination and market allocation between competing uses are governed, at least in Kerala, essentially by factors which influence the demand for fresh cassava for human consumption. The starch, chip, and export markets essentially serve to set a price floor and absorb any surpluses at this price. Because of the very marked seasonality of harvest such surpluses occur seasonally during the year, as well as periodically from year to year. Because the fresh human consumption market makes up such a large part of total production - compared, for example, to Java - any changes in either cassava supply or fresh root demand will create substantial instability in supplies going to alternatives markets. Due to this factor and the very severe constraint on expansion in production area, the development of these alternative markets has been very fragmented.

Although cassava consumption and prices are obviously influenced by rice availability and prices, there are no studies which measure the degree of this influence. Planning and investment in rice production, cassava production, and ration rice distribution in Kerala are critically dependent on such a study. Price series provides the only data which shed light on the interaction between the rice and cassava markets and here several inexplicable trends become apparent. One special difficulty in analyzing price series is separating out the effects of inflation in the general price level. Since the consumer budget is weighted so heavily by food purchases, the consumer price index will reflect changes in food prices more than other products. These tend to be somewhat volatile anyway but in India upto 1977 food zoning heavily restricted interstate trade in food grains. Food price levels thus varied by state and using the consumer price index for India as a whole to deflate prices in any particular state will probably not be reflective of price inflation in that particular state. For this reason the consumer price index in Trivandrum was used to deflate all prices in Kerala.

During the decade of the 1970's real, retail rice price rose till 1974 and then fell dramatically (Table 24). Retail cassava prices, on the other hand, remained relatively constant through the period, resulting in rice becoming relatively cheaper to cassava. While the marketing margin for fresh cassava in Kerala is proportionally low compared to margins in other countries, the margin has masked much higher variability in cassava prices at the farm-level (Table 25). At the farm-level comparable, though not as marked, trends to those that have occurred in the retail rice market have occurred. In particular, there is a falling real cassava price at the farm-level at a time when production was declining rapidly. This would support a marked influence of rice prices and availabilities on cassava prices.

The dominant issue then is what has been happening with rice availabilities? Through the decade of the 1970's rice production in Kerala was relatively stable (Table 20). The component of variability in rice supplies in Kerala was the availability of ration rice. What is inexplicable with the available data is the low rice prices in 1978 and 1979. Since food zoning and restrictions on interstate trade of food grains was eliminated in 1977, it is possible that there have been flows of rice into Kerala from other states brought by private traders and sold on the open market. However, even the limited evidence on open market availabilities suggest that such supplies were not much changed in the years 1978 and 1979 and that eliminating food zoning has had no impact on rice supplies in Kerala. Rice prices in Kerala have been traditionally higher than in the other Indian states, and while the liberalization of trade flows should bring prices more in line, the mechanism to do this has to be increased availabilities.

Thus, while it is not clear why, declining rice prices are putting a damper on cassava prices, that would otherwise be rising in response to declining production. This has allowed cassava prices to remain competitive in the world market. To the extent that increased rice supplies can be assured, this would have the greatest impact on nutrition in Kerala. What is clear, however, is that there are no such assurances. Maintaining low priced cassava for the human consumption market provides a critical element of stability in food supplies. What is needed, however, is better integration with alternative markets which can handle surpluses when rice supplies are adequate. What this requires is a larger production base and this can only be achieved with further increases in yields.

Conclusions

Cassava serves a major, if somewhat distinct, role in the agricultural economies of Kerala and western Tamil Nadu. In Kerala internal rice production is stagnant and there is an increasing portion of the upland area being planted to higher value tree crops. Food supplies thus rely critically on rice allocations from the central pool and more recently apparent, privately-traded inflows from outside the state. However, in maintaining or improving the food intake and nutrition of the low income strata, the options are increases in rice rationing off-take or more plentiful and cheaper cassava. Since an increase in the poor's rice ration allotment implies an increase for everyone, cheaper cassava would target directly on the poor and would not involve subsidies from the public treasury. The design of a food and nutrition policy in Kerala is heavily dependent on the prognosis for rice production in India as a whole given that food zoning is a policy of the past. Nor should policy makers appear insensitive by suggesting that the poor should just eat cassava. Pure pragmatism suggests that the calorie intake of the poor is critically low and that cassava can be as cheap a means as any of increasing calorie intake.

In Tamil Nadu, on the other hand, a potential growth industry, much like the case of Indonesia, exists in the starch and tapioca pearl market. The industry is constrained by lack of raw material for processing and for farmers there is no restrictions on finding market outlets for their production. Prices are in most respects relatively stable and any increases in yields will directly improve farmer incomes.

The issue, then, is how much higher farm level yields can be raised in these two states over the relatively high level which farmers already achieve. Such increases will almost certainly depend on higher yielding varieties. The research of the CTCRI suggests that there is scope for doing this in Kerala. An issue which CTCRI is very conscious of is that the quality characteristics of these improved varieties shall have to remain high, since cassava is essentially consumed in a fresh form. In Tamil Nadu, on the other hand, there are no such restrictions, other than that the yield gap to be exploited there appears to be much smaller. India is probably the only of the major cassava producing countries in Asia where the only frontier for cassava to exploit is the yield frontier.

able . India: Trends in Area, Production and Yield for the Country and the Major Producing States, 1964-1981.

rop Year	India			Kerala			Tamil Nadu		
	Area (000ha)	Production (000 t)	Yield (t/ha)	Area (000ha)	Production (000 t)	Yield (t/ha)	Area (000 ha)	Production (000 t)	Yiel (t/h
964-65	240.0	3,033.0	12.6	209.0	2,763.0	13.2	25.0	243.0	9.7
965-66	271.0	3,467.0	12.8	230.0	3,095.0	13.5	35.0	339.0	9.6
966-67	290.0	3,817.0	13.2	245.0	3,410.0	13.9	39.0	377.0	9.8
967-68	335.0	4,520.0	13.5	298.0	4,198.0	14.1	30.0	285.0	9.7
968-69	359.0	4,636.0	12.9	298.0	4,081.0	13.7	55.0	527.0	9.6
969-70	353.0	5,214.0	14.8	296.0	4,666.0	15.8	44.0	513.0	11.8
970-71	353.0	5,216.0	14.9	294.0	4,617.0	15.7	47.0	567.0	12.1
971-72	353.7	6,025.9	17.0	303.3	5,429.3	17.9	42.6	545.0	12.8
972-73	363.2	6,317.4	17.5	304.8	5,629.4	18.7	50.0	629.5	12.6
973-74	368.2	6,420.9	17.1	306.4	5,659.5	18.5	51.7	681.6	13.2
974-75	387.6	6,325.9	16.3	317.9	5,625.1	17.7	52.7	564.9	10.7
975-76	392.0	6,638.3	16.9	326.9	5,390.2	16.5	50.1	1,115.8	22.3
976-77	385.8	6,375.0	16.5	323.3	5,125.5	15.9	48.0	1,128.2	23.5
977-78	358.3	5,688.3	15.9	289.7	4,188.6	14.5	52.8	1,310.3	24.8
978-79	361.5	6,050.1	16.7	289.9	4,226.3	14.6	54.0	1,682.0	31.2
979-80	365.3	5,952.2	16.3	290.3	4,223.6	14.5	58.1	1,591.4	27.4
980-81	320.8	5,868.1	18.3	243.3	4,097.8	16.8	53.3	1,539.3	28.9
981-82	310.2	5.267.4	17.9	241.8	4,073.0	16.8	42.3	1,324.8	31.3

ource: "Bulletin on Commercial Crop Statistics" and "Agricultural Situation in India", Ministry of Agriculture.

Table . India: Annual Rail Shipments of Starch and Pearl from Salem and Purchases by the Salem Sago and Starch Merchant's Association, 1970-1977.

Year	Rail Shipments Pearl (t)	Rail Shipments Starch (t)	Association Purchases Pearl (t)	Association Purchases Starch (t)
1970	52,589	39,553	N.A.	N.A.
1971	55,171	28,987	N.A.	N.A.
1972	41,133	41,488	N.A.	N.A.
1973	22.249	41,102	N.A.	N.A.
1974	18,871	42,822	N.A.	N.A.
1975	44,774	45,827	N.A.	N.A.
1976	36,394	30,656	38,605	29,583
1977	55,702	35,081	55,095	26,596

Source: Uthamalingam, 1980.

Table . India: Average Prices of Fresh Cassava Roots at the Farm, Wholesale and Retail Level, 1970-80.

Year	Farm-level		Wholesale		Retail	
	Nominal (Rupee/t)	Real 1/ (Rupee/t)	Nominal (Rupee/t)	Real 1/ (Rupee A)	Nominal Rupee/t)	Real 1/ (Rupee/t)
1970	N.A.	N.A.	209	386	300	550
1971	214	391	222	407	310	570
1972	235	406	240	415	320	550
1973	309	446	311	449	400	580
1974	384	423	397	437	510	560
1975	400	400	391	391	540	540
1976	398	449	391	441	550	620
1977	325	376	323	373	500	580
1978	316	353	326	363	490	590
1979	398	411	410	424	590	610
1980	N.A.	N.A.	443	N.A.	N.A.	N.A.

1/ Deflated by consumer price index in Trivandrum, 1975 = 100

Source : Government of Kerala, "Statistics for Planning", Directorate of Economics and Statistics, Trivandrum, various years.

Table . India: Area under Principal Tree Crops in Kerala, 1970-80

Crop Year	Coconut (000 ha)	Black Pepper (000 ha)	Rubber: Less than 2 has (000 ha)	Rubber: Total (000 ha)	Cashewnut (000 ha)
1970-71	719.1	N.A.	68.5	20.31	N.A.
1971-72	730.3	116.3	71.7	208.8	N.A.
1972-73	745.4	116.3	74.1	213.1	N.A.
1973-74	744.8	118.2	77.1	217.5	103.2
1974-75	748.2	118.4	79.4	221.3	104.9
1975-76	692.9	108.2	81.9	224.4	109.1
1976-77	695.0	110.6	85.5	230.6	113.3
1977-78	673.5	108.3	88.4	233.4	127.0
1978-79	660.6	108.3	91.3	235.9	N.A.
1979-80	663.8	N.A.	N.A.	N.A.	N.A.

Source: Government of India, "Bulletin of Commercial Crop Statistics", Directorate of Economics and Statistics, Ministry of Agriculture, various years.

Table . India: Wholesale Prices of Cassava Chips at Kozhikode and Comparison with European Import Prices, 1970-79.

Month	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	Rupees/100 kg									
Jan.	30	40	35	45	56	55	55	60	55	80
Feb.	30	41	35	45	75	55	53	57	48	88
Mar.	32	45	38	52	70	55	52	55	47	98
April	36	44	47	62	75	55	80	62	55	110
May	37	40	47	70	85	55	80	60	58	N.A.
June	40	48	50	62	80	57	88	55	65	N.A.
July	40	48	60	62	73	55	100	50	70	N.A.
Aug.	45	50	50	78	78	52	103	50	65	N.A.
Sept.	50	50	N.A.	75	80	55	100	40	65	105
Oct.	50	52	N.A.	82	85	65	105	40	65	120
Nov.	58	47	58	80	70	85	110	35	85	120
Dec.	43	45	52	68	70	85	80	50	90	110
Average	41	46	43	65	75	61	94	51	64	104
$/t Equivalent	55	61	57	84	93	73	105	58	78	128
cif Rotterdam ($/t)	N.A.	66	74	87	149	124	118	108	101	164

Source: Government of India, "Bulletin on Commercial Crop Statistics," Directorate of Economics and Statistics, Ministry of Agriculture, various years.

Table . India: Characteristics of Starch and Pearl Factories in Salem District Tamil Nadu, 1978/79 1/

	Starch		Pearl	
	Small	Large	Small	Large
Root Input (t)	1,629.6	2,416.1	1,635.3	3,287.3
Starch Output (t)	431.6	652.8	411.8	822.0
Conversion Rate (%)	26.5	27.2	25.2	25.0
Average Operating Period (days)	135	144	175	184

1/ In Salem District there are 269 starch factories and 228 tapioca pearl factories

Source: Uthamalingam, 1980

Table . India: Monthly Rural Consumption of Cassava and Rice by Income Strata

	Kumar Survey				National Sample Surve[y]	
Income Strata (Rupees/capita)	Cassava (kg/capita)	Ration Rice (kg/capita)	Open Market Rice (kg/capita)	Total Rice (kg/capita)	Cassava (kg/capita)	Rice (kg/capit[a])
0-15	19.95	1.60	.69	2.29	6.27	1.88
15-24	17.68	2.29	1.46	3.75	6.47	3.83
25-34	16.13	2.51	2.04	4.55	6.70	5.03
35-49	16.09	2.67	2.06	4.73	7.18	6.17
50-74	14.35	3.46	1.64	5.10	7.20	8.43
Greater then 75 1/	4.19	3.55	2.35	5.90	7.16	12.08
Average	14.13	2.89	1.98	4.87	6.99	7.23

1/ For Kumar sample there are two observations only.

Sources: Kumar, 1979; Government of India, 1973/74.

Table . India: Estimated Capacity and Output of Starch Plants in Kerala

Plant	Capacity (t of starch/day)	Production Estimate (t/year)
Lekshmi (Quilon)	80 t	15,125
Tapioca Products (Trichur)	100 t	17,500
Mode Chemical Sago (Quilon)	10 t	1,500
Pemba Starch (Quilon)	10 t	1,500
50 small-scale plants	3 t	21,500
Total		57,125

Source: Report of the Sub-Committee of the Tapioca Market Expansion Board, Department of Food, Government of Kerala, Trivandrum, 1972.

Table . India: Monthly Per Capita Consumption of Cassava and Rice by Income Strata, 1973/74.

Income Strata (Rupees/capita)	Cassava Rural (kg/capita)	Cassava Urban (kg/capita)	Rice Rural (kg/capita)	Rice Urban (kg/capita)
0-13	5.04	-	1.96	-
13-15	8.33	0.20	1.75	3.60
15-18	4.63	12.50	3.42	1.67
18-21	7.60	3.23	3.18	2.95
21-24	6.49	3.05	4.34	4.23
24-28	5.14	5.59	4.98	4.06
28-34	7.49	3.06	5.06	5.60
34-43	6.48	4.10	6.05	5.59
43-55	7.79	4.04	7.26	7.81
55-75	7.20	4.73	8.43	7.32
75-100	6.86	3.24	10.44	9.90
100-150	7.35	2.02	11.88	8.81
150-200	11.16	1.65	15.37	9.63
Greater than 200	5.43	1.50	18.67	10.50
Average	6.99	3.64	7.33	7.23

Source: Government of India, "The National Sample Survey", 28th Round, National Sample Survey Organization, 1973/74.

Table 3.30. India: Yield Distribution from Crop Cutting Survey, Tamil Nadu, 1979-80 (287 farms)

Yield Strata (t/ha)	Percentage Distribution
0- 7.5	13
7.5-15.0	14
15.0-22.5	16
22.5-30.0	25
30.0-37.5	16
37.5-45.0	8
45.0-52.5	5
52.5-60.0	2
60.0-75.0	1
75.0-90.0	0.3

Average Yield = 24.5 t/ha
Standard Deviation = 14.1 t/ha
Maximum Yield = 84.2 t/ha
Irrigated Yield = 27.4
Unirrigated Yield = 15.6

SOURCE: Unplublished results of crop cutting survey, Tamil Nadu.

Table 3.26. India: Consumption of Rice and Cassava by Income Strata and by Source of Supply, Rural Kerala, 1977 (kg/household/week)

Annual Household Income (Rupees)	Rice				Cassava		
	Total Consumption (kg)	Ration (kg)	Own Production (kg)	Open Market (kg)	Total Consumption (kg)	Own Production (kg)	Open Market (kg)
Less than 600	8.40	5.65	-	2.75	12.90	0.40	12.50
601-1200	9.43	6.39	-	3.04	11.31	2.96	8.35
1201-2400	13.47	7.70	1.77	4.00	15.46	4.13	11.33
2401-3600	13.89	6.67	1.11	6.11	12.66	4.33	8.33
3601-4800	12.00	4.90	2.00	5.10	6.70	4.50	2.20
More than 4800	13.42	5.14	5.71	2.57	3.29	3.29	-

SOURCE: George, 1979.

Table 3.24 India: Caloric Consumption by Income Strata in Kerala, 1971-72

Per Capita Monthly Expenditure (Rupees)	Rural		Urban	
	% Distribution of Households	Per Capita Calorie Consumption	% Distribution of Households	Per Capita Calorie Consumption
0-15	3.1	893	3.3	953
15-21	5.9	1229	7.6	1079
21-24	4.6	1716	5.7	1575
24-28	8.5	1466	6.9	1490
28-34	13.0	1900	12.1	1787
34-43	9.5	2320	14.5	1989
43-55	15.6	2603	14.2	2289
55-75	18.6	2900	10.9	2700
75-100	9.2	3614	7.3	3060
More than 100	12.3	4293	17.6	3907
Average	100.0	2023	100.0	2103

Source: Statistics for Planning 1980, Government of Kerala.

Table 3.21. India: Percentage Distribution of Farms by Size in Kerala, 1970-71.

Size of Holding (ha)	Distribution of Holding (%)
Below 0.04	18.7
0.04 - 0.25	37.2
0.25 - 0.50	15.6
0.50 - 1.00	13.3
1.00 - 2.00	9.7
2.00 - 3.00	3.2
3.00 - 4.00	1.4
More than 4.00	0.9
Total	100.0

SOURCE: Statistics for Planning 1980, Government of Kerala, 1980.

Table . India: Annual Costs of Production of Starch and Tapioca Pearl in Tamil Nadu, 1978-79.

Cost Item	Starch: Small Factory (Rupees)	Starch: Large Factory (Rupees)	Tapioca Pearl: Small Factory (Rupees)	Tapioca Pearl: Large Factory (Rupees)
Variable Costs				
Cassava Roots	465,611	690,303	497,227	989,237
Temporary Labor	25,294	39,236	43,826	78,011
Fuel	-	-	5,060	11,492
Electricity	4,292	7,624	4,687	9,240
Coconut Oil	-	-	2,955	4,864
Gunny Bags	23,891	36,035	25,602	50,436
Interest on Working Capital	23,039	36,605	33,333	69,067
Total Variable Costs	542,127	809,803	612,689	1,212,346
Fixed Costs				
Permanent Labor	9,091	11,277	7,237	12,908
Office Overhead	2,171	4,181	2,040	3,825
Depreciation				
Buildings	2,174	2,870	1,703	2,695
Machinery	6,832	10,285	5,003	10,617
Interest on Fixed Capital	15,937	22,910	13,295	19,618
Taxes	3,250	4,000	2,756	3,786
Total Fixed Costs	39,455	55,523	32,034	53,449
Total Costs	581,583	865,326	644,723	1,265,795
Annual Output (tons)	431.6	652.8	411.8	822.0
Total Cost per Ton	1347	1326	1566	1540
Output Price per Ton	1333	1333	1556	1555
Value of By Products per Ton	85	93	72	72

Source: Ulthamalingam, 1980

Table . India: Different Estimates of Per Capita Consumption of Fresh Cassava in Kerala.

Source	Sample Size	Sample Structure	Period	Annual Per Capi[ta] Consumpt[ion]
Kumar	43 households	Trivandrum District Rural Only Bottom 50% of Income Strata	Feb-Sept.1974	171.9
George	100 households	Two Villages Rural Only	Nov. 1977	114.7
National Sample Survey	890 households	Complete State Rural and Urban	Oct.1973-June 1974	78.3
Tapioca Market Expansion Board	unknown	All but One District Rural and Urban	1971	56.5
U.N.Dept. of Economic and Social Affairs	-	Food Balance Tables	1961/62-1970/71	208.4
Govt. of Kerala	-	Food Balance Tables	1974	276

Sources: Kumar, 1979; George, 1979; Government of India, 1973/74; Government of Kerala, 1972; U.N. Department of Economic and Social Affairs, 1975; Government of Kerala, 1977.

Table . India: Labor Use in Cassava Production Systems, Tamil Nadu, 1978-79.

Activity	Irrigated Men (days/ha)	Irrigated Women (days/ha)	Rainfed Men (days/ha)	Rainfed Women (days/ha)
Preparatory Cultivation	27.2	-	11.9	-
Seeds and Sowing	15.2	3.6	6.5	5.3
Manuring	5.4	-	7.1	-
Irrigation	25.3	-	-	-
Weeding	-	96.7	-	91.9
Harvesting	30.6	-	28.1	-
Miscellaneous	-	1.8	-	1.9
Total	103.7	161.6	53.5	85.0

Source: Uthamalingam, 1980.

Table . India: Availability of Rice in Three Major Markets in Kerala, 1970-81.

Year	Jan-Mar (000 t)	Apr-June (000 t)	July-Sept. (000 t)	Oct-Dec. (000 t)	Total (000 t)
1970	21.0	10.7	5.5	4.4	41.3
1971	7.2	12.1	9.4	11.3	40.0
1972	25.7	25.7	15.3	15.3	82.0
1973	11.2	9.8	8.5	12.2	41.7
1974	8.6	9.6	8.4	4.7	31.3
1975	4.2	8.3	11.3	4.5	28.3
1976	4.3	12.4	7.8	10.9	35.4
1977	12.6	12.5	11.7	9.7	46.5
1978	12.0	13.9	8.7	11.2	45.8
1979	8.1	10.6	5.5	7.1	31.3
1980	8.0	5.1	5.0	13.1	31.2
1981	10.2	8.6	3.3	24.9	47.0

Source: Government of India, "Bulletin on Food Statistics", Directorate of Economics and Statistics, Ministry of Agriculture, various years.

Table . India: Growth in Area Planted to Cassava in Kerala, 1920-1980.

Crop Year	Area (000 ha)
1920-21	164
1925-26	170
1930-31	194
1934-36	175
1940-41	183
1944-45	197
1952-53	205
1955-56	222
1960-61	245
1965-66	260
1970-71	294
1975-76	327
1980-81	243

Source: Panikar et.al., 1977 and Government of Kerala, "Statistics for Planning", Directorate of Economics and Statistics, Trivandrum, various years.

Table . India: Cost of Production of Cassava in Tamil Nadu and Kerala, 1978-79.

Cost Item	Tamil Nadu Irrigated (Rupee/ha)	Tamil Nadu Rainfed (Rupee/ha)	Kerala Rainfed (Rupee/ha)
Variable Costs			
Preparatory Cultivation	273.0	180.4	466.6
Seeds and Sowing	220.5	222.0	221.1
Manures and Manuring	1,101.6	529.2	687.6
Irrigation	300.1	-	79.8
Weeding	477.6	228.2	349.5
Plant Protection	-	-	17.0
Harvesting	237.7	177.5	200.6
Interest on Working Capital	274.1	140.4	212.3
Total Variable Cost	2,884.7	1,477.7	2,234.5
Fixed Costs			
Rental Value of Land	1,776.4	989.7	
Depreciation	210.7	147.8	
Interest on Fixed Capital	387.5	228.4	
Total Fixed Capital	2,374.6	1,365.9	1,880.0
Total Costs	5,259.3	2,843.6	4,114.5
Yield (t/ha)	22.96	10.74	13.63
Variable Cost per Ton	123.9	137.6	163.9
Total Cost per Ton	229.7	265.2	301.9

Source: Uthamalingam, 1980; Hone, 1973.

Table . India: Average Consumer Expenditure Pattern, Kerala, 1973-74

Item	Rural		Urban	
	Amount (Rupees)	Percent (%)	Amount (Rupees)	Percent (%)
Cereals	18.14	32.8	18.10	26.3
Rice	17.70	32.0	17.26	25.0
Cassava	3.53	6.4	1.67	2.4
Grams and Pulses	0.72	1.3	1.21	1.8
Vegetable Oil	1.12	2.0	1.72	2.5
Milk and Dairy Products	1.82	3.3	3.93	5.7
Meat, Fish, Eggs	2.52	4.6	3.42	5.0
Other Food Items	11.75	21.2	16.69	24.2
Total Food	39.60	71.5	46.74	67.8
Fuel and Light	2.97	5.4	3.60	5.2
Clothing	2.63	4.8	2.55	3.7
Rent	0.10	0.2	1.26	1.8
Other Non-Food	10.05	18.2	14.78	21.4
Total Non-Food	15.75	28.5	22.19	32.2
Total	55.35	100.0	68.93	100.0

Source: Government of India, the National Sample Survey, 28th Round, 1973/74.

Table . India: Production and Utilization of Cassava Roots by State, 1977/78.

State	Production (000 t)	Export (000 t)	Domestic Utilization: Human Consumption: Fresh (000 t)	Dried (000 t)	Starch (000 t)	Animal Feed (000 t)	Waste (000 t)
Kerala	4189	22	2437	619	499	-	503
Tamil Nadu	1310	-	126	-	1162 1/	-	131
Andra Pradesh	137	-	-	-	123	-	14
Other	52	-	47	-	-	-	5
India	5688	22	2610	619	1784	-	653

1/ Includes 109 thousand tons of roots and chips imported from Kerala.

Source: CIAT estimates

Table . India: Estimates of Production and Utilization of Cassava in Kerala, 1977/78

Useage	Estimate (t)	Conversion Rate	Fresh Root Estimate (t)
Human Consumption-Fresh	1,854,850 [1]	1.0	1,854,850
Human Consumption-Dried	225,045 [2]	2.75	618,875
Starch	110,808 [3]	4.5	498,636
International Export-Chips	7,950 [4]	2.75	21,860
Interstate Export-Chips	12,700 [5]	2.75	34,925
Interstate Export-Roots	75,000 [6]	1.0	75,000
Waste	502,630	1.0	502,630
Total Utilization			3,606,776
Production			4,188,600

Sources: [1] National Sample Survey, 1973/74; [2] Tapioca Market Expansion Board; [3] Kerala State Planning Board; [4] Renshaw, 1983; [5] Government of Kerala, "Statistics for Planning"; [6] Estimate.

Table . India: Cassava Root Yield of Different Varieties in a Fertilizer Trial

Varieties	NK Combinations (kg/ha of N and K20)										
	50:50	50:100	50:150	75:75	75:150	75:225	100:100	100:150	100:200	100:250	Mean
H-165	22.67	23.01	22.88	24.24	22.84	26.47	28.30	25.08	23.87	27.93	24.73
H-2304	24.07	25.99	25.27	27.84	30.42	28.64	32.16	32.96	32.43	31.41	29.12
H-1687	19.29	19.04	21.47	19.62	20.13	22.96	26.05	26.39	25.31	25.02	22.53
M-4	15.18	14.76	15.66	16.95	16.10	15.83	18.62	18.66	17.48	18.62	17.79
Mean	20.30	20.70	21.32	22.16	22.16	22.37	23.47	26.28	24.77	25.74	-

Source: Central Tuber Crops Research Institute, Annual Report 1978-79, Trivandrum.

Table . India: Imports by the EEC of Cassava Chips, 1975-1980.

Year	Quantity (tons)
1975	0
1976	0
1977	7,949
1978	37,182
1979	26,799
1980	11,915

Source: Renshaw, 1983

Table . India: Rice Production, Ration Rice Take-off, and Rice Availabilities in Kerala, 1971-1980.

Year	Rice Production 1/ (000 t)	Ration Card Take-off (000 t)	Total Supplies (000 t)
1971	857	844	1701
1972	892	874	1766
1973	908	764	1672
1974	830	786	1616
1975	814	539	1353
1976	879	937	1816
1977	828	1380	2208
1978	854	872	1726
1979	048	570	1418
1980	N.A.	812	N.A.

1/ Rice production is on a milled basis by crop year.

Source: Government of Kerala, "Statistics for Planning", and Government of India, "Bulletin on Food Statistics."

Table. . India: Percent of Farm Production Commercialized in Various Districts of Kerala State, 1971

District	Percent Commercialized
Trivandrum	46.8
Quilon	32.2
Alleppey	33.9
Kottayam	28.5
Ernakulum	16.9
Trichur	53.4
Palghat	77.6
Malappuram	42.6
Kozhikode	38.2
Cannonore	23.0
Kerala	39.3

Source: Tapioca Market Expansion Board, 1972

Table India: Constant[1] Retail Prices of Rice and Cassava in Kerala, 1970-1979.

Year	Rice (Rupee/kg)	Cassava (Rupee/kg)	Rice/ Cassava	Open Market/ Ration Rice
1970	2.87	.55	5.2	1.5
1971	2.78	.57	4.9	1.4
1972	3.04	.55	5.5	1.6
1973	3.47	.58	6.0	1.8
1974	3.84	.56	6.8	2.6
1975	3.53	.54	6.5	2.7
1976	3.02	.62	4.9	N.A.
1977	2.73	.58	4.7	N.A.
1978	2.43	.55	4.4	N.A.
1979	2.33	.61	3.8	N.A.

[1] Prices deflated by consumer price index in Trivandrum, 1975 = 100

Source: Government of Kerala, 1980; George, 1979.

TRENDS AND DISTRIBUTION OF CHINESE CASSAVA PRODUCTION AND USE 1820 - 1984

Production trends and distribution

No official national data series for cassava in the Peoples Republic have been published by Chinese authorities. It is possible to obtain estimated series from the Food and Agricultural Organization of the United Nations.[1] Such series are based on assumed annual increments in harvested area for most years and somewhat less regular, but a similar monotonically non-decreasing set of estimates for production. Yields appear to be derived from the rough area and production estimates by calculation. The only figure among these which appears to have come from a Chinese source is the 3 million ton production figure circa 1980, provided unofficially as an undated estimate to the 1982 CIAT delegation by one of the agricultural science institutes visited in Guangdong. Earlier work[2] has concluded that the entire FAO series for root and tuber crops bears little relation to the aggregate series published since 1979 by Chinese statistical authorities.[3] It is now also clear that the FAO

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[1]e.g. FAO, "Supply Utilization Tapes, 1984," Rome 1985; FAO, "Standardized Commodity Balance Tape, 1984," Rome, 1985; and FAO, "Production Yearbook Tape, 1984," Rome, 1985.

[2]Bruce Stone, "An Examination of Economic Data on Cassava Production, Utilization and Trade," a paper prepared for the International Center for Tropical Agriculture (CIAT), International Food Policy Research Institute, Washington, D.C., August 1983.

[3]e.g. He Kang et al, Zhongguo Nongyebu [Ministry of Agriculture of China], (eds.) Zhongguo Nongye Nianjian 1980 [Agricultural Yearbook of China 1980] (Beijing: Nongye Chubanshe [Agricultural Publishing House], 1980) and Zhongguo Guojia Tongjiju [State Statistical Bureau], Zhongguo Tongji Nianjian - 1983 [Statistical Yearbook of China - 1983] (Beijing: Tongji Chubanshe [Statistical Publishing House], 1983).

series for cassava, per se, conflict with officially published series for one of the two principal growing regions and with scattered national estimates for individual years found elsewhere in Chinese publications. Since 1984, the FAO has taken account of some of the recent information in formulating current root and tuber crop estimates for publication in FAO Production Yearbooks. But much recent information has not been reflected in FAO series and additional work is required to obtain a reliable impression of long-term trends for individual crops, including cassava.

According to Chinese sources, [4] cassava had been introduced into China from South America via "nanyang" [the "South Seas" or Pacific Ocean] by 1820, although it is not clear whether it entered Guangdong Province directly from the West or whether it was introduced indirectly following regional cultivation in Sri Lanka, India or Indonesia. By far the main Chinese producing area is the extreme south, below the Tropic of Cancer (23.5°N), especially Guangdong

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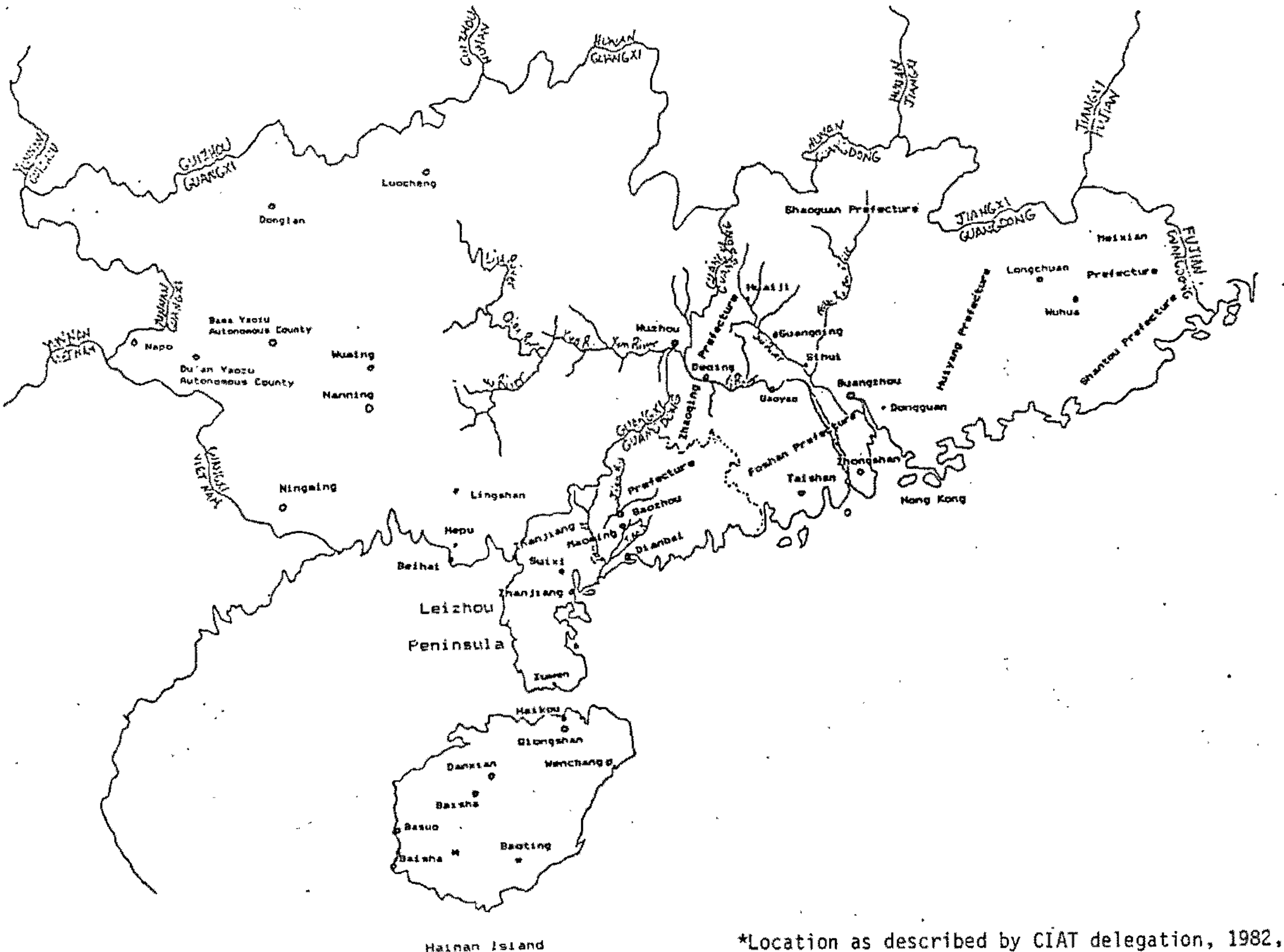
[4] Liang Guangshang (ed.), Mushu Zaipei yu Liyong [Cassava Cultivation and Use] (Guangzhou: Guangdong Keji Chubanshe [Guangdong Scientific and Technical Publishing House], 1981), author's preface and p. 4. Cassava is confirmed to have been grown in China for more than 100 years in Zhongguo Kexueyuan, Dili Yanjiusuo, Jingji Dili Yanjiushi [Chinese Academy of Sciences, Institute of Geography, Economic Geography Research Room], Zhongguo Nongye Dili Zonglun [A General Treatise on China's Agricultural Geography], (Beijing: Kexue Chubanshe [Scientific Publishing House], 1980), p. 129. 1820 was also the introduction date mentioned during a spring 1982 delegation from the International Center for Tropical Agriculture (CIAT) and recorded in James H. Cock and Kazuo Kawano, "Cassava in China," unpublished trip report, CIAT, Palmira, Colombia, June 1982, p. 1. However, Mushu Zaipei yu Liyong clearly indicates that 1820 is the earliest record of cassava cultivation so far uncovered; the introduction date may well have been earlier.

Known Cassava-Growing Regions of the People's Republic of China (see text for details)



*Location as described by CIAT delegation, 1982, as the most southwestern tip of Hainan Island.

Province and Guangxi Zhuang Autonomous Region. Of the two, production has typically been greatest in Guangdong. Cassava is also cultivated in Fujian, Yunnan, Hunan, Guizhou, and Taiwan Provinces, but much less extensively, and to a very minor extent in Hubei, Jiangxi, Zhejiang and Sichuan. Some estimates of provincial cultivated area gleaned from Chinese sources are arranged in Table 1.

While cassava had been introduced into Guangdong and Guangxi by the first half of the 19th century and a book devoted to cassava planting methods had been published as early as 1900, the first cultivation record in Fujian is 1920 and in Taiwan, 1929. Introduction dates for most other provinces, were considerably later: Hunan 1941; Guizhou 1942; Zhejiang 1954; and Jiangxi 1959. Cultivation of cassava in Yunnan though potentially beginning earlier, was estimated at only two thousand hectares in 1960. Most farmland in these provinces fall within what is described in Chinese sources as the expansion area: north of the Tropic of Cancer and south of 30°N. There is experimental cultivation of cassava even north of 30°N with the northernmost plantings at the Hebei Forestry Science Institute at 39°20'N. These experiments began during the famine years in 1960 and 1961 in Hubei, Anhui, Jiangsu, Shaanxi, Shandong, Liaoning, Sichuan and Hebei, which constitute the first record of cassava-related activities in these provinces.[5] Cassava

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[5]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, author's preface and pp. 4, 9 and 10.

Table 1. Area Sown with Cassava in China and Major Chinese Cassava-Growing Provinces, 1943-1984

	China	Guangdong	Guangxi	Fujian	Taiwan	Yunnan	Guizhou	Hunan, Zhejiang Jiangxi
	(thousand hectares)							
1943		33.4						
1950			41.5					
1951			37.6					
1952			48.5		8.0			
1953			41.3		9.0			
1954			67.5		10.4			
1955			62.6		10.7			
1956			93.0		10.6			
1957			104.3		10.9			
1958			132.6		12.3			
1959			118.8		11.9			
1960			127.9		13.0	2.0		
1961	365.3		104.4	>6.7	17.2		0.6	
1962			(183.5/158.7)		18.2			
1963			153.4		20.2			
1964			154.3		19.8			
1965		<149*	158.5		20.5			(-0.3)
1966			102.2		21.0			
1967			70.3		22.0			
1968			73.7		25.0			
1969			124.7		25.9			
1970		<201*	145.6		24.7			
1971			129.6		24.6			
1972		167.3	124.5		24.6			
1973			107.9		24.3			
1974			100.8		26.8			
1975		<223*	131.9		21.8			
1976			110.5		22.2			
1977			74.6		22.3			
1978	(470-530)	<236*	131.0		19.5			
1979			156.0		17.0			
1980			207.8		14.9			
1981	(~350)	(~200)	190.4		13.9			
1982		≤195	175.2		9.9			
1983		≤158	120.6		5.8			
1984		≤159	94.0		5.2			

Notes: Empty data cells indicate that the statistical information is not available and do not denote zero values. Parentheses enclose rough estimates for the indicated or nearby years. The applicable years for parenthesized estimates were not stated in the source. Other provinces where farmers grow cassava include Hubei and Sichuan, but sown area is minor. Taiwan Province is now normally not included in national aggregated statistics for the People's

Republic of China, although separate data entries for Taiwan are not unusual among PRC statistical compendia. Taiwan is probably included in the 1961 national figure, however.

* These figures probably overestimate officially recorded plantings by 20-40 thousand hectare. See Table 7.

Sources:

Guangxi: Guangxi Jingji Nianjian Bianjibu [Guangxi Economic Yearbook Editorial Department] (eds.) Guangxi Jingji Nianjian 1985 [Guangxi Economic Yearbook 1985] (Nanning: Guangxi Jingji Nianjian Bianjibu, 1985), pp. 531 and 593.

The 1976 figure was confirmed in Guangxi Nongye Dili Bianxiezu [Guangxi Agricultural Geography Editorial Board] (eds.), Guangxi Nongye Dili [Guangxi Agricultural Geography] (Nanning: Kexue Chubanshe [Scientific Publishing House], 1980), p. 76.

The lower figure for 1962 is from Liang Guangshang (ed.), Mushu Zaipei yu Liyong (Guangzhou: Guangdong Keji Chubanshe, 1981), p.9.

Taiwan: Republic of China, Executive Yuan, Directorate-General of Budget, Accounting and Statistics, Statistical Yearbook of the Republic of China 1985 (Taipei: Republic of China, 1985), p. 281.

The 1952-54 figures were added from:

Republic of China, Directorate-General of Budget, Accounting and Statistics, Statistical Yearbook of the Republic of China 1982 (Taipei: Republic of China, 1982), p. 115.

China and other Provinces:

The "1978" figure is from Zhongguo Kexueyuan, Dili Yangjiusuo, Jingji Dili Yanjiushi [Chinese Academy of Science, Institute of Geography, Economic Geography Research Laboratory], Zhongguo Nongye Dili Zonglun [A General Treatise on Chinese Agricultural Geography] (Beijing: Kexue Chubanshe, 1980), p. 129.

The "1981" figure is from James H. Cock and Kazuo Kawano, "Cassava in China", unpublished trip report, International Center for Tropical Agricultural Research (CIAT), Cali, Colombia, June 1982, pp. 1-2.

The 1961 figure is from Liang, Mushu Zaipei yu Liyong, p. 9. This source also stated that national cassava-sown area remained around 5 million mu during the 1960s (300-367,000 hectares, assuming 4.5-5.5 million mu.) The figure for Hunan, Zhejiang and Jiangxi combined was given as around 5,000 mu (333 ha.) in each year of the 1960s.

Guangdong: The overestimates for Guangdong for 1965, 1970, 1975, 1978, 1979 and 1982-84 are from Table 7. A 1981 overestimate of 201 thousand hectares was also calculated. The 1979 and 1982-84 estimates are relatively close approximations. The 1965, 1970, 1975 and 1978 figures probably overestimate by at least 20-40 thousand hectares. See Table 7. The 1943 and 1972 figures are from Liang, Mushu Zaipei yu Liyong, p. 9 and the "1981" estimate is from Cock and Kawano, "Cassava in Asia," p. 1.

seems to enjoy some very minor farmer cultivation in Sichuan, but probably not elsewhere within the experimental area. In fact, it is not yet clear from the estimates of national, Guangdong and Guangxi cultivation assembled in Table 1, that cassava expansion efforts have resulted in significant increased plantings outside of those two provinces.

In the absence of a reliable national cassava production series, the best approximation would be to synthesize production series for Guangdong and Guangxi. Fortunately, complete 1950-84 series for Guangxi were published in 1985 (Table 2). These data, though not necessarily without flaws, provide the best understanding of year-to-year movements in cultivation and yields. A glance at Table 2 will ble 2. Cassava Production, Area and Yield in Guangxi Zhuang Autonomous Region, 1950-1984

	Production		Area	Yield	
	(Grain Equivalent) Tons	(Fresh Root) Tons	(Hectares)	(Grain Equivalent) T/Ha.	(Fresh Root T/Ha.
50	30,045	150,225	41,507	0.724	3.619
51	39,365	196,825	37,567	1.048	5.239
52	41,870	209,350	48,493	0.863	4.317
53	36,635	183,175	41,340	0.886	4.431
54	42,535	212,675	67,453	0.631	3.153
55	35,365	176,825	62,647	0.565	2.823
56	58,280	291,400	93,013	0.627	3.133
57	91,000	455,000	104,320	0.872	4.362
58	165,205	826,025	132,567	1.246	6.231
59	140,330	701,650	118,840	1.181	5.904
60	88,045	440,225	127,913	0.688	3.442
61	115,855	579,275	104,353	1.110	5.551
62	189,260	946,300	183,547	1.031	5.156
63	152,335	761,675	153,433	0.993	4.964
64	160,225	801,125	154,307	1.038	5.192
65	167,835	839,175	158,520	1.059	5.294
66	84,435	422,175	102,220	0.826	4.130
67	173,715	868,575	70,300	2.471	12.355
68	162,120	810,600	73,667	2.201	11.004
9	216,750	1,083,750	124,733	1.738	8.689
0	235,990	1,179,950	145,600	1.621	8.104
1	211,295	1,056,475	129,613	1.630	8.151
2	262,270	1,311,350	124,480	2.107	10.535
3	206,545	1,032,725	107,900	1.914	9.571
4	170,765	853,825	100,847	1.693	8.467
5	260,425	1,302,125	131,900	1.974	9.872
6	187,065	935,325	110,473	1.693	8.467
7	141,865	709,325	74,567	1.903	9.513
8	258,295	1,291,475	131,020	1.971	9.857
9	312,645	1,563,225	155,993	2.004	10.021
0	481,215	2,406,075	207,760	2.316	11.581
1	484,280	2,421,400	190,387	2.544	12.718
2	468,255	2,341,275	175,173	2.673	13.365
3	326,680	1,633,400	120,640	2.708	13.539
4	241,180	1,205,900	94,001	2.566	12.829

es: Cassava production and yield data are often quoted in Chinese statistical sources on a "grain equivalent basis". Since 1964, the conversion to "grain equivalence" for all root and tuber crops has meant dividing the fresh weight by five, although this would undervalue cassava, sweet potatoes and taro relative to most cereal crops in terms of calories per unit weight. It is assumed that the production and yield data in the source for this table appeared in "grain equivalent" form. The original data have therefore been multiplied by five to calculate fresh root weight.

Source: Guangxi Jingji Nianjian Bianjibu (eds.), Guangxi Jingji Nianjian 1985 (Nanning: Guangxi Jingji Nianjian Bianjibu, 1985), pp. 531-532 and 593.

confirm that the 35-year period encompasses considerable variation in both.

During the 1950s, some government-initiated efforts were undertaken to expand cultivation of cassava which was viewed as a crop capable of providing considerable bulk and caloric content per unit area. One cannot rule out the possibility, however, that a portion of the implied increase in cultivation reflected previously unregistered cassava areas eventually included in statistical coverage, especially during the formation of agricultural producers' cooperatives (1954-56) and the people's communes (1958). Elsewhere[6] it has been demonstrated that most of the implied growth in total root and tuber crop area since 1952 is likely to be real, the actual figures remaining, in all probability, within about 5 percent (below) the official data.

The considerable increase in cassava area in 1958 parallels an even larger reported increase for all root and tuber crops. While 1958 was a year of extreme statistical distortion, casting doubt on

[6]Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," The China Quarterly, September 1984, pp. 594-630.

the magnitude of the increase, the implied growth was no greater than that of 1956, much of which may have been real. 1958 was also a year in which great efforts were made to increase foodcrop production by whatever means possible. Root and tuber crops, including cassava, were correctly identified as the easiest means to effect a short term leap in bulk food production. It is difficult, however, to accept the implied 1958 increase in average yield to an unprecedented level, especially in view of the (except for sweet and white potatoes, more modest) expansion of area planted with other food crops and maintenance of yields in that year. In sum, while it appears that the total Guangxi foodcrop data (excluding cassava) have been adjusted in the 1985 Guangxi Economic Yearbook for the statistical distortion typical of 1958 published materials, it is quite possible that those for cassava may not have been, particularly in the yield category.

The decline in 1959 area, however, followed by some recovery in 1960 are undoubtedly real, although it is impossible to verify the exact figures. Inflated reports of miraculous grain production success in 1958 led authorities to increase area sown with economic crops in 1959 at the expense of staples. [7] When the truth became clear (1958 had been a good, but not spectacular year), it was too

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[7]Li Choh-ming, The Statistical System of Communist China (Berkeley: University of California Press, 1962); Kenneth R. Walker, Food Grain Procurement and Consumption in China (Cambridge: Cambridge University Press, 1984); Nicholas R. Lardy, Agriculture in China's Modern Economic Development, Cambridge: Cambridge University Press, 1983.

late to correct spring planting. Some compensation would have been made with 1959 fall planted cassava, however, and in 1960, in view of poor harvests for all foodcrops the previous year. The yield decline in 1960 is consistent with widespread natural disasters throughout China estimated to be the worst in the twentieth century. These were somewhat less severe in Guangxi than in some other provinces, but yields of other Guangxi food crops reportedly decline by a weighted average of 9 percent during 1960 and 1961. [8] Spring planted cassava, in particular,is subject to insect damage during the seedling period and in the fall, typhoon damage.

The low area figure for 1961 is consistent with both poor statistical coverage during the period and significant rural dislocation associated with the 1960-61 famine throughout China which may have partially extended into Guangxi. The large increase in cassava area in 1962, followed by subsidence during the following few years is also explainable in terms of reaction to the 1960-61 famine.

Geographic coverage may not have been consistent throughout the series. Qinzhou Special District was transferred from Guangxi to Guangdong in 1955, then back to Guangxi in 1965. Qinzhou includes the entire current Guangxi coast and extends north from the current provincial border to the Yu River, then angles southwest towards the

[8]Guangxi Jingji Nianjian Bianjibu [Guangxi Economic Yearbook Editorial Board], Guangxi Jingji Nianjian, 1985 [Guangxi Economic Yearbook 1985] (Nanning: Guangxi Jingji Nianjian Bianjibu, 1985), p. 530.

border with Vietnam. In 1976, area sown with foodgrains in Qinzhou covered 461,333 hectares. Area planted with root and tuber crops in the western district of Guangdong circa 1957 (including Qinzhou Special District and Zhanjiang Prefecture) consisted of 28.3 percent of total area sown with foodcrops (excluding soybeans), a little less than 5 percent of which was planted with cassava and "mao" potatoes. [9] These reports suggest that something on the order of 6 thousand hectares of cassava were transferred from Guangxi to Guangdong in 1955, then (potentially more extensive cassava area) back to Guangxi in 1965. This could explain the counter-trend movements of cassava area in the Guangxi series for 1955 and 1965.

Data oscillations during the succeeding decade (1966-77) are less understandable as a function of nationwide economic developments and may be peculiar to cassava or to Guangxi. Hypotheses for explaining these oscillations include the lagged effect of earlier shocks echoed via the rotation system (see below) and periodic reclamation initiatives. In Guangxi, cassava is often grown during the early years of a reclamation project in order to earn some economic return before reclamation is complete. When the quality of farmland construction and field preparation permits, cassava is often phased out to make way for more highly valued crops.

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[9] Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," pp. 612-615.

The low planted area figures for 1967 and 1968 and, particularly, the high average yield estimates for those years are especially anomalous. Although fertilizer use accelerated during the 1960s, widespread application to cassava as early as 1967-68 is very unlikely. One is consequently motivated to hypothesize about a statistical quirk: e.g. independent production and area estimates with the latter underestimated due to statistical confusion typical of the early years of the Cultural Revolution period (1966-77).

Even excluding 1967 and 1968, the data indicate a marked increase in yields from an average of 4.5 tons per hectare (1950-66) to 9.0 tons per hectare (1969-77) or 10.3 tons per hectare (1969-84). Some of this increase per unit productivity is explainable in terms of initiation of fertilizer application, and cultivation of cassava on state farms with plentiful access to fertilizers. But state farms in Guangxi occupied only 20 thousand hectares (1982) and large portions of this total were devoted to cultivation of grain crops and sugar cane.[10] It seems unlikely, therefore, that increased fertilizer use alone can fully explain this yield increase.

In the absence of definitive information, what could explain a sudden doubling of average yields in the mid-1960s? One hypothesis would emphasize technical change. Much of the important selection and breeding work was undertaken in the late 1950s and early 1960s.

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[10]Zhongguo Guojia Tongjiju, Zhongguo Tongji Nianjian 1983, pp.

The South China Tropical Crops Research Academy bred or selected many of the well-known varieties under current production representing significant improvement in aggregate speed and quantity of root production during the 1959-62 period. The South China Agricultural Science Academy in Guangzhou bred or selected for multiplication and dissemination, several other higher yielding varieties during the 1957-62 period.[11] Particular attention paid to cassava during this period may also have produced important results in improving field cultivation techniques.

Another hypothesis would suggest that cassava cultivation on somewhat better land was initiated during this period. The Cultural Revolution decade (1966-77) was marked by a policy of local self-sufficiency in grain production and escalation of quota deliveries. In some cases, quotas were specified in terms of particular crops needed by the state. In other cases, quotas were specified only in terms of weight of staples leaving the choice of crops to each collectivity of farmers. Although farmers received compensation for quota deliveries, prices were notoriously low, involving an implicit tax. Land taxes, amounting to roughly 5-13 percent of output during this period depending on location, were also payable in kind. Taxes and quotas were therefore obligations to be discharged with commodities achieving the highest bulk yield per unit area. Although fresh weight of root and tuber crops was divided by 4 for these

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[11]Liang Guangshang (ed.), <u>Mushu Zaipei yu Liyong</u>, pp. 77-78.

accounting purposes through 1963, and by 5 thereafter, cassava may have been cultivated and even fertilized by a wider variety of localities in South China with the express purpose of expeditiously discharging these obligations. [12]

The determinants of variation during the final period (1978-84) are somewhat easier to identify with confidence. The steady growth in yields is almost certainly related to an increase in manufactured fertilizer nutrient application. Although average application levels for cassava are not known with precision, nutrient application within China as a whole tripled between 1976 and 1984 and doubled between 1978 and 1984 culminating with an average rate of 120.6 kg./ha. of sown area. Efficiency of utilization also increased during the period. Although the average level in Guangxi was somewhat lower, it grew even more rapidly than the national average between 1976 and 1982 (to 110.2 Kg./ha.), then stagnated in 1983 (112.4 Kg./ha.) and 1984 (109.7 Kg./ha.), paralleling yield progress in Guangxi.[13]

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[12]For further discussion of these issues, see Bruce Stone, "China's 1985 Foodgrain Production Target: Issues and Prospects" in Anthony M. Tang and Bruce Stone, Food Production in the People's Republic of China IFPRI Research Report no. 15, (Washington, D.C.: International Food Policy Research Institute, 1980), pp. 147-149.

[13]Bruce Stone, "Chinese Fertilizer Application in the 1980s and 1990s: Issues of Growth, Balance, Allocation, Efficiency, and Response" in US Congress Joint Economic Committee (eds.), China's Economy Looks to the Year 2000, vol. 1 The Four Modernizations (Washington, D.C.: U.S. Government Printing Office, 1986, pp. 453-496; and State Statistical Bureau, PRC, Statistical Yearbook of China 1985 (Hongkong and Beijing: Economic Information and Agency, and China Statistical Information and Consultancy Service, 1985), p. 283.

Application of manufactured fertilizers to cassava is likely to be much below the average level for all crops in Guangxi except on state farms, but scattered survey reports [14] confirm that on farmers' fields near cassava research institutions in South China, yields which are comparable to the recent Guangxi provincial averages are only obtainable with fertilizer application, or under good soil and climatic conditions atypical of most Chinese cassava growing areas. One of the survey respondents, however, also indicated that the cassava research in China had made significant progress in developing improved varieties and low-cost cultural practices a decade earlier. Yet the predominant varieties planted in the 1980s were among those selected (or bred) during the late 1950s and early 1960s (see below).

The rise and fall in cassava area during the 1978-84 period is attributable to a number of factors, the most powerful of which has been the rise and fall of opportunities for export to the European Community. With EC pressure on Thailand (the dominant and low cost supplier) to reduce exports during the late 1970s, Chinese exports responded to the opportunity with rapid growth in 1979, 1980 and 1981

[14] "Delphi Survey for the Assessment of Potential Yields of Cassava" circulated to cassava breeding institutions in China and elsewhere by J. S. Sarma, International Food Policy Research Institute, 1986. The respondent who mentioned varietal and cultural improvement a decade ago was Liu Yingjing of the South China Institute of Botany in Guangzhou.

(Table 3) before similar pressure eventually forced a deceleration beginning in 1982 (with 1981 fall sown cassava).[15]

Other circumstances contributing to this responsiveness involve changes in rural institutions since 1978-79: farmers have been allowed more control over cropping and management decisions, but are also afforded less market security from the government as a guaranteed buyer. At the same time, very poor locations typical of many Chinese cassava-growing areas have been released from tax and quota obligations, while the government, in response to substantial success in accelerating national foodcrop production growth, began emphasizing higher quality in farm procurement items compared with the considerable previous period emphasis on cheaper bulkier products such as most root and tuber crops and the lowest quality grades of cereal crops. These considerations, coupled with the overall liberalization of economic activities in rural areas explains the fall in cassava area to a 1984 level below that typical of the pre-1978 period. The decline in sown area cuts across most grain crops throughout China, but is particularly noteworthy in proportional terms in the case of crops typically grown in poorer farmlands and characterized by low prices and weak markets such as sorghum, white potatoes, bean crops and, no doubt, cassava (Table 4). In Guangdong and Guangxi, although unsuitable for such a warm moist climate,

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[15]Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," pp. 623-625; Bruce Stone, "An Examination of Economic Data on Cassava Production, Utilization and Trade in China," pp. 16-22.

Table 3. PRC Cassava Exports, 1963-1984

	Dried Cassava			Cassava Tapioca	Cassava Starch	TotalCassava Exports in Fresh Root Equivalents
	To European Community Only	Share of EC net Cassava Imports	Total Exports			
	(metric tons)	(percent)	(metric tons)	(metric tons)	(metric tons)	(metric tons)
3	20,977					
4	33,393					
5	72,676					
6	57,077					
7	53,173					
8	28,015					
9	1,324					
0	4,984					
1	14,859					
2	16,070					
3	8,083					
4	4,111	0.2^-	4,000		11,429	
5	4,211	0.2^-	4,000		11,429	
6	7,253	0.2^+	7,000	6,500	2,000	60,657
7	999	0.0^+	1,000	2,000		11,948
8	1,327	0.0^+	1,000	1,000		7,403
9	51,449	1.0^-	51,000	5,800	2,060	183,522
0	335,989	6.9^+	336,000	20,500	2,500	1,067,070
1	606,589	9.1^-	607,000	10,000	1,500	1,788,073
2	440,181	5.4^+	445,000	14,000	1,500	1,343,397
3	15,222	0.4^-	460,000			1,314,285
4	143,000	2.7^-			1,314,285	

es and Sources:

European Community data for dried cassava imports from China and other countries are
oiled from EUROSTAT and NIMEXE Analytic Tables for Foreign Trade (which are in close
eement). Total dried cassava, cassava tapioca and cassava starch export data are from Food
Agriculture Organization of the United Nations, "Supply Utilization Accounts Tape, 1984,"
e, 1985. The fresh root equivalents of all cassava exports aggregated together appear in
"Standardized Commodity Balance Tape, 1984" Rome, 1985. The 1983 and 1984 data must be
irded as open to some question and may be revised in future compendia.

Table 4. Area Sown with Major Cereals, Bean Crops, Roots and Tubers in China, 1976-85

	Rice	Wheat	Corn	Soybeans	Millet	Sorghum	Sweet and White Potatoes	Only Sweet Potatoes	Only White Potatoes	Other Cereals & Bean Crops	Total Foodgrains
						(thousand hectares)					
1976	36,217	28,417	19,228	6,691	4,501	4,329	10,366			10,994	120,743
1977	35,526	28,065	19,658	6,845	4,477	3,759	11,229			10,841	120,400
1978	34,421	29,183	19,961	7,144	4,271	3,456	11,796	-6,800	-5,000	10,355	120,587
1979	33,873	29,357	20,133	7,247	4,173	3,173	10,952			10,355	119,263
1980	33,879	29,228	20,353	7,227	3,872	2,693	10,153			9,829	117,234
1981	33,295	28,307	19,425	8,023	3,888	2,610	9,621			9,789	114,958
1982	33,071	27,955	18,543	8,419	4,039	2,783	9,370	6,916	2,454	9,283	113,463
1983	33,137	29,050	18,824	8,414	4,087	2,707	9,402	6,840	2,562	8,426	114,047
1984	33,179	29,577	18,537	7,286	3,797	2,384	8,988	6,426	2,562	9,136	112,884
1985	32,070	29,218	17,694	7,718			8,571				108,845

Sources: Most data were converted from Chinese unit figures or were calculated from data appearing in State Statistical Bureau (SSB), PRC, _Statistical Yearbook of China 1985_ (Hong Kong and Beijing: Economic Information and Agency and China Statistical Information and Consultancy Service Centre (CSICSC) 1985), p. 253. 1985 data were added from SSB, PRC, _China: A Statistical Survey in 1986_ (Beijing: CSICSC, 1986), p. 37. 1982-84 figures for sweet potatoes and for white potatoes are from He Kang et al, Zhongguo Nongye Nianjian Bianji Weiyuanhui [Chinese Agricultural Yearbook Editorial Committee] (ed.), _Zhongguo Nongye Nianjian 1983_ [Agricultural Yearbook of China 1983] (Beijing: Nongye Chubanshe [Agricultural Publishing House], 1984), p. 40; He Kang et al, _Zhongguo Nongye Nianjian 1984_ (Beijing: Nongye Chubanshe, 1985), p. 88; He Kang et al, _Zhongguo Nongye Nianjian 1985_ (Beijing: Nongye Chubanshe, 1986), pp. 147-148. The estimates for sweet and white potatoes in 1978 are from Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," _The China Quarterly_ September 1984, p. 628.

wheat had been cultivated for import substitution purposes. With relaxation of this uneconomic emphasis on wheat, sown area declined in the two provinces. Less drastically, area sown with several other food crops, such as paddy, sweet potatoes, sorghum and millet, also fell in favor of economic crops, especially sugarcane (Tables 5 and 6).

After 1979, is it possible to confirm that the trends indicated for Guangxi are representative nationally? Even without national data, the addition of series for Guangdong would provide a reasonable proxy. Unfortunately, cassava series for Guangdong are unavailable, but a very rough approximation may be discerned from Table 5. The left-hand column is comprised of figures quoted for Guangdong specifically. The center column is derived from data appearing in the 1984 and 1985 Guangdong Statistical Yearbooks. These data are not estimates of cassava area *per se*, but are formed by deducting data for sugar cane, peanuts, sesame, jute, kenaf and tobacco from figures for total area planted with economic crops. The estimates in parentheses to the right more closely approximate cassava plantings inasmuch as area sown with all oil crops, all fibers, and medicinal herbs have also been deducted from the "economic crop" area along with sugarcane and tobacco on the basis of recent Agricultural Yearbook of China volumes to arrive at the residuals. During the recent decade at least, cassava has been classified as an economic crop in production statistics, rather than as a foodcrop, and the calculated residual should be predominantly

Table 5. Sown Area and Production of Foodgrains, Edible Economic Crops and Other Edible Farm Crops for Guangxi Zhuang Autonomous Region, 1979 - 1984

	Sown Area						Production					
	1979	1980	1981	1982	1983	1984	1979	1980	1981	1982	1983	1984
	--- thousand hectares ---						--- thousand metric tons ---					
All Foodgrains	4094.40	3957.13	3933.07	3939.80	3834.27	3690.33	11730	11905	11495	13520	13630	12130
Paddy Rice	2830.47	2784.33	1791.67	2773.00	2737.27	2661.07	10070	10070	9815	11745	12080	10675
Wheat	102.07	41.66	24.33	21.00	17.80	14.87	39	25	20	20	15	15
Corn	565.93	535.20	569.13	546.47	520.73	500.27	985	1110	1290	1220	1070	1040
Soybeans	152.80	173.00	218.27	273.13	258.07	229.60	95	100	140	215	185	160
Sweet and White Potatoes (1/5 nat. weight) a/	167.33	164.20	175.67	227.67	215.60	210.67	175	170	180	270	235	220
Other Miscellaneous Grains b/	255.60	278.73	146.00	69.67	79.40	68.97	366	430	140	55	45	35
Sorghum	2.00	2.50	1.87	1.93	1.67	1.67	1.20	1.70	na	...	...	...
Millet	8.53	8.73	6.13	4.93	3.53	3.33	5.00	5.00	na	5.00	...	5.00
All Economic Crops c/	570.35		562.53	578.27	511.20	na						
All Edible Oilcrops	181.47	167.47	166.53	178.20	175.93	188.33	152.55	137.35	142.35	174.35	185.70	219.30
Peanuts	153.27	141.53	134.00	143.80	146.20	157.33	144.86	128.75	130.75	161.50	175.35	208.35
Rapeseed	9.33	5.86	12.00	10.80	8.53	8.47	2.70	2.60	4.70	4.85	3.65	3.80
Sesame	15.00	16.60	17.07	18.87	18.00	18.73	3.80	4.50	5.15	6.05	5.90	6.25
Sunflower												
All Sugar Crops	127.73	111.73	127.00	157.73	151.93	158.07	3810.00	4019.25	5276.90	7229.45	6806.50	7219.70
Sugar Cane	127.73	111.73	127.00	152.73	151.93	158.07	3810.00	4019.25	5276.90	7229.45	6806.50	7219.70
"Other" Economic Crops	193.67		200.87	187.80	134.20	na						
Cassava	156.97	207.76	190.39	175.17	120.64	na	312.64	481.22	484.28	468.26	326.68	na
All Fruit			46.73	51.33	56.00	55.67	156.05	209.05	276.60	316.20	291.00	332.45
Bananas				2.67	4.13	na	7.25			35.60	33.75	na
Pears				1.73	1.73	1.53	7.90		13.70	7.95	8.50	11.80
Citrus Fruit				22.67	27.67	28.69	40.75		105.25	127.25	102.55	147.10
Pineapples				na	na	na	21.70		16.70	37.20	na	na
Persimmons				na	na	na	6.65			9.75	na	12.75
Red Dates				na	na	na	1.60			1.89	1.90	2.45
Other Farm Crops d/	434.53		333.60	292.27	279.53	302.07						
Vegetables	65.07		75.87	90.93	93.53	84.93						
Melons	2.93		4.40	7.60	7.40	11.93						

Notes: "na" indicates that the data is not available.

a/ Suburban and perhaps some rural private plot plantings as vegetable crops may be excluded. Although both crops have been grown in Guangxi Zhuang Autonomous Region, these data consist predominately of sweet potatoes.
b/ "Other Miscellaneous Grains" include grain legumes such as broad beans, field peas and mung beans.
c/ Economic crops include cotton, oilseeds, sugar crops, bast fibers, tobacco and "other economic crops" such as cassava.
d/ "Other Farm Crops" include vegetables, melons, green manure, green fodder crops and others.

Sources: Guangxi Jingji Nianjian Bianjibu, Guangxi Jingji Nianjian, 1985; Table 2 (above); Table 7: He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1980; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1981; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1982; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1983; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1984; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1985; Zhongguo Tongjiju, Zhongguo Tongji Nianjian - 1981.

Table 6. Sown Area and Production of Foodgrains, Edible Economic Crops and Other Edible Farm Crops for Guangdong Province, 1979 - 1984

	Sown Area 1979	1980	1981	1982	1983	1984	Production 1979	1980	1981	1982	1983	1984
	--- thousand hectares ---						--- thousand metric tons ---					
All Foodgrains	5598.47	5320.07	5061.87	5019.93	5004.67	4947.53	17380	18985	16555	19420	19695	19725
Paddy Rice	4251.53	4163.73	4059.20	4004.60	4028.67	3933.67	15420	16230	14790	17445	17915	17730
Wheat	404.60	236.07	107.47	98.73	98.47	65.87	355	240	140	165	66	125
Corn	44.60	45.87	43.00	41.67	38.80	40.13	65	65	65	70	65	70
Soybeans	130.07	139.27	140.07	153.60	138.73	135.60	100	115	120	145	110	120
Sweet and White Potatoes (1/5 nat. weight) a/	666.73	647.00	615.60	623.73	621.60	605.13	1390	1365	1360	1520	1490	1425
Other Miscellaneous Grains b/	80.53	88.13	90.80	93.33	74.53	65.80	50	70	80	80	50	50
Sorghum	2.33	1.27	1.20	1.33	1.27	1.20	1	1	na	...	...	...
Millet	5.67	5.20	4.33	2.93	2.53	2.13	3.50	4.50	na	5.00	...	5.00
All Economic Crops c/	917.20		964.93	1007.40	833.80	953.80						
All Edible Oilcrops	451.87	445.47	475.26	476.13	394.33	414.67	481.15	531.55	610.15	665.60	518.90	579.20
Peanuts	386.67	404.67	430.00	431.07	363.67	334.73	428.65	519.50	594.75	651.00	511.15	568.80
Rapeseed	23.00	21.60	24.47	26.07	15.60	18.87	7.15	7.00	9.25	9.15	3.50	6.40
Sesame	21.93	19.20	20.80	19.00	15.07	11.07	5.30	5.00	6.15	5.45	4.25	4.00
Sunflower	0.20	...	...	...	...	...	0.02	...	...	...	...	...
All Sugar Crops	181.80	175.87	220.80	278.47	282.26	316.13	8219.20	9226.50	13698.50	17222.90	12500.00	17692.00
Sugar Cane	181.80	175.87	220.80	273.47	282.26	316.13	8218.20	9226.50	13698.50	17229.80	12590.00	17692.00
"Other" Economic Crops	214.60		200.80	194.60	157.80	159.13						
Cassava	na	(20)	na				na	na	na			
All Fruit			41.67	139.27	141.87	191.73	285.55	322.35	418.40	512.45	570.20	792.45
Bananas				2.80	4.13		55.80	na	na	134.70	143.05	
Pears							3.30	na	6.65	4.75	4.55	5.60
Citrus Fruit				21.13	24.47	31.73	87.20	na	119.85	157.95	178.55	267.35
Pineapples							45.50	na	91.00	66.70		
Persimmons							6.65	na	na	9.60		12.70
Red Dates												
Other Farm Crops d/	470.90		368.67	372.60	399.07	456.60						
Vegetables	182.00		199.67	232.87	263.20	305.73						
Melons	7.33		10.73	10.73	12.47	21.47						

Notes: "na" indicates that the data is not available.

a/ Suburban and perhaps some rural private plot plantings as vegetable crops may be excluded. Although both crops have been grown in Guangdong Province, these data consist predominately of sweet potatoes.

b/ "Other Miscellaneous Grains" include grain legumes such as broad beans, field peas and mung beans.

c/ Economic crops include cotton, oilseeds, sugar crops, bast fibers, tobacco and "other economic crops" such as cassava.

d/ "Other Farm Crops" include vegetables, melons, green manure, green fodder crops and others.

Sources: Guangdongsheng Tongjiju, Guangdongsheng Tongji Nianjian, 1985; Table 2 (above); Table 7; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1980; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1981; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1982; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1983; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1984; He Kang et al (eds), Zhongguo Nongyebu, Zhongguo Nongye Nianjian, 1985; Zhongguo Tongjiju, Zhongguo Tongji Nianjian - 1981.

comprised of, but should overestimate area planted with cassava. The estimate in the right-hand column is derived by deducting published Chinese estimates for area sown with cassava in Guangxi (1961), Taiwan (1961), Fujian (1961), Yunnan (1960), Guizhou (1961) and Hunan, Zhejiang and Jiangxi (circa 1960s) from a published 1961 national figure. The calculated figure substantially exceeds the residual-based overestimates of cassava area in Guangdong for surrounding years in a period when cassava area in other Chinese provinces was undoubtedly small. These data are evidently in conflict.

An examination of 1950s Chinese material provides an impression that 1950s cassava area in Guangdong was greater than that implied by the residual-based "overestimates" in the center column of Table 7. Guangxi cassava area in 1957, for example, was around one-quarter of all Guangxi farmland planted with root and tuber crops. If the same proportion were relevant for Guangdong, 1957 cassava area would total more than 300 thousand hectares. But whereas 36.21 percent of Guangxi root and tuber crop production consisted of crops other than sweet potatoes, this figure was only 13 percent for Guangdong, and included cassava, taro, white potatoes and "mao" potatoes, primarily the first two categories.[16] Still, 1957 Guangdong cassava area could easily have been in the range of 100-200 thousand hectares.

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[16]See data and Chinese sources cited in Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," pp. 609-616.

able 7. Estimates of Area Sown with Cassava in Guangdong Province, 1943-1984

	Guangdong Cassava area estimates in Chinese sources	Residual-based estimates of "other" economic crops in Guangdong (thousand hectares)		National estimate minus Guangxi, Yunnan, Fujian, Taiwan, Guizhou, Hunan, Zhejiang & Jiangxi
943	33.4			
952		25		
957		57		
961				-240
962		25		
965		149		
970		201		
972	167.3			
975		223		
978		236		
979			(215)	
980		237		
981	-200		(201)	
982		243	(195)	
983		188	(158)	
984		206	(159)	

ources: Data appearing in the left- and right-hand columns are based on Table 1 except that the Taiwan Province figure deducted along with those from other provinces from the national estimate for 1961 (10,000 ha.) was taken from the same source as the national figure, Liang Guangshang (ed.) Mushu Zaipei yu Liyong, p. 9. Data appearing in the center column are based on data from Guangdongsheng Tongjiju [Guangdong Province Statistical Bureau] (ed.), Guangdongsheng Tongji Nianjian 1984 [Guangdong Province Statistical Yearbook 1984] (Xianggang: Xianggang Jingji Daobao Shechuban [Hong Kong Economic Reporter Publishing House], 1984), pp. 113-114; and Guangdongsheng Tongjiju, Guangdongsheng Tongji Nianjian 1985 [Guangdong Province Statistical Yearbook 1985] (Xianggang: Xianggang Jingji Daobao Shechuban, 1985), pp. 107-108. Sown area data for sugarcane, peanuts, sesame, jute, kenaf and tobacco were deducted from total area sown with economic crops. Data for rapeseed and other oilcrops, other fibers, and medicinal herbs have also been deducted from the figures appearing in parentheses on the basis of Zhongguo Nongyebu [Chinese Ministry of Agriculture], Zhongguo Nongye Nianjian, 1980, 1982, 1983, 1984 and 1985 (Beijing: Nongye Chubanshe [Agricultural Publishing House], 1981, 1983, 1984, 1985 and 1986).

During the 1950s, cassava was treated explicitly as "shulei" [including both tuber crops and tuberous roots], which in turn were classified as "liangshi" [staple food crops], occasionally as part of "miscellaneous grains." By the mid-1970s, however, it is clear that cassava was excluded from "shulei" and "liangshi" statistics and incorporated as a sub-category or as a residual within "jingji zuowu" [economic crops]. The transition date has not been clearly determined, although 1964 and 1976 have been suggested as candidates.[17] In view of the trends exhibited for Guangxi in Table 2 and the foregoing discussion attempting to resolve the conflict implied in Table 7, it seems likely that the 1950s economic crop statistics appearing in the Guangdong Province Statistical Yearbooks, though recently published, are unlikely to have been adjusted for inclusion of cassava; hence the center column cannot be used as a proxy for cassava area for the 1950s nor probably for 1962. From 1965 onward, however, these residuals may well provide the best indication of trends in (though not exact estimates of) Guangdong cassava area, since cassava is likely to dominate the category. It should be noted, however, in view of economic liberalization since 1979, that the divergence of this residual series and actual cassava area is likely to have increased, especially since the decline in export opportunities in the early 1980s.

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[17] op. cit., pp. 600-604.

Unfortunately, despite the availability of an official cassava series for Guangxi and a rough approximation of trends for Guangdong, it is still not possible to be definitive about national trends for China. It is clear that cassava was planted on less than 100 thousand hectares in the mid-1940s, rising quickly to perhaps around 250 thousand hectares by 1957 and 355 thousand hectares (excluding Taiwan) by 1961 during the famine. Total plantings on the Chinese mainland probably subsided to roughly 300 thousand hectares by 1965 and were certainly not much lower in 1972 when plantings in Guangdong and Guangxi alone totalled 292 thousand. Official area sown with cassava in the two southern provinces seems to have risen to 370 thousand hectares in 1979, perhaps peaking in 1980 at 410-420 thousand hectares, subsiding to 390 tha and 370 tha in 1981 and 1982 and plummeting to 275 tha and 250 tha in 1983 and 1984.

But whether cassava area rose appreciably outside of these two southern provinces since the early 1960s is not clear. The (undated) total of 350 thousand hectares given to the CIAT delegation by Chinese cassava breeders in spring 1982 would imply that it has not, while the (undated) Institute of Geography estimate (around 500 thousand hectares) published in 1980 suggests either considerable expansion into other provinces or more aggressive estimates of non-field cultivation. Barring the unlikely event of relatively even distribution among other mentioned provinces, officially recorded plantings of 120-190 thousand hectares outside of Guangdong and Guangxi implied by the Institute figure and the provincial estimates would surely have been mentioned by the breeders or in cassava-related publications, while the 350 thousand hectare figure, though purportedly including an estimate for cassava on private plots, does not even appear to cover probable plantings in the two southern provinces.

Part of the problem is that cassava area is undoubtedly more difficult to estimate than that of most field crops, since considerable proportions are grown on private plots, on narrow strips adjacent to roads and fields, on hilly and incompletely cleared land not yet or normally considered farmlands, and on tiny corners not even counted among private plot statistics. There is even some illegal cultivation: under trees on state rubber plantations, for example.[18] The Institute of Geography figure probably incorporates a more aggressive estimate, based on some survey evidence of these kinds of plantings which in large part elude official statistical coverage.

All that can be claimed with near certainty is that national cassava planting reached another major peak in the late 1970s or early 1980s, and then declined rapidly with the subsidence of opportunities for international trade, increasing liberalization of rural economic activities and a probable cut back in the government's role in cassava marketing.

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[18] op. cit., p. 621.

National production trends are even less discernible. The only available figure for recent production is 3 million tons provided to the CIAT delegation in spring 1982, [19] although like the 350 thousand hectare figure provided at the same time, it may well be an underestimate. The best indication of national yield trends is undoubtedly the Guangxi series in Table 2 with some reservations about a few of the years such as 1967 and 1968. The national average implied by the figures given to the CIAT delegation is 8.6 tons per hectare, suggesting that average yields in Guangdong and elsewhere are lower than in Guangxi. But this comparison, too, cannot be taken too literally, since the four to five tons per hectare 1981 Guangdong average suggested by such an exercise implies too great a divergence between Guangxi and Guangdong, particularly in view of greater general availability of fertilizer in the latter province.

Within these two southern provinces, some of the principal cassava-growing areas can be identified. The first record of Chinese cassava cultivation was in 1820 in Gaozhou County, part of Zhanjiang Prefecture in southwestern Guangdong.[20] Gaozhou is not a coastal county and earlier cultivation is entirely possible. In the 1950s, there is continued record of cassava in Zhanjiang Prefecture, where uplands constituted 27.5 percent of cultivated land, a greater

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[19]James H. Cock and Kazuo Kawano, "Cassava in China," unpublished trip report, International Center for Tropical Agriculture, Palmira, Colombia, June 1982, p. 1.

[20]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 4.

proportion than in other Guangdong Prefectures. Suixi County and the Zhanjiang city suburbs (where uplands comprised 12 percent) in the center of the prefecture, and Xuwen County on the southern tip of the Leizhou Peninsula are mentioned in 1950s literature on cassava, but the crop may have been grown more generally throughout the grain deficient Leizhou Peninsula and in the uplands adjacent to the Jianjiang Plain where "miscellaneous grains" (80.9 percent of which were root or tuber crops) comprised 44 percent of staple foodcrop production in 1955. Throughout the Zhanjiang Prefecture and enclosed municipal areas, root and tuber crops (valued at one-fourth fresh weight) constituted only 28 percent of staple crop production which occupied 95 percent of sown area. Sweet potatoes were the principal root crop, however, with cassava and "mao" potatoes comprising a little less than 5 percent of root and tuber crop production.[21]

But cassava cultivation clearly was not limited to southwestern Guangdong in the 1950s. There is also record in the Economic Geography of South China (1959) of cassava and taro being grown in the mountainous uplands surrounding the Sui and Xi River Valleys in West Central Guangdong, notably Huaiji, Guangning, Sihui, Gaoyao and Deqing Counties, all in Zhaoqing Prefecture. Cassava was not specifically mentioned in the discussion of Hainan Island, but has

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[21]Sun Jingzhi (ed.), Huanan Dichu Jingji Dili [Economic Geography of South China] (Beijing: Kexue Chubanshe [Scientific Publishing House], 1959). Translated in Joint Publications Research Service, August 24, 1969, no. 14954, pp. 137-138 and 178-179. When these statistics were gathered, the region included the Qinzhou Special District encompassing known cassava-growing areas such as Hepu County and the Beihai suburbs.

been grown there at least since 1912 when a well-known Malaysian variety was introduced into Dan Xian rubber plantations. According to 1951 statistics, roots and tubers accounted for 38.5 percent of grain consumption in plains areas of the Island and 69.8 percent in hilly districts, paddy rice providing most of the remainder in both cases.[22]

In Guangxi, cassava was generally distributed in the Xunjiang and Liujiang Valleys (east central Guangxi) characterized by relatively barren, drought-prone land. Yet yields of 7.5-15.0 tons per hectare were cited. It was used as food, feed and to produce starch for cotton yarn, in the city of Wuzhou in east central Guangxi on the Guangdong border where Guangxi's first starch factory was opened in 1952. Cassava was also widely planted in southeastern Guangxi and along the southern coast, especially Hepu County and the suburbs of Beihai on the southeast coast. But although Beihai and Wuzhou remained major centers, by the mid-to-late 1950s, cassava starch factories and consequently expanded cassava cultivation had spread widely in the Autonomous Region including Ningming in the southwest, Bama Yaozu Autonomous County toward the northwest and Wuming in the center of the Region.[23] In Yunnan, cassava cultivation in 1960 was recorded in Hekou Yaozu Autonomous County in the south

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[22]op. cit., pp. 137-138 and p. 201. See details of varietal transfer below.

[23]op. cit., pp. 258 and 333-334; Guangxi Jingji Nianjian Bianjibu, Guangxi Jingji Nianjian 1985, p. 192.

along the Vietnamese border, in Dehong Daizu Jingpozu Autonomous Prefecture in the west along the Burmese border, and elsewhere.[24]

By 1972, Zhaoqing Prefecture had taken over as the principal cassava growing region of Guangdong, accounting for 57 thousand hectares or 33.9 percent of the provincial figure for that year. Zhanjiang Prefecture was next with 33 thousand hectares or 19.5 percent. The remaining 77+ thousand hectares were distributed throughout Guangdong, including Hainan Island and Shaoquan, Meixian, Shantou, Foshan and Huiyang Prefectures. Some of these secondary regions increased cassava plantings rapidly in the late 1970s. Cassava area in Meixian Prefecture for example, in the northeast corner of the province, grew from 10,800 hectares in 1977 to 40,000 hectares in 1978.[25]

In spring of 1982, a delegation of cassava breeders from the International Center for Tropical Agriculture (CIAT) visited a number of cassava growing areas in Guangdong, including Baisha County and Haikou Municipality on Hainan Island, three state farms in Zhanjiang Prefecture and Dongguan County (Huiyang Prefecture) on the Pearl River Delta. Some impression of area trends on the Delta can be obtained from statistics for Dongguan. Cassava plantings declined from 8,600 ha. (1957) to 4,600 ha. (1977) with much of the decline occurring in the 1970s. Cassava area then fell even more rapidly to

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[24]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 9

[25]ibid.

3,157.4 ha. in 1978, then 3,100 ha. (1981) and 2,816.8 (1982). But on the other side of the Delta in Taishan (Foshan Prefecture), cassava was not grown on a large scale until recently. And Fucheng Commune (within Dongguan County) cassava area fell from 500 to 367 hectares between 1980 and 1981, but recovered to 434 ha. in 1982. [26]

Yields observed by the CIAT delegation were generally in the 6 to 8 ton/ha. range, but 20-25 tons/ha. was claimed for some state farms and experiment stations.[27] Average yields for Dongguan County on the Delta were 11.73 tons/ha. in 1978 and 15.76 tons in 1982. Fucheng Commune within Dongguan County claimed around 15 tons/ha. in 1980, 14.43 tons/ha. in 1981 and 17.75 tons/ha. in 1982. [28] In Guangdong generally, with 1200-1800 mm of annual rainfall, yields on farmer's fields with poor soils have been estimated by one Chinese breeder to fall typically between 5 to 7 tons per hectare and between 10 to 13 tons under good climatic conditions and soil conditions. Throughout Southern China (800-2000 mm/yr annual rainfall) yields are estimated by another breeder to be 5 to 9 tons per hectare on poor soils and 15-30 tons/ha. (avg. 20 tons/ha.) under good conditions. Without fertilizer or irrigation, however, poor soil yields were reported to be 3 to 6 tons/ha. (average 4 tons) and for good soils

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[26]Cock and Kawano, "Cassava in Asia", op. cit. The 1957, 1977 and 1981 figures for Dongguan County are from p. 13. The 1978 and 1982 data, the Fucheng Commune data and the impressions for the 1970s and for Taishan are from Prof. Graham Johnson, Dept. of Anthropology and Sociology, University of British Columbia, correspondence, Sept. 19, 1983.

[27]Cock and Kawano, "Cassava in China", p. 1.

[28]Graham Johnson, op. cit.

with good weather 12 to 18 tons/ha. In Zhaoqing and Shaoguan Prefectures (1450-1700 mm/yr. avg. rainfall) farmers' yields without fertilizer and irrigation were reported by an agronomist specializing in cassava to average 6.4 tons/ha. under poor conditions and 11.2 tons/ha. under good conditions. With fertilizer but without irrigation, these averages rose to 11.69 tons/ha. and 19.7 tons/ha. with ranges of around 4 tons/ha. Average yields on research stations run 2 to 10 tons per hectare higher than those quoted above for farmers' fields.[29]

These data in sum would seem to suggest that most cassava in Guangdong is grown on poor land, especially uplands and until recently, rarely received much fertilizer. Total cassava area has fallen during the past decade or so on better lands such as those typical of the Pearl River Delta (with scattered temporary exceptions due to the short-lived EC export opportunities) leading to some decline in the average quality of farmland growing cassava. This decline has been more than counterbalanced by the increase in fertilizer application to cassava in recent years such that average yields (though not necessarily total production) have increased sharply. The higher cassava yields on state farms and for private and cooperative farming in the Pearl River Delta locations like

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[29]Delphi survey responses sent to J.S. Sarma (IFPRI) for Shaoquan and Zhaoqing Prefectures by Huang Xi of the Institute of Drought Grain Crops, Guangdong Province Academy of Agricultural Sciences, Guanzhou, June 28, 1986; for Guangdong by Liu Yingjing of the South China Institute of Botany, Chinese Academy of Sciences, Guangzhou, June 30, 1986; and for South China Academy of Tropical Crops Research, Dan Xian, Hainan Island, June 20, 1986.

Dongguan County are partially explainable in terms of greater access to (and more attractive relative prices for) manufactured fertilizers, as well as to often better soil and higher standards of agronomy. But an additional important factor relates to varietal adoption. An especially small portion of cassava grown on state farms and on the Delta is likely to be utilized for direct human consumption, so there is little reason for managers and farmers to cultivate the lower yielding sweeter varieties characterized by low cyanide and higher protein content, as well as greater overall palatibility (see below). The argument is at least partially relevant for Zhaoqing and Shaoguan Prefectures, which are becoming one of Guangdong's major regions for processing industries utilizing cassava, and, for similar reasons, east central and southern Guangxi, historically among the principal cassava-growing areas within the Autonomous Region.

Cassava production systems:

Cassava in China is grown both extensively and in small plots and scattered plantings. Extensive cultivation is most notable on, but by no means confined to state farms, and is principally associated with starch production, the domestic animal feed market and exports. Outside the state farm sector, with the formal dissolution of the communes in favor of the household production responsibility system, it is safe to assume that extensive cultivation has declined somewhat since the early 1980s. However, Graham Johnson has pointed out [30] that rural reforms have, in some instances, strengthened rather than weakened cooperation in South China, so it cannot be assumed that extensive cultivation in the old cooperative sector has disappeared.

Since the formation of agricultural producers cooperatives (1954-56) and the people's communes (1958), collective lands constituting the vast majority of Chinese farmlands, have been cultivated communally. However the 54 thousand communes have normally not been the principal cultivation unit. More often smaller units, the 719 thousand brigades, or most commonly, the 5.6 million production teams have cultivated as cooperative groups. A production team normally consisted of around thirty farm families (an average of 139 people) that pooled usually contiguous land and shared cultivation responsibilities.[31] The principal farm unit varied geographically in size, but by the late 1970s averaged around 8.6 hectares in Guangdong and 8.9 hectares in Guangxi, and certainly less in the very densely populated Pearl River Delta of Guangdong.[32]

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[30]Graham E. Johnson, "The Production Responsibility System in Chinese Agriculture: Some Examples from Guangdong "Pacific Affairs, vol. 55, no. 3 (Fall) 1982, pp. 430-449.

[31]Zhongguo Guojia Tongjiju [State Statistical Bureau of China], Zhongguo Tongji Nianjian 1983 [Statistical Yearbook of China 1983] (Beijing: Tongji Chubanshe [Statistical Publishing House], 1983), p. 147.

[32]ibid., p. 148; Dili Yanjiusuo, Zhongguo Nongye Dili Zonglun, pp. 77-79.

Since the early 1980s, however, cultivation of collective lands is no longer a communal responsibility but has been delegated to several specialized households. Normally, it is the particularly skilled farmer who is entrusted with responsibility for farming collective lands. But in relatively advanced communes or in suburban areas, non-agricultural activities with higher income earning potential attract the most able workers.

Aside from collective lands, individual farm families maintain private plots of normally 0.03-0.05 hectares which are used primarily for family production of food items, especially vegetables and livestock products (and consequently fodder for the latter). Although no estimates are available for cassava cultivation on such lands, the importance of cassava as a swine feed, the considerable importance of swine in the livestock economy of South China and the dominance of family-owned and managed swine within the swine husbandry sector, suggest that private plot cultivation of cassava in South China is not trivial.

In addition to formally established private plots assigned to each family, there appears to be cultivation of cassava on an even more fragmentary basis: on narrow strips adjacent to roads and fields, on steep hillsides and other areas not formally counted among cultivated lands and illegally in economic forests, reclamation areas and other lands managed by the state. The latter may be distinguished, however, from planned cultivation on such lands by the State Farm and Reclamation Bureau. While land is being cleared and reclaimed, cassava is often grown as an intermediate crop for a few years until it is discontinued when field transformation progress allows cultivation of the principal crop.[33]

Finally, cassava is planted as a field crop on state farms. There its cultivation is especially extensive and is characterized by high standards of agronomy and abundant application of modern inputs, particularly fertilizers. Visitors interested in cassava are often brought to state farms to view extensive cultivation and high yields, but state farm plantings remain a small proportion of total cassava area. Cultivated area on state farms in Guangdong varied between only 60 and 64 thousand hectares from 1981 to 1984, and remained at 20 thousand hectares in Guangxi. In 1984, state farm sown area in Guangdong was only 86,900 hectares or less than 1.8 percent of the provincial total, of which 72,200 hectares were planted with cereals, beans, sweet and white potatoes, oilcrops and sugarcane, leaving a residual of 14,700 hectares which could have been planted with cassava, vegetables, green manure, other fodder crops or other southern industrial crops such as sisal hemp. In Guangxi, state farm sown area was only 17,400 hectares or less than 0.5 percent of the regional total of which the residual category including cassava

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[33]Bruce Stone, "An Analysis of Chinese Data on Root and Tuber Crop Production," The China Quarterly, September 1984, p. 621; Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 36; Bruce Stone, "An Examination of Economic Data on Chinese Cassava Production, Utilization and Trade".

comprises but 3,300 hectares.[34] Thus private and collective plantings dominate cassava area in China.

Available international data on cassava utilization in China is unreliable, but it is clear that animal (especially swine, but also cattle, fish and silkworm) feed is associated with each of the cassava production systems. Exports and starch production as well as less traditional industrial and processing uses are associated with collective production and the state farms, while direct human consumption is associated with private production and the collective sector in poorer areas. Machine cultivation is associated with a portion of the extensive plantings between 100 m and 300 m above sea level. Between 300 m and 1,000 m, cassava is grown in rotation with dryland crops as far as 30°N. Most cassava in China is unirrigated, but the climate provides adequate moisture in most years and locations. This is especially true in the south where fall-planted cassava is common.[35]

Cassava is cultivated year round in South China, with the principal plantings concentrated in spring and fall. The planting material may be either freshly cut stakes or stored material. Storage is practiced by cutting long stakes which may either be left in the sun in bundles or placed under trees. Cuttings are fairly

[34] China Agricultural Yearbook Editorial Board, China Agricultural Yearbook 1985 (Beijing: Agricultural Publishing House, 1986), pp. 114 and 185-186.

[35] Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 36.

short (10-15 cm) with minimal selection. Planting is fairly deep (up to 10 cm and horizontal). Germination varies considerably by location but is frequently very poor and strands are not uniform. Land preparation is generally acceptable and is done manually, by draft animal or tractor-drawn implements.[36]

Spring cassava (e.g. in the Guangzhou area) is typically planted between January and March and harvested in the fall, after at least 8 months especially from October, although for fodder purposes, cuttings may be taken continuously over an extended period of time. The spring and summer seasons considerably aid leaf and stem growth of spring-planted cassava and fall arrives optimally for starch formation. Yields of spring-planted cassava tend to be large, but are less reliable since typhoons in fall occasionally cause damage. Furthermore, low temperatures in spring extend the budding and sprouting period and thus the risk of insect damage. But spring-planted cassava fits well into South Chinese intercropping and rotation systems, facilitating the achievement of as many as three crops per year, including one of cassava.[37]

Fall- and winter-planted cassava is common in the most tropical areas with harvests starting the following fall. The peak period for both planting and harvesting is September to November. Fall-planted

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[36] Cock and Kawano, "Cassava in China," p. 7.

[37] The discussion of spring- and fall-planted cassava is primarily from material appearing in Liang Guangshang (ed.), Mushu Zaipei yu Liyong, pp. 10-11 and 33-34.

cassava is practicable from around Gaozhou County (21°56'N, Zhanjiang Prefecture, Guangdong Province) south, where temperatures average about 22.7°C annually and the lowest average January temperatures exceed 15°C. These areas also enjoy 1304-1718 mm of rainfall per year and 1941-2455 hours of sunlight, higher than more northerly regions, especially during the winter, thereby providing more hospitable conditions for fall planting. Of course, fall-planted and spring-planted cassava are not mutually exclusive. Qijing Brigade, for example, in Dianbai County (within the coastal zone lying along the South China Sea well to the south of Gaozhou), planted 25 thousand hectares of cassava in 1972, approximately one-third fall-planted, two-thirds spring-planted.

A principal advantage of fall-planted cassava is the potential for avoiding typhoon damage. This is particularly important on the Leizhou Peninsula and Hainan Island. Insect damage to the sprouts is also lower since cricket populations decline rapidly in fall and the sprouting period is collapsed, with sprouts and roots beginning within a week after planting. Fall-planted cassava can be more conveniently linked with sericulture, since leaves are provided more opportunely, without influencing root yield. With the longer season, cassava planted in fall facilitates fuller utilization of production capacity in local starch factories, and is convenient for on-farm livestock development. The principal drawbacks are the slower winter growth and the inconvenience of the longer season for rotation and multiple cropping. Thus even in the far south, if the cropping intensity is high, cassava is apt to be planted in spring. With virtually all cassava north of 22°N and an important portion of the remainder planted in spring, the majority of cassava in China is likely to be spring-planted.

The Chinese are well aware of the necessity of rotation and intercropping for continued cassava cultivation. They estimate that yields decline by 20-30 percent in a second consecutive year of cassava cultivation, and by 30-40 percent for three consecutive years.[38] The CIAT delegation noted, however, that cassava is grown as a monocrop in some areas.[39] South Chinese rotation systems are complex and varied; those including cassava are no exception. Figure A presents notable 2-year through 6-year rotation systems for cassava and other dryland food crops. In newly reclaimed areas, cassava is often grown for one or two years among jade cassia (Chinese cinnamon), mountain apricot, bamboo, tong oil, tea oil, rubber trees, or in other economic forests. Chinese literature points out the importance of rotation of cassava with green manure crops in economic forests to avoid erosion.

Cassava is normally the principal crop in a small number of exceedingly poor localities and a very few state farms. As Table 5 and 6 indicate, the most important crop in South China is unquestionably paddy rice comprising 63 percent of sown area in Guangdong in 1984 and 59 percent in Guangxi. Paddy fields occupy 63

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[38]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 40.

[39]Cock and Kawano, "Cassava in China," p. 8.

Figure A. Cassava Rotation Systems in China

2-year systems

cassava - upland rice, sweet potatoes
cassava - peanuts, sweet potatoes
spring peanuts, fall-planted cassava - fall harvested cassava, spring soybeans

3-year systems

cassava - sugar cane - sugar cane
cassava - peanuts, wheat - upland rice, sweet potatoes

4-year systems

cassava- mung beans, sweet potatoes - sugar cane - sugar cane

5-year systems

peanuts, wheat - upland rice, sugar cane - sugar cane- sugar cane

6-year system

cassava - sugar cane - sugar cane - soybeans, sweet potatoes - upland rice, radishes - peanuts, sweet potatoes

Notes and Sources

Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 40. In Cock and Kawano, Cassava in Asia, p. 8, the authors noted that cassava was often grown with legume crops, predominantly peanuts.

percent of cultivated land in Guangxi and are similarly dominant in Guangdong. Sweet potatoes are second in order of planted area in Guangdong and, combined with white potatoes, totalled 10 percent of sown area. Peanuts (6 percent) and sugar cane (5 percent) rank third and fourth, probably followed by cassava at around 3 percent. Soybeans, maize, bast fibers and tobacco are also grown, and until its de-emphasis in recent years, wheat area exceeded cassava plantings. In Guangxi, maize is second at 11 percent of sown area, followed by soybeans and sweet potatoes (5 percent each), sugar cane and peanuts (3.5 percent each) and green manure crops as a group (2.5 percent). Cassava at 2.1 percent is slightly below vegetables and melons as a group. When cassava area peaked in 1980, its share was 4.3 percent, ranking fifth behind rice, maize, soybeans and sweet potatoes and higher than all economic crops.[40]

Yields

Most available information on cassava yields was provided in the section on production trends and distribution. In that section it was suggested that the considerable increase in average yields during the latter 1960s (Table 2) was due to varietal improvement and to some extent, improvement in cultural practices, while yield growth since the late 1970s has been principally the result of increased fertilizer application to cassava, complemented by some improvement in varieties and cultivation techniques. Mean cassava yields throughout China (- 8.6 tons/ha in 1980) approximate the average for

[40]Table 5 and 6; China Agricultural Yearbook 1985, pp. 114-126; and Dili Yanjiusuo, Zhongguo Nongye Dili Zonglun, pp. 77-79.

the rest of the world, but are somewhat higher than mean yields in the remainder of Asia. Mean yields in Guangxi (13.1 tons/ha. 1981-84 average), however, are somewhat higher than the international average, and the highest yields from field cultivation in China (average 20-25 tons/ha with a maximum of 30 tons/ha.or more) are comparable to the very highest yields in the world.[41] But Chinese cassava is also grown on poor soils with no fertilizer or irrigation where average yields have been characterized in the 3 to 8 ton range. The average figures cited above suggest that those poor conditions are more typical of Chinese cassava cultivation than the state farm or Pearl River Delta private and cooperative farming experience. However, survey results suggest that even on poor soils without irrigation, fertilizer application can increase yields on both research stations and operating farms by an average of at least 6 tons per hectare.

Yield differences among farms are due not only to differences in soil fertility, climatic conditions, adopted varieties and applied fertilizers, but to substantial differences in management as well. Farmers in some areas use unselected planting materials giving very poor stands and low yields. On private plots, management varies more than on collective lands within a single vicinity, but the level of agronomy is often fairly high.[42]

[41]ibid., p. 1 and 8; Delphi Survey responses; and correspondence from James H. Cock, June 24, 1983; Table 2.

[42]Cock and Kawano, "Cassava in China"; correspondence from James Cock, June 24, 1983.

Among the responses of three Chinese cassava breeders surveyed, low yield potential of existing varieties and unavailability of fertilizers were both listed by each respondent as important constraints on farmers' yields. But the survey results also suggest that output marketing problems, storage and processing difficulties and general lack of production incentives may restrict application of labor and fertilizers to cassava in some areas.[43] Although there is considerable variation in the quality of cultivated varieties, China has several popular varieties, such as South China 205, providing reasonably high and stable yields. It is the provisional conclusion of one international breeder that, like Thailand in the recent past and Malaysia currently, rigidly selected CIAT clones could outyield the <u>best</u> Chinese cultivars only slightly. This contrasts with Indonesia and the Philippines where the best local varieties are more easily dominated.[44]

Poor fertilizer response and inadequate extension were listed as a secondary constraint on yields as was inadequate moisture in some areas. The 1982 CIAT delegation noted that fertilizer applications were not generally linked to soil analyses or recommendations made on the basis of experimental results. Each of the surveyed breeders appeared to agree that pests and diseases were relatively unimportant

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[43] Delphi Survey results

[44] Kazuo Kawano, "Trip Report to China (18-24 January, 1986)," unpublished trip report provided in correspondence from Kawano, April 14, 1986.

in limiting cassava yields. The 1982 CIAT delegation also found that although pests and diseases were not chemically controlled, they appeared to be of very low incidence and harvest losses from such sources were concluded to be minimal. The most commonly observed disease was Cercospora leaf spots and during the dry months Tetranychus mites are reported to be a problem.[45]

Costs of production and labor utilization

The 1982 CIAT delegation was told that labor use varied from 100 man days per hectare with mechanical land preparation to 270 days without machines, and total production costs were estimated at $550 US per hectare. 170 days may be somewhat excessive for manual land preparation, but although the total of 270 days per hectare is higher than in some Asian countries it is not unprecedented. The total cost figures are likely to have come directly from the production accounts of one or more Guangdong state farms where workers are paid set wages, or from a small sub-group of more prosperous cassava-growing collectives which happened to have kept good records and where yields are high. Most of the implied cost per man-day of around $2 US would be labor. A project prospectus for an agricultural credit application to the World Bank involving cassava cultivation implied a return to labor of $1.25 US per day. Much of the labor involved,

[45]Cock and Kawano, "Cassava in China," p. 7.

especially where cassava is fertilized, is for hand-weeding since herbicides are not used.[46]

Much of the non-labor costs on state farms would consist of fertilizer application. The highest per hectare application rates encountered by the CIAT delegation in 1982 were 20 tons of organic manures, 375 kilograms of superphosphate (45-68 kg. of P_2O_5) and 150 kilograms of muriate of potash (37.5 kg. of K_2O).[47] Such rates are likely to have existed only on state farms with plentiful access to fertilizers and/or few alternative uses. Implied per hectare retail value of this level of manufactured fertilizer use alone would have totalled $ US.[48] On collective lands with plentiful access to fertilizers, use of manufactured products is less lavish but organic manure use with associated high labor requirements is very substantial. In Fucheng Commune of Dongguan County on the Pearl River Delta, average yields of 21-22.5 tons per hectare on 400 hectares of cassava were achieved with 225 kilograms of ammonium sulfate per hectare. But in addition, three organic manure applications were undertaken involving total per hectare use of 3 tons of swine and cattle manure, 3-4.5 tons of human night soil, and 15 tons of green manure (primarily legumes) mixed with 22.5 tons of soil. On the Huashan State Farm in Lingshan County, Guangxi per

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[46]Ibid., pp. 7-8; correspondence from John Lynam, CIAT Cassava Program, December 22, 1983; Stone, "An Examination of Economic Data on Chinese Cassava Production, Utilization and Trade," pp. 6-9.

[47]Cock and Kawano, "Cassava in China," p. 7.

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hectare applications of 255 kilograms of ammonium sulphate and 15 tons of organic manure yielding 19.62 tons per hectare were estimated to provide 141 kilograms of nitrogen, 79 kilograms of phosphoric acid and 180 kilograms of nitrogen.[49]

One of the 1986 Chinese survey respondents provided a combined per hectare estimate of farmer fertilizer use on poor soil cassava lands in Guangdong of 150 kilograms, associated with average yields of only 5 tons per hectare, while another respondent, based on Hainan Island (Guangdong), implied that no manufactured fertilizers were used on cassava by farmers regardless of soil conditions.[50]

It is very unlikely that much fertilizer has been applied to cassava on distant collectives and private plots. This is due to low farmgate cassava prices, a weak cassava market in many areas (see below) and to the higher prices and difficult access associated with fertilizer purchase unless such purchase is linked to sales to government procurement organizations of farm goods in particular state demand. Private plot production of cassava employing household labor and without manufactured fertilizer use, could be conducted for purposes of home consumption and hog feed at very low implied return to labor. However, with the low yields associated with most production, such returns could be well under $1 US per day, and may have been sustainable only as a function of Chinese labor market

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[49]Liang Guangshang (ed.), <u>Mushu Zaipei yu Liyong</u>, p. 86.

[50]Delphi Survey responses.

restrictions. With increasing liberalization of economic activities in the 1980s, labor opportunity costs have risen substantially in suburban and wealthier rural farm areas. As export opportunities have declined, these healthy economic movements have undoubtedly worked against cassava cultivation in such areas. Opportunity costs would be less affected in poorer and more distant farm areas, but the state's declining marketing role is less apt to be vigorously replaced by private market development in such areas.

Technology development

Publication of Liang Tingdong's Zhong Mufanshu Fa [Cassava Planting Methods] in 1900 was a benchmark in the initiation of a formal process of cassava technology improvement in China, which could span time and space. As indicated in the first section, cassava spread to Fujian and Taiwan in the 1920s, roughly 100 years after its first known cultivation in neighboring Guangdong. Introduction in Hunan and Jiangxi in the early 1940s may have been the first example of deliberate trans-provincial dissemination by Chinese scientific institutions.

The Peoples Republic agricultural science establishment gave attention to cassava as a bulky, relatively drought-resistant crop which could be grown on poor soils and still provide growth in available calories per unit of farmland, with some advantages in yield stability. Alternatively it could also furnish raw materials for industry. This orientation toward bulky cheaper food items and industrial crops was well within a tradition established early in the history of most socialist governments and still continues to distinguish the pattern of food production and availability, although to a decreasing extent over time, in the Soviet Union, Eastern European countries and North Korea as well as in China, Vietnam and other socialist nations more suited to cassava production.[51]

Although dissemination of cassava was emphasized throughout the 1950s, broadening cultivation in the two southern provinces, and initiating it in Zhejiang and Jiangxi, cassava research began to show results in the late 1950s. Between 1957 and 1962, the Agricultural Science Department's Grain Crops Laboratory of the South China Academy of Agricultural Science in Guangzhou (23°8'N) selected 10 varieties from a pool of 30 for dissemination, at least six of which have been extensively cultivated, including Zajiao [Hybrid] no. 4 and YInni Xiye [Indonesian thin leaf], exhibiting 11 percent and 23 percent yield improvements over widely planted Hongweizhong [Red Tail Variety], and Mianbao Mushu [Bread Cassava], Zajiao no. 1 and Nanwan Mushu [South Bay Cassava], yielding 70-86 percent of Hongweizhong, but exhibiting other desirable characteristics such as superior edibility, higher starch rates and/or yield stability. Although breeding objectives for cassava have broadened considerably since the 1950s, higher root yields and improved edibility remain as central

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[51]Shigeru Ishikawa, "China's Food and Agriculture: A Turning Point," Food Policy 2 (May 1977), p. 93; Bruce Stone "China's 1985 Foodgrain Production Target: Issues and Prospects," in Anthony M. Tang and Bruce Stone, Food Production in the Peoples Republic of China, Research Report no. 15 (Washington, D.C.: International Food

Table 9. Cassava Root Nutritional Content
(percent)

Variety	Water Content	Starch Rate	Soluble Sugar	Protein	Fat	Fi
Mianbao Mushu 101 [Bread Cassava 101]	64.0	29.2	1.29	0.61	0.20	0
Naomi Mushu 102 [Glutinous Rice Cassava 102]	63.0	29.0	2.15	0.81	0.20	0
Malaihuang 103 [Malay Yellow 103]	63.2	31.3	1.46	1.09	0.15	0
Wenchang Hongxin 104 [Wenchang Red Heart 104]	62.4	30.5	1.26	1.55	0.21	0
Maoming Baixin 105 [Luxuriant & famous White Heart 105]	60.6	32.6	1.54	1.04	0.13	0
Hainan Hongxin 211 [Hainan(Island) Red Heart 211]	67.0	26.8	1.85	0.50	0.21	0
Huguang ~~C~~Qhingjing 210 [Huguang Green Stem]	57.6	36.8	1.23	1.40	1.14	0
Hongweizhong 201 [Red tail variety 201]	71.0	23.7	2.22	0.59	0.32	0
Yinni Xiye 202 [Indonesian Thin Leaf 202]	65.4	27.7	2.03	0.73	0.13	0
Yinni Daye 203 [Indonesian Big Leaf 203]	66.0	28.2	1.69	0.92	0.14	0
Nanyang Qingpi 204 [South seas Green skin 204]	66.0	28.8	2.87	0.60	0.17	0.
Nanwan Mushu 205 [South Bay Cassava 205]	66.0	28.1	1.85	1.13	0.17	0.
Huanan 206 [South China 206]	59.0	35.6	1.93	0.99	0.16	0.
Huanan 207 [South China 207]	64.8	29.6	1.00	0.88	0.12	0.
Zijingzhong 208 [Purple stem variety 208]	70.1	21.5	3.43	0.47	0.19	0.
Fanyu Zijing 209 [Fanyu (County)Purple Stem 209]	61.8	23.0	2.02	0.86	0.15	0.
Average of all varieties	64.2	28.8	1.86	0.89	0.17	0.

Sources: Liang Guangshang (ed.), Mushu Zaipei yu Liyong [Cassava Cultivation and Use] Guangzhou: Guangdong Kezhi Chubanshe [Guangdong Scientific and Technical Publishing House], 1981), p.108.

foci of the Chinese breeding program.[52]

South China 201 is also known as Hongweizhong or Dongguan Hongwei [Dongguan Red Tail]. A high yielding cultivar with high cyanide content, it is the most popular variety for flour production. Cultivated on plains, hilly tracts and mountainous uplands, this variety covers 70-80 percent of cassava area in many Guangdong and Guangxi Prefectures. It is also experimentally cultivated in the Yangzi Valley.

South China 202 or Yinni Xiye was introduced from Indonesia in 1956 by the South China Agricultural Science Department in Guangzhou. It typically outyields Hongwei by a small margin, but has the highest cyanide content of popular varieties and is thus also used in processing industries, primarily for flour and starch production. Plantings are concentrated on the Aoxi State Farms. There has also been successful experimental cultivation in Nanjing.

South China 205 or Nanwanmushu was the shortest of the sixteen leading cultivars tested and is famous for withstanding the August 17 typhoon in 1963. It combines yield stability with high potential,

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[52] Liang Guangshang (ed.), Mushu Zaipei yu Liyong, pp. 10 and 77. Much of the succeeding discussion on varieties and institutions is based on pp. 77-80 and Table 9, with a few additions from Cock and Kawano, "Cassava in Asia."

and is good for flour and especially starch production where it significantly outperforms other popular varieties. As Table 9 indicates, Huguang Qingjing [Huguang Green Stem] or South China 210 and South China 206 have by far the highest starch rates per unit weight, but Nanwanmushu's respectable rate coupled with higher yield potential make it a clear leader in starch per unit of harvested area. Following Nanwanmushu, South China 206, 207, and Yinni Xiye feature the highest starch content per unit area. South China 205 is an internationally recognized cultivar with similar characteristics to those of the Vassourinha variety of Brazil and the Philippines. The greatest area of Nanwanmushu concentration is Zhongshan, Dongguan and other counties in the Pearl River Delta, but it is planted widely throughout Guangdong.

South China 101 or Mianbao Mushu is also known as Malaihong [Malay Red] since it was introduced onto rubber plantations in Dan Xian from Malaysia in 1912. The variety combines yield stability with low cyanide content and reasonably high yield potential, and is recognized as China's best tasting cultivar. Plantings are concentrated on Hainan Island, especially in Dan Xian, Wenchang, and Baoting Counties, but bread cassava is also grown in most areas of Guangdong, and has been experimentally cultivated in Hebei Province, farther north than any other variety (39°20'N). Its characteristics are relatively similar to those of Aipin Valencia of Southeast Asia.

South China 104 or Wenchang Hongxin [Wenchang Red Heart] is the highest yielding variety among the better tasting (sweeter) cultivars. It has the highest protein content of the 16 leading varieties, also features low cyanide concentrations, reportedly outyields Mianbao Mushu by 22 percent, but is not typically preferred to the latter for direct consumption. South China 104 is planted predominantly in Wenchang and Qiongshan Counties on Hainan Island with little cultivation elsewhere.

Among other palatable varieties, Maoming Baixin [Maoming White Heart] or South China 105 from Maoming Municipal Area near Guangdong's Leizhou Peninsula, and Nuomi Mushu [polished glutinous rice cassava] or South China 102 are worthy of mention. Both outyield Mianbao Mushu by 10-11 percent, with substantially greater superiority in more northern areas. Both are sweet, and low in cyanide content, with South China 102 lowest of the sixteen prominent varieties. A variety known as 6068 is also famous for its excellent eating qualities and is planted on around 10,000 hectares despite its modest yields.

In sum, the South China Tropical Crops Research Academy concentrated not only on selection and dissemination of cultivars featuring higher and more stable root yields and improved edibility, but has focused breeding attention in combining those characteristics, and initiated research on starch content. By focusing on faster, as opposed to strictly higher root yields, the Academy also brought to cassava breeding in this early period, the beginnings of a quintessentially Chinese orientation: breeding to fit rotational patterns and multiple cropping sequences.

With the catastrophic famines of 1960-61 centered in North China and the Yangzi Valley, efforts to spread cassava cultivation northward intensified considerably. The focal institution in this effort was the Zhejiang Province Sub-tropical Crops Institute in Pingyang (27°38'N). Between 1962 and 1964, the institute introduced 31 varieties from Guangdong, Guangxi and Fujian including Hongwei, Nanwanmushu, Inni Daye, Shibeiqingjing [stone tablet green stem] and Zajiao nos. 1-6. But as Table 10 indicates, there has been experimental cultivation much further north, although the South China Tropical Crops Research Academy has indicated that good growth and yields are consistently obtained only up to around 26°N, which cuts across southern Hunan, Guizhou, Jiangxi and Fujian.

Aside from the above-mentioned institutions, some cassava-related research is reportedly conducted in each of the provinces within which cassava has been introduced. In South China, other relevant institutions are the Guangxi Province Asian Tropical Crops Research Institute in Nanning, the South China Crop Research Institute and the South China Institute of Botany within the Chinese Academy of Sciences, the Institute of Drought-Resistant Grains and the Upland Grains Department in the Guangdong Agricultural Science Academy, and the South China Agricultural College, all in Guangzhou. However cassava research is not reputed to be a significant current focus of any of the Guangzhou institutions.

Cassava research and development in China is increasingly shifting its focus from the original narrowly defined goals of

Table 10. Results of Cassava's North Migration Cultivation Experiments

perimenting Unit	Location (N latitude)	Variety	Planting Date	Harvest Date	Total Growing Days	Fresh Root Yield (tons/ha.)
rthwest Agricul- ral Science ademy	29°30'	A, B	Apr.25	Nov.25	216	33.0
bei Dashahu Farm	30°	A,B,D	Apr.21	Nov.22	216	18.75-30.0
hui Province ops Institute	31°53'	B	Apr.12	Nov.3	206	20.325
njing Botanical stitute	32°04'	A,B,C	Apr.15	Nov.5	205	23.25-24.45
ina Root and ber Institute	33°58'	A,B	May 6	Oct.24	172	37.5-45.0
aanxi Province ains Crops Inst.	34°21'	A,B	May 7	Oct.23	170	5.775-17.775
andong Province ops Institute	36°41'	A	Apr.15	Oct.24	193	22.5
da (Dalian) . 1 Farm	38°54'	A,B	May 6	Oct.23	171	12.75-19.5
bei Province restry Science stitute	38°20'	A,B	Apr.21	Oct.24	187	37.5-45.0

tes: A= Naomimushu [Glutinous Rice Cassava]
B= Mianbaomushu [Bread Cassava]
C= Inni Xiye [Indonesian Thin Leaf]
D= Malaihuang [Malay Yellow]

urces:Liang Guangshang (ed.), Mushu Zaipei yu Liyong [Cassava Cultivation and Use]
angzhou: Guangdong Kezhi Chubanshe [Guangdong Scientific and Technical Publishing
use], 1981), p. 26.

improving yield and edibility. The main improvement efforts still include edibility, but also emphasize cultivation techniques, especially cassava's relation to other crops in various systems, and the combined development of cassava and non-crop rural activities. Breeding objectives also include early planting, early ripening and rapid maturity goals, as well as disease resistance, high yields, and high starch and protein content.[53]

Research and development goals related to cultivation techniques feature improvement in rotation synergies, seasonal cultivation, intercropping, and achievement of two or even three ripenings per year. Bean crop and cassava rotations and intercropping are of particular interest as techniques for developing soil strength. The 1982 CIAT delegation observed that cassava was often intercropped with grain legumes in more intensively cultivated areas and estimated that yields of both crops were probably reduced by only 15-30 percent resulting in relatively efficient land use with good soil conservation properties.[54]

Since 1979, non-crop agriculture has been emphasized in China, partially correcting for the substantial pre-1979 stress on food crops, especially staples. Consequently a recent goal for cassava development has been to integrate cassava with forestry, animal husbandry, sericulture, aquaculture and rural sidelines for

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[53]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 10.

[54]Ibid.; correspondence from James H. Cock, Cassava Program Director, CIAT, June 24, 1983.

cooperative production. Investigation of additional and even novel industrial uses is also of increasing interest.

Survey respondents among Chinese cassava breeders and agronomists [55] appeared optimistic about the potential for growth in farmers' yields during the next 4 and 14 years. Respondents were instructed to base their assessments on existing varieties and those currently under development, but their estimates differed considerably. They were also optimistic about the prospects for increasing that potential via a doubling of research expenditures related to cassava, with the most conservative assessments provided by the representative of the institution where most research on cassava is conducted. In his view, farmers' yields on poor soils could increase from currently 3-6 tons per hectare to 4-8 tons by 1990 and 5-9 tons by 2000 or 5-10 tons and 6-12 tons respectively with a doubling of research expenditures. With good soil and climatic conditions, farmers' yields could increase from currently 15-30 tons/hectare with fertilizer, to 18-35 tons by 1990 and 20-40 tons by 2000 or 25-35 tons and 35-45 tons with a doubling of research resources.

It is clear that yields can improve, especially in Guangdong, via greater access to manufactured fertilizers, analysis and extension related to its optimal use, and to proper selection of planting materials. Fertilizer pricing, distribution and analytic systems are undergoing considerable structural change in China.

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[55]Delphi Survey responses.

Proper resolution of remaining and newly emerging difficulties will be instrumental in achieving yield progress through growth in fertilizer use.[56]

It also appears that there may be some limited potential exploitable with further international exchange of genetic materials.[57] State farms are technological leaders in cassava cultivation, though not for most staple crops, and careful selection of planting materials and quest for improved cultivars are evident on state farms. Yield progress on several state farms in recent years has allowed continued profitability of cassava cultivation despite declining prices. This means that new improved varieties can move rapidly into full scale production in China. What may be called for are institutional links which can bring state farm developments into the private and collective economy more expeditiously. A new variety must undergo regional testing for three years. The results are presented to the provincial seed commission which may then recommend the variety to seed production companies for multiplication.

Work on intercropping and rotational systems is something Chinese researchers do particularly well and is likely to lead to some further improvements. Some of these may not immediately

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[56]For details see Bruce Stone, "Chinese Fertilizer Application in the 1980s and 1990s: Issues of Growth, Balance, Allocation, Efficiency and Response" in U.S. Congress Joint Economic Committee (eds.), China's Economy Looks Toward the Year 2000, vol. 1: The Four Modernizations (Washington, D.C.: U.S. Government Printing Office, 1986), pp. 453-496.

[57]Cock and Kawano, "Cassava in China"; Kawano, "Trip Report to China (18-26 January, 1986).

increase cassava yields per se but may improve the attractiveness of planting cassava and thus arrest its decline in area. What is singularly missing for cassava, as well as for many other crops, is socio-economic research in cassava areas, particularly poorer ones. Lack of agro-economic data and analysis for assessing constraints limiting farmers' yields is recognized by the South China Tropical Crops Academy.[58]

Finally, with the reduction in export opportunities and the curtailed government role in marketing, development of demand and market institutions are of particular importance for continued expansion of cassava production and use. These issues will be undertaken in the following sections.

MARKETS AND DEMAND

A synthesis of production and utilization

As indicated above, production statistics for cassava in China are highly fragmentary, except for Guangxi Zhuang Autonomous Region for which data are complete, though even for Guangxi, questions of reliability and comparability remain. Utilization data, however, are almost wholly unavailable, with the exception of the international trade data compiled from European Community Analytic Tables for Foreign Trade appearing in Table 3. Government procurement data for cassava assuredly exist, but have not been made available in Chinese

[58]Delphi Survey response from Tan Xuecheng, breeder.

statistical compendia on marketing and trade. Production data from cassava flour and starch factories as well as from other industrial processors are certainly generated, but are not of sufficient importance to appear among national statistical series in the relatively detailed Guangdong Province Statistical Yearbooks, and the Guangxi Economic Yearbook 1985, although the latter contains a single column of discussion of the starch market in which cassava is mentioned. As a regionally concentrated crop, cassava has not turned up among published results from national farm surveys. Even Liang Guangshang's cassava-specific publication, Mushu Zaipei yu Liyong [Cassava Cultivation and Use], provides not a single statistic on aggregate utilization.

In the past, it has been clear that FAO estimates of cassava use were all based on constant percentages of estimated production.[59] For example, the FAO Supply Utilization Accounts Tape 1981 evidently incorporated the following percentages: feed use (25 percent), waste (5 percent), food use (67 percent), processing (3 percent), use for tapioca (70 percent of processing), starch use (30 percent of processing).[60] Since the production series was mechanically generated from virtually no statistical base, the utilization series were inevitably unreliable, even if the percentage shares were roughly correct. Conversely, regardless of the accuracy of the production estimates, the utilization shares have assuredly not been

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[59]Bruce Stone, "An Examination of Economic Data on Chinese Cassava Production, Utilization and Trade," pp. 13-22.

[60]Food and Agriculture Organization of the United Nations," "Supply Utilization Accounts Tape 1981," Rome, 1982.

constant over time, with feed and processing use increasing in importance, at the expense of direct human consumption. Moreover, shares for feed and processing would exceed the shares implied by the 1981 Utilization Tapes even for the 1960s.[61]

As an examination of Tables 11 and 12 will reveal, FAO utilization series for China are now generated in a more complicated fashion, but historical production, area and yield figures are identical to those appearing on the older tapes. Aside from the international trade series which relates well to, and is probably based on the EC Analytic Tables for Foreign Trade, FAO series are still generated from an extremely weak statistical basis which probably consists of no more than the partner-country trade data and the single production figure circa 1980, provided to the 1982 CIAT delegation.

In these recent FAO series, such as "Supply Utilization Accounts Tape 1984," released at the end of 1985, unprocessed feed is set at 10 percent throughout the 1961-83 period and waste is dropped from 5 percent on previous tapes to 3 percent for the entire period. Direct food consumption estimates have become trended values declining from 72.0 percent of production in 1962 to 67.0 percent in 1979. (Table 12). Processed uses have become monotically non-decreasing trended values beginning somewhat arbitrarily at 15.0 percent in 1962 and rising to 20.0 percent in 1979, of which dried cassava (chips and

[61]Stone, "An Examination of Economic Data on Chinese Cassava." This paper was provided to both CIAT and the FAO Statistical Division's Basic Data Unit in 1983 and provided part of the basis for subsequent adjustments.

Table 11. FAO Estimates of Chinese Cassava Production, Area, and Yield, 1961-1984

	Harvested Area (1000 hectares)		Production (1000 metric tons)		Yield (tons per hectare)	
	1982 Tape	1984 Tape	1982 Tape	1984 Tape	1982 Tape	1984 Tape
1961		80		940		11.750
1962		85		1000		11.765
1963		85		950		11.176
1964		90		1000		11.111
1965		90		1100		12.222
1966	95	95	1100	1100	11.579	11.579
1967	100	100	1200	1200	12.000	12.000
1968	120	120	1400	1400	11.667	11.667
1969	130	130	1500	1500	11.538	11.538
1970	140	140	1600	1600	11.429	11.429
1971	150	150	1800	1800	12.000	12.000
1972	160	160	1900	1900	11.875	11.875
1973	170	170	2000	2000	11.765	11.765
1974	170	170	2000	2000	11.765	11.765
1975	180	180	2100	2100	11.667	11.667
1976	180	180	2200	2200	12.222	12.222
1977	190	190	2200	2200	11.579	11.579
1978	200	200	2300	2300	11.500	11.500
1979	200	200	2500	2500	12.500	12.500
1980	226	226	3000	3300	13.274	14.602
1981	236	230	3120	3500	13.232	15.217
1982		235		3600		15.319
1983		240		3800		15.833
1984						

Source: FAO, "Supply Utilization Accounts Tape, 1981," Rome, 1982; FAO, "Supply Utilization Accounts Tape, 1984," Rome, 1985.

Table 12. FAO Estimates of Chinese Cassava Production and Use, 1961-1983

	Production	of which: Feed	Waste	Food	Processed	of which input to: Chips & Pellets	Tapioca	Starch
					(1000 tons)			
1961	940	94	28	668	140	90	20	30
1962	1000	100	30	720	150	100	20	30
1963	950	95	28	666	160	110	20	30
1964	1000	100	30	699	171	120	21	30
1965	1100	110	33	756	201	150	21	30
1966	1100	110	33	740	217	160	22	35
1967	1200	120	36	807	237	180	22	35
1968	1400	140	42	959	259	200	24	35
1969	1500	150	45	1014	291	230	26	35
1970	1600	160	48	1099	293	230	28	35
1971	1800	180	54	1246	320	250	30	40
1972	1900	190	57	1330	323	250	33	40
1973	2000	200	60	1384	356	280	36	40
1974	2000	200	60	1380	360	280	40	40
1975	2100	210	63	1467	360	280	40	40
1976	2200	220	66	1519	395	300	50	45
1977	2200	220	66	1519	395	300	50	45
1978	2300	230	69	1606	395	300	50	45
1979	2500	250	75	1675	500	400	55	45
1980	3300	330	99	1466	1405	1300	60	45
1981	3500	350	105	1545	1500	2000	65	45
1982	3600	360	108	1512	1620	1500	75	45
1983	3800	380	114	1606	1700	1700	78	45

Notes and Sources: FAO, "Supply Utilization Accounts Tape, 1984," Rome, 1985. To reach quantities of processed products, extraction rates of 35 percent for chips and pellets (dried cassava), 22 percent for tapioca, and 18 percent for starch are applied in FAO data.

pellets for feed, either for domestic use or export) starts at 2/3 of the processed amount in 1962 and rises to 80.0 percent in 1979. Cassava input to starch production begins at 20.0 percent of the processed amount in 1962 and declinesto 9.0 percent in 1979. The absolute quantities in FAO data form a step function, remaining constant for five-year periods, then increasing by 5 thousand tons in a single year, then remaining constant again for five years. Cassava input to tapioca production comprises the remainder, with absolute quantities rising in similar monotically non-decreasing fashion, but with shares declining slightly to 11 percent by 1979.

FAO data appear in other formats, but the statistical base, or lack thereof, remains the same. For example, the "Standardized Commodity Balances Tape 1984" (Rome, 1985) includes series for availability (production minus exports), food (direct food consumption plus cassava input to tapioca processing) and "other uses" (waste plus cassava input to starch processing). Because of the massive increase in exports in 1979-81, the post 1979 FAO series exhibit some peculiarities. Dried cassava input on the "Supply Utilization Tape" increases from 20.0 percent to 42.6 percent of production from 1979 to 1980 (Table 12), for example, and the program synthesizing these series generated large negative numbers for "other uses" in 1980 and 1984 on the "Standardized Commodity Balance Tape."

Nevertheless, these series represent some improvement in credibility over the 1981-82 tapes. The waste percentage has been lowered (to what is probably the minimum parametric value used by FAO). The estimated production shares of processed cassava have been raised very substantially and exhibit a rising trend including slightly rising, then stagnating absolute quantities for starch production, and a massive acceleration in dried cassava to parallel the appearance of lucrative export opportunities in the 1980s. Food uses exhibit a plausible declining share of cassava production, and the FAO trade data now includes the overwhelmingly important movements in the dried cassava trade since 1979. But it must be remembered that there is no actual statistical basis for these utilization shares save a very indirect one based on the foreign trade data, and all series are essentially derived from the almost wholly unreliable production estimates.

Of course, it is much easier to criticize than to suggest superior alternatives since little quantitative information from China is available. But it may be reasonable to suggest that several of the improvements since the 1981-82 tape did not go far enough. China has developed a considerable reputation for low food waste. As others have previously indicated, this reputation may be somewhat exaggerated.[62] But with a large proportion of the cassava crop allocated to same-farm animal feed and high labor application per hectare, one may reasonably expect that at least cassava waste in China is quite low.

The 1982 CIAT delegation observed that the primary use of cassava was as animal feed. Of course, their sample was biased toward more productive farms, though they visited some very poor

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[62] e.g. Vaclav Smil, "China's Food: Availability, Requirements, Composition, Prospects," Food Policy (May 1981), pp. 67-77.

communes where cassava was the principal human food source. Visiting any of the state farms immediately biased the sample on such a brief trip. Based on Table 1 and other figures provided above, state farm cassava plantings could not have exceeded 3.5 percent of Guangxi cassava area in 1984, although probably totalling 5-10 percent of production. In Guangdong, the proportions could be slightly higher, but state farm cassava is clearly a minor share of the total. However, the CIAT delegation found cassava primarily grown for animal feed on communes as well as on state farms.

According to the extensive surveys (also biased toward more productive farms) conducted by Nanjing University students supervised by John Lossing Buck between 1929 and 1933, 18 percent of the output of sweet potatoes (generally a food preferred by Chinese to cassava) was employed as animal feed in the region. The proportion was almost half in the more productive areas of eastern Guangdong. Only 60 percent of the taro crop was used for human food.[63] Since the 1930s, swine stocks and grain and sugar production have increased more rapidly than the human population in the region (Table 13), and per capita incomes have increased. Oilseed and soybean production has declined in Guangxi, but in Guangdong, production increased at about the rate of population growth over the 5-decade period given that included 1930s figures are somewhat prone to overestimation. Cattle stocks declined over the 1970s in Guangdong but due to their smaller numbers and diet preference for leaves and grasses over roots, this

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[63] John Lossing Buck, Land Utilization in China (Atlas and Study) (Nanking: Nanking University, 1937), Atlas pp. 82 and 98.

Table 13. Growth Indices for Human Population, Livestock, and Grain, Sugarcane, Peanut and Soybean Production in Guangdong and Guangxi, 1930s-1984

	1979-84 Average			
	Guangdong	Guangxi	Guangdong	Guangxi
	(1952-1957 avg.=100)		(1930s=100)	
Human population	162 a/	181	174	221
Swine stocks	280 b/	257		
Cattle & buffalo stocks	74 c/	261		
Small ruminant stocks	15 c/	310		
Foodgrain production	171	181	178-199	205-249
Sugarcane production	246	691	1631	
Peanut production	285 d/	138	168	69
Soybean production	182 e/		156	469
Cassava production		757		

Notes:

a/ Based on a weighted average of midyear figures for 1954 and 1957 to approximate a midyear 1955 figure. 1979-84 data are year-end figures.

b/ Based on a midyear 1955 figure. A weighted average of midyear 1953, midyear 1955 and a year-end 1957 is slightly lower.

c/ Based on year-end 1984 and 1957 figures.

d/ Based on 1953-56 average. The index number based on 1957 alone is 199.

e/ Based on 1952-56 average. The index number based on 1957 alone is 94.

Sources: Bruce Stone, "An Examination of Economic Data on Chinese Cassava Production, Utilization and Trade," paper prepared for the International Center for Tropical Agriculture (CIAT), IFPRI, Washington, D.C., August 1983, Table 11. Data have been supplemented from Guangxi Jingji Nianjian Bianjibu, Guangxi Jingji Nianjian 1985, pp. 519,530, 532 and 594; and from State Statistical Bureau, PRC, Statistical Yearbook of China 1983, 1984, and 1985.

decline would have less effect on the allocation of the cassava root itself than would the swine stock growth rate.

According to a 1980 survey of 15,914 households, an average of 94.4 kilograms of meat (mostly pork), 35.6 kilograms of "grains" and 126 kilograms of "vegetables" were produced on private plots. Although hog feeding regimens in China have been concentrate-poor historically, the fattening process would still require around 82 kilograms of concentrate per hog and the requirement has been rising with greater peasant autonomy, adjusted purchase price structure, and growing acceptance that extremely concentrate-poor diets are uneconomic.[64] In Guangdong and Guangxi, a sizable proportion of this concentrate consists of cassava, taro and sweet potato. Of the three, cassava would be the crop with the highest proportion allocated for feed. One may conclude that even for domestically utilized cassava, 20-25 percent (for "feed use" plus "dried cassava") from 1961-79 is probably too small a proportion for feed and the trend must have been rising more rapidly over the period than assumed by FAO. When one considers that from 1980-82 dried cassava exports must have constituted 30-60 percent of what the 1982 CIAT delegation was told was national production, and that exports may still exceed 30 percent of annual output, even the current FAO feed proportions of 50-55 percent ("dried cassava" plus "feed") may be too low.

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[64]See Stone, "China's 1985 Foodgrain Production Target," pp. 99-103. The 1980 survey appeared in Xinhua [New China News Agency], news bulletin, June 16, 1981.

Table 14. Development of Starch Production in South China, 1952-1984

	Number of Operating Factories		Starch Production	Required Fresh Root	Proportion of Total Cassava Output
	Guangxi	Guangdong	Guangxi	Guangxi	Guangxi
			(metric tons)		
1952	1		282	(-1,500)	(-1)
1959			12,275	(-68,000)	(-10)
1962	29				
1972		56	-10,000	(40-60,000)	(3-14)
1983	284		59,400	(-242,500)	(-15)
1984	240		49,000	(-200,000)	(-17)

Notes and Sources: Figures in parentheses are calculated estimates. The FAO extraction rate of 18 percent was used for the 1950s data to calculate fresh root equivalent, assuming also that all Guangxi starch was produced from cassava. (Actually small amounts of corn are also used.) For later years, an extraction rate of 24.5 percent was used based on the statement that starch content of dried cassava is more than 70 percent (Guangxi Jingji Nianjian Bianjibu, 1985),[Guangxi Economic Yearbook Editorial Board], Guangxi Jingji Nianjian 1985 [Economic Yearbook of China 1985] (Nanning: Guangxi Jingji Nianjian Bianjibu, 1985), p. 192). If the FAO-adopted drying factor of 35 percent is used, this implies a starch extraction rate of more than 24.5 percent which is possible, especially in view of substantial cassava selection and breeding in China for high starch content. The 1982 CIAT delegation observed extraction rates of 25-29 percent with 5-10 percent residues for animal feed (Cock and Kawano, "Cassava in China," p. 8). It is not clear why the FAO-adopted extraction rate for tapioca (22 percent) is higher than for starch and exhibits as much as a 4 percent difference since tapioca production normally follows from starch production thereby achieving a very slightly lower extraction rate (correspondence from John K. Lynam, Cassava Program, Centro Internacional de Agricultura Tropical (CIAT), December 22, 1983.)

The proportion allocated to starch production is probably also consistently underestimated by FAO. Data assembled in Table 14 suggest that if the Guangxi record can be taken as representative of both southern provinces, utilization of cassava for starch production during the 1960s and 1970s constitute not 10-20 percent of all cassava used for processing as assumed by FAO (2-3 percent of production), but closer to 10 percent of total production, and potentially higher in several low production years. Assuming the adopted extraction rates and the Guangxi series are roughly correct, and that starch produced from raw materials other than cassava was indeed very minor in Guangxi, then the starch industry claimed more than 15 percent of fresh root production in the Autonomous Region in 1983 and 1984. The proportion for Guangdong is probably somewhat lower but appears to be rising at present.

All in all, if forced to estimate, current utilization of Chinese cassava might run 60-65 percent for feed (including "dried cassava" plus fresh feed, exports and domestic use), 15-20 percent for the starch industry, 2-4 percent for tapioca production and as little as 1-3 percent for waste, leaving somewhere around 10-20 percent for direct human consumption. As suggested in earlier papers and as FAO seems to accept, it is quite possible that the 3 million ton circa 1980-81 production figure is an underestimate, but the production trend for the last few years is almost certainly downward.

The Guangxi starch production figure listed somewhat arbitrarily for 1972 is based on the statement that starch production in Guangxi remained at around 10,000 tons during the 1960s and 1970s (Guangxi Jingji Nianjian 1985, p. 192). Most data in the table appeared in ibid. The number of starch factories operating in Guangxi in 1962 and in Guangdong in 1972 are from Liang Guangshang (ed.), Mushu Zaipei yu Liyong [Cassava Cultivation and Use] (Guangzhou: Guangdong Keji Chubanshe [Guangdong Scientific and Technical Publishing House], 1980), p.9. The proportion of total Guangxi cassava production was calculated from data appearing in this table and in Table 2.

Cassava for direct human consumption

The previous section has concluded that cassava for direct human consumption probably comprises only 10-20 percent of current production. There appear to be four principal categories of direct human consumption of cassava in China: consumption related to ethnic minorities where cassava has a traditional dietary role; consumption related to forest cultivation in remote areas; consumption associated with exceedingly poor and/or risk-prone farming areas; consumption related to particular cuisine and especially seasonal preparations. These four categories are not mutually exclusive but seem to characterize the direct human consumption demand for cassava.

Little recent ethnographic information on minorities in South China seems to be available, but taro and cassava are known to be important food items among the Yao minority in northern Guangdong.[65] The Mao people of Thailand are also habitual consumers of cassava. Mao people in South China were likewise reported to eat cassava and "mao" potatoes during the 1950s.[66] Even among Han Chinese (93.3 percent of China's population) home-processed cassava flour is often used as a thickener in southern Chinese soups and in making special cakes at festival times such as New Year's Eve in Fujian, for example.[67]

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[65] Buck, Land Utilization in China, (Atlas), p. 98.

[66] Sun Jingzhi (ed.), Huanan Dichu Jingji Dili; State Statistical Bureau, PRC, Statistical Yearbook of China, 1985, p. 195.

[67] Cock and Kawano, "Cassava in China," p. 11; State Statistical Bureau, PRC, Statistical Yearbook of China, 1985, p. 195.

Poorly developed and poorly integrated markets are almost a defining characteristic of developing countries and China is no exception. In China, market development was further retarded by a number of factors. First, for a thirty year period, civil war and World War II combined to destroy normal market activity in many areas of China. Although Guangdong and Guangxi were spared to a much greater extent than North China, the Northeast and the Yangzi Valley, they were not unaffected by war, and nearby cassava-growing provinces such as Yunnan and Hunan were directly involved, as was Fujian, located directly across the straits from colonial Taiwan. For example, transport vehicles and draft animals were purchased or commandeered for the war effort. War time inflation sent marketing back to a semi-barter era and credit facilities were severely affected.

In the 1950s, conditions stabilized but the government soon began to take over large segments of marketing activities. With grain crises in 1953 and 1955 and the difficulties the government was experiencing with procurement of foodstuffs for cities, grain trading became a state monopoly in 1954, and by 1955 each unit of land in China was assigned a fixed quota of (usually) grain to be delivered to state purchasing organizations at low fixed prices. Taxes were also paid in kind but grain delivery obligations did not end there. After retaining a provincially determined per capita quantity to meet immediate food, feed and seed needs of rural farms and households, and even after tax and quota obligations were met, 80-90 percent of all "surplus" grain was also to be sold to the state. Not only was private grain trading illegal and most grain in excess of a modest standard for home consumption soaked up by government purchasing organization, but private traders were designated as class enemies.

The state, for its part, was having enough trouble providing for urban and army consumption, as well as reserving one-two million tons per year to export for foreign exchange. For the most part, only relatively prominent rural areas experiencing natural disasters received relief grain. More remote and most very poor areas were left on their own without access to grain supplies from the outside. After the famines in 1960-61 and especially during the Cultural Revolution period (1966-76), this situation was institutionalized as a policy of local self-sufficiency with disastrous implications for gains from specialization and trade, and for exceedingly poor risk-prone areas historically dependent on trading and non-agricultural activities to garmer enough to eat. With procurement problems persisting, the government further restricted non-farming activities and made migration illegal in order to limit the state's urban obligations, but thereby binding many farmers even more closely to poor and risk-prone agriculture.[68]

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[68]See Bruce Stone, "Relative Foodgrain Prices in the People's Republic of China: Extractive Rural Taxation Through Public Monopoly," in John W. Mellor and Raisuddin Ahmed (eds.), Agricultural Price Policy for Developing Countries (Baltimore: Johns Hopkins University Press, 1987); and Bruce Stone, "Chinese Socialism's Record on Food and Agriculture," Problems of Communism, vol. 35 no. 5 (Sept.-Oct.) 1986, pp. 63-72. See also Tang and Stone, Food Production in the People's Republic of China; Kenneth Walker, Foodgrain Procurement and Consumption in China (Cambridge: Cambridge University Press, 1984); and Nicholas Lardy, Agriculture in China's Modern Economic Development (Cambridge: Cambridge University Press, 1983).

It is not difficult to imagine that with this institutional framework, cassava, at least in the south, had a particularly important role to play. Cassava was an ideal crop for insuring minimum levels of consumption because it is a relatively drought-resistant, stable yielding, easily stored crop, providing high caloric levels per unit area, and performs well relative to alternative crops even under poor agronomic practice and soil conditions. As a crop cultivable on forest lands and hillsides, it was also ideal for sustaining reclamation teams in remote areas.

With the rapid increases in South Chinese rice production during the past decade (Table 5, 6 and 13), the 1980s legalization of private grain trading and guaranteed state food deliveries for areas concentrating on the production of economic crops, cassava's special institutionally-induced importance has been declining. However, cassava is still grown in exceedingly poor areas in South China for essentially the same reasons: food security and easy provision of needed calories under inoptimal conditions. It should be emphasized, for example, that seven counties in Guangdong and eight in Guangxi averaged per capita collective distributed income in 1977 of less than 50 yuan ($20-25 U.S. at concurrent official rates).[69] While this category excludes important income sources such as private plot and sideline production and some in-kind payments from collective work, it is indicative of the amount of cash available for farmers

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[69]Nongyebu Renmin Gongshe Guanliju [Ministry of Agriculture, Bureau of People's Commune Management], "Yijiuqiqi zhi Yijiuqijiunian Quanguo Qiongxian Qingxing" [The Condition of the Nation's Poor Counties, 1977-1979] <u>Xinhua Yuebao</u> [New China Monthly], no. 2, 1981, pp. 117-120.

from their principal assets in very poor localities.[70] The number of counties falling below this lowest benchmark increased to 11 in Guangdong in 1978 but declined to 7 in 1979 (in Guangxi, 8 in 1978 and 6 in 1979). In Guangdong, the very poorest regions appear to be in the northeast, such as Wuhua and Longchuan Counties, and on Hainan Island in the South, including the known cassava area of Basuo (Dongfang County). In Guangxi, such counties seem to be clustered in the north and west: for example, Du'an Yaozu Autonomous County, Luocheng, Donglan and Napo Counties, as well as Bama Yaozu Autonomous County where cassava is known to be widely cultivated.[71]

But with the exception of the exceedingly productive Pearl River Delta, no part of South China can be excluded as a region where direct consumption of cassava is not important for some segment of the poorer rural population. Areas were cassava is an important direct calorie source need not be remote. Even within the Haikou Municipal Area on Hainan Island, 11 percent of cultivated area in the Yong Sing Township, for example, is planted with cassava, two-thirds of which is consumed directly as a staple.[72] This is because only 4

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[70]Distributed collective income averaged around two-thirds of the total including private plot and sideline income during those years, according to a State Statistical Bureau (SSB) survey of 10,282 households (Zhongguo Guojia Tongjiju, Zhongguo Tongji Nianjian, 1981, pp. 431). But this may have excluded in-kind distribution of production from collective lands. For a full discussion of Chinese distribution data and its problems, see E.B. Vermeer "Income Differentials in Rural China," The China Quarterly, vol. 89 (March) 1982, pp. 1-21.

[71]Nongyebu Renmin Gongshe Guanliju, "1977-1979 Quanguo Qiongxian Qingxing," Xinhua Yuebao, no. 2, 1981.

[72]Cock and Kawano, "Cassava in China," pp. 10-11.

percent of the farmed area is suitable for rice cultivation, the remainder being rocky hillsides upon which fruit tree horticulture is being attempted. Cassava planting provides an economic hedge against heavy market dependence.

The Starch Market

What little quantitative information is available on starch production in Guangdong and Guangxi has been recorded in Table 14. Historically, a significant share of financing for capacity construction and an important share of sales deliveries have been associated with overseas Chinese, especially in nearby Hong Kong and Macau. In 1952, the Wuzhou Charcoal Industry started Guangxi's first starch factory (Jiulian Crude Starch Factory, later renamed the Wuzhou Municipal Starch Factory) with financial assistance from the government and from overseas Chinese. Its "sanjiaopai" [Triangle Brand] cassava starch was exported from Wuzhou in east central Guangxi to Hong Kong, Macau, Southeast Asia, Japan and the Middle East. Since the mid to late 1950s, Beihai in the far south, Bama Yaozu Autonomous County in the northwest, Xijiang Farm in the east, Wuming Overseas Chinese Farm in central Guangxi, Ningming Overseas Chinese Farm in the southwest and other farming areas set up fixed scale factories.[73] The designation "Overseas Chinese Farm" is an indication that overseas Chinese financial resources are involved in the commune's development.

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[73] Guangxi Jingji Nianjian Bianjibu, Guangxi Jingji Nianjian 1985, p. 192.

In Guangdong, cassava starch production may have begun even earlier, but at least by the early 1970s, 56 factories had been set up in the province and "hongpai" [Red Brand] cassava starch from the Dongguan Flour and Starch Factory on the Pearl River Delta was sold widely in Southeast Asia and Eastern Europe.[74] During the 1950s, 1960s and 1970s, it seems that production economies and the price structure concertedly favored cassava as a raw material for starch production since despite the provincial self-sufficiency imperatives for the period, Guangdong and Guangxi exported starch not only to Hong Kong, Macau and foreign countries, but to other Chinese provinces as well.

With liberalization of rural economic activities since the late 1970s, small scale starch processing plants have been established, especially as township and village enterprises. By 1983, the total number of starch factories in Guangxi had increased sharply to 284, though with combined fixed assets of only 25 million yuan.[75] But either production economies no longer so clearly favored the use of cassava as a raw material, or cassava production in other provinces was expanding to meet their demands for starch. This combination of overdevelopment of production capacity and loss of part of the interprovincial market brought about a contraction in the South Chinese starch industry in 1984. In Guangxi, the number of enterprises declined by 17 percent and production fell by 16 percent (Table 14). However, part of this decline may be due to intensified

[74]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 9.

[75]Guangxi Jingji Nianjian 1985, p. 192.

competition from nearby Zhaoqing and Shaoguan Prefectures in Guangdong where starch production has been increasing rapidly.[76]

A variety of industries use cassava starch in China, the most traditional being the cotton yarn industry which provided demand for the first Guangxi factory in Wuzhou.[77] But the Wuzhou and Beihai factories have expanded and diversified to use cassava starch as a basis for glucose production. In 1984, Guangxi produced 7,800 tons of glucose, primarily for the candy industry. 80 percent of this total was produced in the Wuzhou and Beihai factories, the latter exporting to Hong Kong, Thailand and other countries. The Wuzhou factory has also initiated trial production of denatured starch and, with purchase of technically superior equipment from Japan, has increased its extraction rate by more than 5 percent.[78]

In Guangdong, the Dongguan Factory has also diversified and now produces glucose, brewer's yeast and wine.[79] As early as 1972, it exported cassava-leaf starch to Japan, and, to England, large quantities of glucose, partially based on millet as well as cassava.[80] In Shaoguan and Zhaoqing Prefectures, in addition to

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[76]Delphi survey response: comments by Huang Xi, agronomist, Institute for Dryland Grain Crops, Guangdong Province Academy of Agricultural Science, Guangzhou, June 28, 1986.

[77]Sun Jingzhi, Huanan Jingji Dichu, pp. 258 and 333-334.

[78]Guangxi Jingji Nianjian 1985, p. 192.

[79]Correspondence from Graham Johnson, Professor of Anthropology, Department of Anthropology and Sociology, University of British Columbia, Vancouver, September 19, 1983.

[80]Liang Guangshang (ed.), Mushu Zaipei yu Liyong, p. 9.

cassava starch factories, a number of other processing industries have been established which utilize cassava, including a monosodium glutamate factory, molasses plants, breweries and feed-processing plants.[81]

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[81] Delphi survey response from Huang Xi, June 28, 1986.

INDONESIA

Production trends and distribution

Cassava was introduced into Indonesia through Portuguese trade with the Spice Islands but did not become well established as a major crop until the mid to late 1800's. The spread of cassava was promoted by the Dutch as a famine reserve. Also, by the turn of the century the Dutch had developed a large cassava starch industry on Java directed towards export, which also provided incentives for expansion of cassava production. By the mid-1960's area sown to cassava on Java reached a peak of 1.4 million hectares and has since declined (Table). Since 1975 cassava area on Java has been relatively stable at an even one million hectares. Cassava area on the off-islands remained static through the 1960's and early 1970's. Only in the later part of the 1970's has area in the off-islands shown a significant increase, due to the transmigration projects and the expansion of the gaplek trade and starch on Lampung.

The distribution of cassava production in Indonesia to a large extent corresponds with the distribution of population. About 70% of the cassava is produced on Java. Java is followed by Sumatra, which accounts for a little over 10%. The rest of the production is distributed throughout the other islands (Table). Cassava is thus grown throughout Indonesia, almost wholly in upland areas. Cassava has established itself as a major palawidja crop in Indonesia. Over the decade of the seventies cassava production grew at annual rate of 2.7% per annum in Indonesia. However, this production growth was marked by very different rates of growth between regions. On Java cassava production grew at an annual rate of 1.8%, while off-Java the growth rate was 5.2%. Even on Java growth occurred only in Central and Eastern Java, while production was stagnate in Western Java. By far the most rapid rate of growth occurred in Lampung on Sumatra, where production grew at a 12.2% annual rate, tripling in the space of a decade.

The faster rate of growth on the off-islands than on Java would be expected, particularly given the severe land constrain on Java versus the other islands and the policy to settle populations on the outer islands. The 1.8% growth rate in production on Java in the 1970's was due to a decline in area of 0.9% per year and an annual increase in yields of 2.8%.[1] Historically, yields on Java had been static at a little over 7 t/ha since the 1920's (Roche, 1982) and only since 1973 have yields levels shown a consistent rising trend. The natural question is what are the factors that have precipitated this relatively sudden and rapid rise in yields? A corrollary, however, would be the identification of the factors that have kept yields on Java much lower than other major producing countries in Southeast Asia, that is about half the yield levels in India and Thailand. The intensity of production systems on Java and the favorable agro-climatic conditions would suggest similar or higher yield potential.

Production growth on the outer islands during the 1970's showed a distinctly different pattern to that on Java. The principal factor responsible for the 5.2% production growth rate was the 3.2% annual

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[1] See Roche (1982) for a discussion of factors contributing to declining area planted to cassava.

expansion in area. This is similar to the population growth rate off-Java of 3.0% in the 1971-80 period. However, most of this expansion was concentrated on Sumatra, and particularly in Lampung. Area and production expansion thus appeared to be related more to expanding infrastructure and market possibilities than to expanding population. However, expanding area was not extensive in nature, since cassava yields as well rose at a rate of 2.0% per annum on the onter islands.

Thus, trends in cassava production in Indonesia over the past decade have been favorable, particularly given the severe land constraint on Java where the bulk of the cassava is produced. Nevertheless, cassava production on the outer islands is growing much faster, due in part to the unexploited land resources there. This creates something of a dichotomy in planning further expansion of cassava, which, as will be seen in the succeeding analysis, is reinforced by other major differences in both production and utilization between Java and the outer islands.

Cassava production systems

Cassava production systems in Indonesia, unlike other major cassava producing countries in Asia, are complex. Complexity in this case introduces diversity and across Indonesia there is substantial variation in production systems based on agro-climatic conditions, land availability and market access. Unfortunately there has been only one major attempt to study in depth some of these production systems, and thus, this section will by force of necessity principally summarize the research of Roche (1982) in his analysis of cassava cropping systems in three regions of Java.

Because of the differences in land/labor ratios between Java and the outer islands, production systems on Java will be considered independently of those off-Java. The complexity of cassava production systems derives from intercropping and rotation systems and double-cropping with rice in certain land types. Because median farm size of Java is only 0.4 hectares, farmers seek to optimize returns to this limited resource. Over half of cassava grown on Java in intercropped (Table), with the principal intercrops being maize and upland rice, and in West Java legumes such a peanuts and soybeans. In certain areas close to urban areas where fresh market prices are sufficiently high, cassava in monoculture will follow rice on irrigated land particulary, where there is not sufficient water for a second rice crop. Finally, although cassava will in most cases not complete for land with rice, it will have to compete for labor and capital resources, so that appropriate timing of cassava cultural practices is a major factor in production systems.

Agro-climatic conditions, particularly rainfall distribution soil type, and soil fertility together with irrigation availability are determining factors in the choice of cassava cropping system. Rainfall is adequate for cassava all over Java but in certain rainfed areas is limiting for other crops. Thus, as rainfall reliability declines from west to east (Figure), cassava production tends to be concentrated more in the eastern part of Java and on the island of Madura (Figure), even though cassava is grown throughout Java, apart from the irrigated areas of the northern plains.

Soil type, topography and the eroded state of soils define the other major constraint on adaptation of upland crops. Soils with major fertility, acidity, or toxicity problems, such as Ultisols, are principally found on the outer islands. The principal constraints on Java are highly eroded, unterraced hillsides. Such areas tend to be concentrated in the south-central coastal zone, an area where cassava production is most highly concentrated. Whereas rainfall distribution principally affects timing and whether one or two intercrops can be planted, land type determines the range of crops that can be grown. At the extreme where soils are highly eroded, cassava is the crop of last resort.

In general, as soil and rainfall constraints become more severe, first legumes leave the intercropping system, followed by upland rice, and finally maize, leaving cassava as the sole crop on highly eroded soils. Where soil and rainfall are not limiting, all of these crops can be included in one system, as shown in Figure . However, in general upland rice is the principal intercrop in the wetter, western part of Java, while maize is the principal intercrop in the central and eastern regions. In most systems the land is prepared before the start of the heavy rains, in general around October or November. The upland rice and/or maize are planted and after establishment in two to four weeks cassava is planted. Where soil conditions are not limiting, this system provides effective ground cover until cassava reaches full canopy and this aids in controlling erosion under the high rainfall conditions of Java.

The resource structure of the systems vary substantially (Table). Labor use is in general high even in those areas where bullocks are used in land preparation and inter-row cultivation. Fertilizer use tends to be higher in the more productive land types, principally because more responsive crops are planted in the intercrop system and relatedly such systems probably give the higher marginal return to fertilizer use. Cassava yield levels thus vary substantially between systems.

Over 70% of cassava is planted in the major rainy period from September to January (Figure). This introduces two principal constraints on cassava production systems. First, this coincides with the major rice planting season, which creates competition for labor resources. Second, the crop must be harvested and the land cleared by the start of the next rains. Where cassava is dried into gaplek, the harvest must be earlier to take advantage of the dry season. In those systems were cassava follows a rice crop, timing is crucial since the crop has six to eight months before harvest.

Nevertheless, the longer maturity of the cassava complements the harvesting pattern for rice (Figure). The major portion of the cassava harvest occurs in the June-October period after the principal rice harvest, insuring a more stable supply of carbohydrate sources. This tends to coincide with the dry period, so that cassava roots can be processed into gaplek where markets for fresh cassava are not assured. Roche (1982) presents evidence which suggest that cassava continues to grow and add root weight during the dry season -- this would not be the case were soil moisture limiting. Farmers thus face a trade-off between timely harvest for either gaplek drying or early land preparation and eventual cassava yield. Where cassava principally supplies starch factories or urban markets, there is a demand for more continuous supplies of roots. However, this is only possible where rainfall is sufficient to support the intercropping system during most of the year, such as in West Java, or where land types are suited only for pure stand cassava. In general, providing for more continuous supplies of cassava roots is heavily constrained by rainfall distribution and the complexity of the cropping system on the small farms of Java.

Moving from Java to the outer islands, the factors which determine cassava production systems change dramatically; rainfall distribution, soils, farm size and markets all change quite significantly. Cassava production systems on the outer islands are best considered independently of those on Java.

The initial, striking difference is in rainfall distribution. In general the outer islands have a more continuous supply of rainfall than Java (Table). On Sumatra, Kalimantan, and, to a slightly lesser extent, Sulawesi, the major portion of area is suitable for continuous cropping, as compared to only 20% of the area of Java (neglecting the irrigated areas). Interestingly, per capita production of cassava in Indonesia is highest in those areas -- Java and Nasa Tenggara -- where there is a significant part of the area with constraints on water availability during the year (Table).

Soils, in general, also vary markedly between Java and the outer islands. Whereas rainfall is not as limiting on the outer islands, soils in these areas impose much more severe constrains on cereal and legume crops, although not on cassava. The soils are in general ultisols, being quite acidic, of a low fertility status, and occasionally having relatively high levels of exchangeable aluminium. Because of these soil problems together with the erodability on slopes, much of this land area has been classified as marginal for cereal and legume crops. Cassava, however, is well adapted to these soils; but, continuous cropping of such soils requires appropriate crop and soil management to maintain productivity levels.

Cassava production systems on the outer islands have in many ways been conditioned by the dictates of the transmigration schemes. Before the advent of the transmigration schemes, much of cassava on the outer islands was grown in a shifting agricultural system. Such a system was very extensive, particularly since the abandoned fields returned to "alang-alang" (Imperata cylindrica) rather than the original forest fallow. The transmigration schemes superimposed a fixed farm size structure over the original shifting system. Farmers were in general given 3.5 hectares to exploit, and apart from the Lampung area, the settlement areas were chosen where the soils were not ultisols. Farmers, however, could not effectively utilize the whole 3.5 hectares. On the one hand, labor intensive cropping patterns were brought from Java to an area where labor needs relied solely on family availability and there was no bullock power. On the other hand, infrastructure was limited and there was no effective market, even were surpluses to be produced. Until sufficient infrastructure was developed, such as happened on Lampung, there was little incentive to sow over 0.6 to 1.0 hectares, sufficient to meet family food needs.

Cassava provides a certain production without purchased inputs and for this reason cassava has been crucial in meeting the food needs of newly arrived settlers in the transmigration projects, at least until rice paddies can be established in those areas where rice production is feasible. On the poorer soil areas cassava remains in the cropping pattern. Cassava in the outer islands is grown only on rainfed soils and usually in association, either with maize and upland rice or in the establishment of tree crops or between the rows of shorter tree crops like coffee. It is tree crops that are becoming the major cash crops on the outer islands, and it is only in Lampung where cassava has so far carved out a place as a primary cash crop, first as gaplek for export and currently for starch. Even though rainfall is relatively well distributed farmers still prefer to plant upland rice and maize during the months with the highest rain fall, so that there continues to be some seasonality in cassava production.

Because of this seasonality and the history of plantation systems in Indonesia, cassava plantation systems have also been developed on the outer islands. These have usually been developed in conjunction with large-scale starch plants, of which there are at least eleven in Lampung (Nelson, 1982). There is little information on these systems. There is substantial mechanization, even in the harvesting of roots. McIntosh and Effendi (1979) suggest that after opening new land, yields are high the first year but decline over time. Fertilizer is used only after the third or fourth year or the land is left fallow, and new land is opened up. These plantation systems provide continuity of supply, but the factories depend for most of their needs on small-scale production systems.

Cassava production systems in Indonesia, as compared to other producing countries in Asia, are characterized by considerable diversity, depending on rainfall, land type, and market, and a fair degree of complexity, due to the intensive nature of such small size farms. Focusing on just a single crop such as cassava would fail to define the determinants of the system. Improving productivity of cassava will necessarily have to focus on improving the productivity of the whole cropping system.

Yields:

Yields of cassava in Indonesia in 1980 averaged 9.7 t/ha, compared to average yields of 13.1 t/ha in Thailand and 18.3 t/ha in India. Soils and rainfall are probably on average better in Indonesia than the other two countries. Labor and input use are in general on a par with India. These comparisons would tend to imply that apart from variety cropping systems in Indonesia have a substantial affect on cassava yield. Probably three principal factors are influencing yield: plant density in intercrop systems, delayed planting of cassava in the intercrop system, and a shorter growth cycle.

Zandstra (1978) has shown a decline in cassava yield with delayed planting of cassava in intercropping rice and maize. Planting cassava is delayed from 3-4 weeks (Roche, 1982) to two months (McIntosh and Effendi, 1979) after the planting of the rice and maize. Such systems tend to increase the rice yield and decrease the cassava yield. Plant densities also vary in these systems, particularly if a second crop is to be intercropped after the rice and maize harvest. In such cases plant densities are as low as 4,500 plants/ha. On the other hand, in the common rice-maize-cassava system the cassava population can be maintained at 10,000 plants/ha. Depending in part on variety, trials in general show very little response to increased plant population after 10,000 plants/ha (Wargiono, et. al., 1979). Finally, there is substantial evidence to suggest a trade-off between early harvest and yield.

Nevertheless, Roche (1982) among others has shown that intercropping systems are more productive than monoculture cassava. The issue again arises as to what has been responsible for rising yields of cassava, which then leads to the question of what is the potential for raising yields in these systems. Roche suggests that increased fertilizer use has been the principal factor. Since the early 1970's there has been steady development of fertilizer marketing channels, first for irrigated and then for upland areas. Moreover, there has been a policy of subsidizing the price of fertilizer. Application of fertilizer on cassava has thus steadily increased over the 1970's (Table). Nevertheless, average application rates only stand at little over 20 kg/ha, well below application rates on other upland crops. Yet, since cassava is often intercropped with upland rice and maize, cassava is also benefiting from the increased applications to these crops.

The other avenue to increasing cassava yields would be to favor cassava over other crops in the system. Farmers can make marginal adjustments in planting dates, harvest dates, spacing, or density of the intercrops to increase cassava yields, in many cases at the expense of yields of other crops in the system. However, if anything cassava prices have declined moderately in relation to the prices of the other upland crops (Roche, 1982) over the decade, providing little incentive to favor cassava over other crops. The only other incentive would be improved market access. With the rapid expansion in starch production, both at the household and the factory level, more stable market conditions may have developed, resulting in a decrease in risk of marketing the perishable root. Unfortunately, there is no evidence to support the intensification of cassava within upland cropping systems.

The other major characteristic of cassava yields in Indonesia is their variation between systems. Aggregate statistics suggest relatively similar yields between regions but Roche found average cassava yields varying from 2.3 t/ha to 19.5 t/ha, depending on the system. The variability depended in part on rainfall conditions, management, and intercropping system but seemed to be most related to land type. Yields were lowest on eroded hillsides and highest on the level rainfed soils or, in the dry season, bunded land, even though in the latter the growth period was very short. The yield range was further widened because fertilizer tended to be applied to the better soils. Increasing yields will in large part depend on adapting technology to different land systems, a principal feature of IRRI's cropping systems research methodology (Zanstra, et. al., 1981).

Costs of production and labor utilization

Compared to other countries in Asia, labor use in cassava production systems in Indonesia is high, in general double or triple per hectare labor inputs in most other countries. This reflects the very low land/labor ratios on Java, on the one hand, and the more complex cropping systems, on the other hand. Nevertheless, even in monoculture cassava systems where bulloks are used in land preparation, labor input exceeds 200 mandays/ha (Roche, 1982). Even more striking is the fact that labor input off-Java remains high. In a survey by Hambrect (personal communication), labor input in Gedony Tatson district in Sumatra averaged 354 mandays/ha, of which 61 were for peeling and drying into gaplek. Even on the off islands labor intensity of the production systems is not radically altered.

Labor thus forms a major component in costs of production; however, the proportion varies markedly with the inherent productivity of the land system. On the eroded hillsides of Gunung Kidul labor is practically the only input, while on the level rainfed soils of Kediri, labor costs are higher than Gunung Kidul but still form less than half of total variable costs (Table). Higher levels of purchased inputs are applied to the more productive land systems, so that naturally higher yields are achieved with higher per hectare costs.

Arriving at a pure costs of production for cassava in Indonesia is complicated by the intercrops in the system and the costing of farmer owned resources. Using only monoculture systems where possible -- although Roche has shown intercropping systems to be more profitable --, a full costing of all inputs at their market value shows that cassava systems in general are not even covering variable costs. Although cash incomes are positive (Roche, 1982), returns on own factors are in general less than the market price. Certainly at average output prices of 20 rupees/kg of roots there is no profit that can be attributed as a return to land. On Sumatra farm prices can be as low as 9 rupees/kg.

Clearly, the opportunity cost of farm resources can be well below market rates. This is quite logical in systems where subsistence needs have a high priority, where there is substantial underemployment in labor markets, and where land, though having a high scarcity value, is usually merely sufficient to meet subsistence requirements. The very high labor inputs thus are not necessarily translated into high labor costs, and together with subsidized fertilizer prices and the additional income from intercropping, cassava output prices can often fall below implicit production costs and still remain a relatively stable part of the cropping system. This can be seen in the relative stability of cassava in the Jave cropping system over the last several decades, even though cassava is more of a cash crop than a subsistence crop.

Technology development

Since the constraints on cassava yields are both not fully understood and vary substantially across Indonesia, a research program to develop yield-increasing, cassava technology needs both a close linkage to farmer production systems and a quite extensive testing system. Moreover, raising cassava yields will have to be done within intercropping systems, and it will not be possible to heavily sacrifice yields of other crops in increasing cassava yields, especially that of upland rice. Finally, yield potential will be heavily circumscribed by climatic and soil conditions, so that any yield gap analysis will have to be defined in terms of location and land system.

Such a research focus requires a certain critical level of resources, yet reseach resources for palawidja crops have traditionally been limited, as most resources have been devoted to rice. Agricultural research is relatively centralized in Indonesia and comes under the responsibility of the Agency for Agricultural Research and Development (AARI). AARD is divided into seven major research centers, of which cassava comes under the Central Research Institute for Food Crops. These central research institute are in fact a coordinating body for a set of regionally based research centers, of which there are seven under the Central Research Institute for Food Crops. Cassava research in Indonesia is centered in the Root Crop Improvement Program, which is under the Bogor Research Institute for Food Crops. There is some consideration of plans for decentralizing research decision-making and making the seven research institutes semiautonomous, which could mean that cassava research could be done in many these institutes. However, currently cassava research is centered at Bogor, which focuses on more basic research. Thus, all of the cassava breeding research is done at Bogor. Agronomic research and advanced selection of clones are done at some of the other research centers.

Cassava technology development in Indonesia in the postwar period has principally focused on varietal development and fertilizer trials. Two varieties, Andira I and II, were released in 1978. Adira I has a lower HCN content, shorter maturity, higher starch content, and about the same yield potential (35 t/ha) as Adira II. Adira I is apparently grown quite widely on Lampung (Roberto Soenaryo, private communication) but its adoption on Java has not been widespread. Understanding why farmers have not adopted Andina I could offer valuable insights into whether the problem is the variety or its extension. Clearly, in Indonesian cassava systems yield is only one criterion among many that will motivate farmer adoption.

Roche (1982) argues that the most immediate avenue to increasing cassava yields is through a combination of the Adira I variety and appropriate fertilization. In the longer term more finely tuned varietal development together with integrated fertilization, rotation, seed management, and intercropping practices designed for homogenous land systems will probably be the principal means to achieving significant increases in cassava yields. Certainly the objectives will be a stable, continuous cropping system in upland areas with cassava as a significant component.

Another consideration is whether a distinction should be made in a cassava research strategy for Java versus the outer islands. This issue, to a large extent, will depend on land policy and the availability of labor-saving technology. Currently cassava and other food crop production depend on the very labor-intensive, production systems developed on Java. Farmers usually cannot utilize all the land allocated to them because of the lack of labor and/or tenant markets. Most research to date has focused on further intensification of intercropping systems, with focus on the particular soil constraints of the outer islands. The issue is whether higher incomes could be achieved with more labor intensive use of land vis-a-vis less intensive labor use but cultivating more land.

Because of the agroclimatic conditions and this labor constraint on the outer islands, tree crops have become a principal farmer alternative. Cassava in some systems is intercropped with coffee, clove or oil palm, until tree establishment. Small land allotments, movement to tree crops, and lack of less labor intensive soil preparation and weeding practices will thus limit cassava production increases to moderate area growth and yield increase. Policy has thus dictated similar lines of research for cassava on the outer islands as on Java.

MARKETS AND DEMAND

A synthesis of production and utilization

Explainig the sources of increased cassava production in Indonesia provides only half of an analysis of the cassava economy in the country. Increasing production implies increasing consumption, and a complete analysis requires an evaluation of sources of demand growth-Indonesia provides in many respects an example of a well integrated cassava economy, in that the multiple uses of cassava are fully exploited. Before studying the sources of increased cassava utilization, the consistency between the production and consumption estimates are first reviewed.

The supply and distribution estimates are based on data for the year 1976 and the estimates are broken down for Java and the outer islands. Two other estimates of cassava supply and distribution exist; one is the food balance sheets for Indonesia put not by the Central Bureau of Statistics and the other is an estimate by Laurian Unnevehr (1982) for Java only. These estimates will be used as a point of reference in developing the supply and distribution estimates.

Food uses are a dominant form of utilization of cassava in Indonesia. The most systematic estimates of cassava consumption patterns comes from the periodic National Socioeconomic Expenditure Survey (Susenas) -- see Dixon (1982) for a discussion of the structure of the surveys. The 1976 survey (Susenas V) found an average per capita consumption of 21.6 kg of fresh roots and 8.0 kg of gaplek on Java and 34.2 kg of fresh roots and 3.8 kg of gaplek on the outer islands. This resulted in an average for Indonesia as a whole of 26.2 kg of fresh roots and 6.4 kg of gaplek or an average of 45.4 kg of cassava on a fresh equivalent basis.

A standard rate for converting fresh roots to gaplek is more complex in Indonesia than Thailand because roots are peeled and gaplek is not dried to a standard percentage. This introduces peeling loss, moisture content, and dry matter content as variables in the determination of the conversion rate. Field observations suggest a peeling loss of 20% (Unnevehr, 1982), which is in accord with standard percentages of peel to root weight of 15 to 20% found at CIAT (Rupert Best, private communication). Moisture content of gaplek is apparently highly variable. Field observation by Unnevehr suggests levels as high as 25%. Studies at CIAT (Rupert Best, private communication) have found problems of heavy fungal growth on cassava chips with higher than 18% moisture, even after one week. Drying to moisture levels of 20% or above, the storage life of cassava is not substantially extended, unless there are alternative means of control to fungal growth. Unnevehr did find relatively high losses in gaplek storage, but only after relatively long periods. What average moisture content of gaplek is at the point of consumption remains somewhat of a question. So also, does the average dry matter content of cassava roots.

Dixon (1982) and Unnevehr (1982) both employ a conversion rate of roots to gaplek of 2.5 to 1. Assuming a 20% weight loss due to peeling, gaplek at a 25% moisture content implies a dry matter content of 27.5%, while at 20% moisture, a 30% dry matter content is implied. These dry matter percentages are well within the normal range and may even be somewhat on the low side when compared to different genotypes evaluated at Bogor. A 2.5 to 1 conversion rate is then probably a reasonable balance between root dry matter and gaplek moisture content.

The 45.4 kg average level of cassava consumption from the expenditure surveys compares to an estimate from the food balance sheets of 76.0 kg per capita. Food consumption in the food balance sheets is estimated as a residual, after all other uses have been deducted. The discrepancy between the two estimates is significant and provides the first indication that there may be some discrepancy between production and consumption estimates.

Gaplek is not only used directly for human consumption but is also exported and Unnevehr (1982) found some gaplek being milled into flour by wholesalers and used in bakery products. Gaplek exports from Indonesia are highly variable and in 1976 exports, particularly from Java, were especially low. A five year average around 1976 is therefore used as a normal export level. Cassava flour is assumed to be produced only on Java and Unnevhr's estimate is used.

Starch is a major utilization form in Indonesia and although it principally goes into food uses, starch consumption is not included in the human consumption estimates. Utilization of cassava as starch comes from starch production estimates. The most rigorous evaluation of these estimates is provided by Nelson (1982) for the years 1973 and 1979. Geometric growth rates are used to interpolate a 1976 estimate.

Animal feed provides the only other possible end use of cassava. Roche's (1982) survey of cassava production systems suggested no feeding of fresh roots to animals. Given the limited importance of swine, the dominance of ruminant animals and their ability to utilize lower cost feedstuffs, and cassava's role either as a cash or food crop, any on-farm feeding of cassava roots would be expected to be limited, although there are not reports to confirm this assessment. Incorporation of gaplek into balanced feeds is also thought to be limited, given that market channels for gaplek are directed principally to export. Unnevehr in her study of gaplek marketing channels mentions no movement of gaplek into, what is in many respects, a very limited feed concentrate industry. The assumption will be made then that any use of cassava in animal feed is limited.

These data then lead to the supply and utilization estimates in Table . Without even considering a waste component, there is a very close correspondence between production and consumption estimates for the outer islands. On the other hand, for Java production estimates are significantly higher than consumption estimates by almost 2.9 million tons. Assigning all the difference to waste is not justified given the intensive nature of production systems, the close integration with markets, and because of the very limited incomes, the tendency for both farmers and, middlemen to be very conscious of loss. In marketing channels for fresh roots Unnevehr reports losses of around 8%. The more significant losses occur in the storage of gaplek from the main production period for consumption in the period of high rice prices. Unnevehr reports losses in this context of from 10 to 20%. Applying 8% losses to marketed cassava and 15% to all gaplek for human consumption -- the lower moisture content and better storage facilities would militate against such losses in the export trade -- yields a loss figure of .36 million tons. This leaves 2.5 million tons unaccounted for on Java.

The discrepancy is too large to attribute just to underreporting in the different consumption estimates. Moreover, conversion rates of roots to processed product have consistently been assumed to be on the high side. A tendency to overestimate production somewhat would therefore seem to be implied, with no particular reason to suggest whether yields or area or both are being overestimated. All factors considered there is probably a firmer basis for accepting the consumption estimate over the production estimate.

The supply and distribution analysis suggests a significant difference in utilization patterns between Java and the outer islands. On Java utilization forms are fairly balanced between fresh roots for human consumption, gaplek and starch. On the outer islands, on the other hand, fresh root consumption is by far the largest consumption form, a not surprising fact given the lack of infrastructure and the focus on subsistence consumption. The other major characteristic of cassava utilization patterns in Indonesia is its diversity, particularly in relation to other Asian cassava producers. Indonesia heavily exploits the multi-use characteristics of cassava, with major markets for fresh human consumption, starch and gaplek, both for human consumption and export. Understanding how cassava production is allocated to these various markets, each with relatively different growth potential, may aid in developing similar market structures in other countries.

Cassava for direct human consumption

The food economy of Indonesia is based on rice. While less preferred than rice, cassava, nevertheless, is the second most important carbohydrate source according to Susenas data (Table) but still makes up no more than 10% of average calorie intake. The successful extension in irrigated areas of the high yielding rice varieties resulted in increasing per capita availabilities of the grain during the decade. Trends in cassava consumption are more difficult to interpret. The food balance estimates follow production trends and suggest a distinct increase in consumption since 1973; on the other hand, the Susenas estimates suggest more or less stable consumption over the decade (Table). What is clear is that cassava continues to maintain a secondary but yet important role in the Indonesian food economy, with this importance lying more in distribution of cassava consumption rather than in aggregate averages.

Cassava is consumed principally in the form of fresh roots and gaplek, with these two forms being prepared in a variety of forms in the home. There is a marked regional variation in consumption patterns of both fresh roots and gaplek. Although per capita consumption levels for cassava are the same for Java as the outer islands, fresh consumption is much more important off-Java, probably due to the less seasonal nature of root production and the greater difficulty in drying. Gaplek consumption is concentrated in the eastern part of Java, where soil and rainfall are more marginal (Figure), while fresh consumption on Java is relatively more evenly distributed. The importance of cassava in the diet and the relatively ubiquitous distribution of fresh root consumption implies that quality characteristics cannot be sacrificed in a varietal development program.

The locus of cassava consumption is very much in the rural sector, due not only to the bulk of the population residing in rural areas but also to the much higher per capita consumption of cassava in these areas. There is a significant change in consumption of non-preferred staples between rural and urban areas (Table). Gaplek and maize are rarely consumed in an urban setting and yet are quite important in rural areas. Fresh cassava consumption, while higher in rural areas, nevertheless is still at significant levels in urban areas, even given the problems of marketing such a perishable commodity. Unnevehr (1982) estimates that in rural areas about two thirds of fresh cassava and one-half of gaplek are subsistence consumption. Counting urban consumption, only 37% of fresh cassava that is utilized for human consumption is marketed.

Probably the most important component influencing the distribution of cassava consumption is income. Gaplek consumption shows a consistently declining trend with income (Table). Gaplek is a non-preferred food, principally consumed by the poor. Fresh cassava consumption, at least in rural areas, increases markedly with increasing income at low levels of income, levels off at medium income levels, and declines slightly at high income levels. The overall tendency is for total cassava consumption to decline with income.

Approximately 40% of the population in Indonesia consumes less than 1900 calories per day (Table). This group is obviously constrained by income in the amount of food which they can purchase and thus must make more use of cheap calorie sources. The poorer income groups, principally in the rural areas, substitute cassava and maize for the more expensive, but more highly preferred, rice (Figure). Cheap cassava allows the lower income segments of the population to achieve a higher calorie intake with their limited food budget than they would have been able to achieve with just rice. Cassava is thus a potentially key commodity in policies focusing on nutrition and the related issue of rice import management.

The role of cassava within an overall nutrition policy follows from an analysis of demand parameters. Estimates of income elasticities by Dixon (1982) show that among the poorer income strata there is a significant increase in cassava consumption, both as fresh and gaplek, with increases in income (Table). Such changes in cassava consumption could come from real increases in income or from changes in the rice price, since expenditure on rice makes up such a large part of the consumer budget. Substantial substitution between caloric staples would be expected depending on relative prices and in fact, elasticity estimates suggest substantial responsiveness to price changes. Timmer (1980) reports a cross price elasticity of fresh cassava with rice of 0.77, showing a very marked effect of rice prices on cassava consumption [2].

Cassava's role in the Indonesian food economy, while not central, is nevertheless critical to the support of that proportion of the population facing a risk of not meeting their caloric needs from rice supplies. This population is essentially defined by low incomes and in years of poor rice status can be put further at risk by rising rice prices. The government's policy has been to try to maintain stable rice prices and this task is vested in the government grain marketing agency BULOG, which attempts to stabilize rice prices through rice imports, and to a certain extent through wheat imports.

BULOG was aided in this effort in the last decade and a half by the widespread adoption in the irrigated areas of the high yielding rice varieties. Nevertheless, rice imports have almost consistently exceeded one million tons and have occasionally almost reached two million tons. At these levels Indonesia can account for as much as a third of the world export market, having a pronounced affect on world rice prices and, therefore, the foreign exchange costs necessary to meet import requirements. As the benefits of the new rice technologies start almost certainly, to plateau, Indonesia will be faced with even higher import requirements in a world rice market that is very thin. To resolve this dilemma, Indonesia has increasingly turned to wheat imports, which are both cheaper and a minor percentage of the world market.

However, Indonesia has on the whole failed to consider the potential role of the secondary staples, cassava and maize. Total consumption of both of these commodities has essentially been static over the past decade and a half, implying a declining contribution to total caloric consumption, since rice consumption has risen dramatically. Since there are real supply-side constraints on meeting nutritional objectives with rice, since the locus of wheat consumption is principally in urban areas, and since cassava and maize are already important staples for the rural poor, a strategy to increase production of these crops at lower prices (that is, technical change) would contribute directly to increased calorie consumption of the most vulnerable pupulation. By integrating cassava into overall food policy, BULOG would have considerable more flexibility in managing rice imports and prices. However, because of the overall inelasticity in food demand for cassava, this flexibility is dependent on diversifying end markets. That is, diversifying the end uses as the production base expands not only provides a certain market stability for farmers but as well ensures alternative food supplies when rice is in short supply.

<u>The starch market</u>

Starch is the largest single market (on a root equivalent basis) for cassava in Indonesia. A cassava starch industry has existed on Java since

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2 Dixon (1982), on the other hand, could find no significant cross price elasticities but based his estimation only on Java, whereas Timmer's was based on Indonesia as a whole. harvests, their nutritional

the turn of the century. Prior to World War II and independence, this industry was based principally on plantations and was geared principally to export. The recovery from the damage incurred during the war induced a shift from foreign to domestic ownership, which in turn entailed a shift from export to domestic markets. Indonesia is currently the largest producer of cassava starch in the world, and essentially all the production is destined to domestic markets. Unlike other countries in Asia, there is virtually no production of starch from maize [3].

The structure of the cassava starch industry is characterized by great diversity (Table). Starch factories are spread throughout Java and Sumatra, but with a particular concentration in West Java. Location of the starch industry is primarily dependent on access to a ready water supply, to a sufficient concentration of root production, to adequate transport infrastructure, and to non-seasonality of root supply. These factors have until recently given the edge to West Java as the center of starch production. However, as transport infrastructure has improved on Sumatra, particularly in Lampung, starch production has expanded rapidly. This has been enhanced by the less seasonal supply of roots on Lampung. From virtually no production in the early 1960's, the starch industry on Lampung has expanded rapidly, especially in the 1970's, to become the second largest starch-producing province after West Java.

Diversity is also a characteristic of the scale of processing. Rudimentary, household processing techniques co-exist with large-scale, capital intensive factories, with a significant range of plant sizes between these two extremes. Nelson (1982) has recently analyzed the economics of starch production in Indonesia. At 1980 prices all processing modes were found to be profitable (Table). The large mills were found to be most profitable, but only because the tax incidence was much less than on household production and medium-scale factories. To motivate investment the government has instituted tax holidays for three to six years for large-scale firms. This, together with a subsidy on diesel fuel and exemption from import duty for imports of processing equipment, give a distinct advantage to insuring the profitability of the large scale plant. However, from a social point of view, Nelson finds that the household production generates both the highest level of social profit as well as the most employment. Nelson further reports that household starch production has expanded rapidly in the 1970's, motivated by the increased capacity utilization from the introduction of mechanical graters.

The few figures on starch suggest that production has increased rapidly through the 1970's (Table). This growth was characterized by significant increases in household production on Java and very rapid growth of large-scale processing on Lampung. The starch market was both large and growing, providing quite strong demand for cassava roots. Root production, at least on Lampung, responded accordingly.

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[3] A single starch/corn oil plant, Indocorn, is operating in Indonesia. It principally relies on maize imports for its operation and was not in operation in 1984.

The factors that were driving this increased demand for cassava starch are less well documented. Concensus seems to exist that the largest end use for starch is as krupuk, a crispy wafer consumed as a snack food. Nelson reports that this industry takes as much as 65% of total starch production, while the rest goes into other food processing industries (15%), the textile industry (10%), and glucose production (3%). The only complementary data comes from the SUSENAS consumer budget surveys. The 1976 survey reports an average annual per capita consumption level of starch of 6.9 kg on rural Java and 0.7 kg in urban areas of Java (Dixon, 1984). Assuming only 2.0 kg in the rural areas off-Java and the same level of consumption (0.7 kg) in urban areas off-Java, leads to a total starch consumption as food of 587 thousand tons, based on 1980 population estimates. This figure is 89% of the total starch production figure estimated by Nelson.

On Java more cassava (on a root equivalent basis) is consumed for food as starch than as fresh roots. Moreover, Dixon (1984) suggests that the SUSENAS data significantly underreport starch consumption, since the starch equivalents of direct purchases of krupuk and bakery goods are not included. Dixon estimates per capita consumption figures of 12 kg in rural Java and 5 kg in urban Java. However, these figures result in aggregate consumption levels of 935 thousand tons of starch for Java alone. These data would suggest that household production of cassava starch is underestimated, which in turn would account for a large part of the discrepancy between cassava production and consumption estimates on Java.

A large and relatively diverse cassava starch industry already exists in Indonesia, moreover, the limited evidence on demand suggests that this market will continue to grow for a significant period into the future. Most of this growth comes from the use of starch as a food source, with consumption in this case being skewed toward the higher income strata. Dixon (1984) estimates income elasticities for krupuk of 1.56 in rural areas and 1.35 in urban areas. Significantly, consumption patterns for cassava starch, skewed as they are toward the rich, are the mirror image of those for gaplek, which are highly skewed toward the poor. Product differentiation and market segmentation allows cassava in this case to serve two very distinct roles, as a basic secondary staple for the poor and as something of a luxury food for higher income groups.

A unique feature of the cassava starch industry in Indonesia, compared to that of the other countries in Asia, is that there is no effective competition from maize starch, even though maize is a major crop in Indonesia. The situation is further confounded by the fact that maize is, at least intermittently, exported at world prices, while gaplek, while also exported, competes at the higher price levels set in the European Community. Maize should thus be more competitive as a raw material source for starch production than cassava. However, in the particular case of Indonesia, starch substitution is limited by quality factors, and, in particular, course, sun-dried starch is necessary in preparing krupuk, the dominant market. The fine, flashdried starch cannot be used in krupuk unless mixed with the coarser starch. Thus, maize starch was constrained to competing in the much smaller, industrial market with cassava starch produced in the larger factories, and, given the scale economies in wet milling, maize could not establish a large enough market to justify a factory.

Nevertheless, the competition between maize and cassava becomes a factor in the recent interest in the production of high fructose sweetners. Indonesia has over the past decade consistently increased its imports of sugar to the point that imports now total between 500 to 700 thousand tons a year. Not only are imports increasing but Indonesia maintains high internal sugar prices to support producers, on the one hand, and to limit consumption, on the other hand. A policy directed at self-sufficiency in sugar is limited by the availability of land suitable for sugar cane and the competition between rice and cane for this land. Therefore, producing high fructose sweetners from either maize or cassava in upland areas holds some attraction.

However, the substitution of liquid high fructose sweetners for sugar occurs over only a limited range of end uses of sugar. The largest market, direct human consumption, has limited possibilities for substitution at this stage of market development. Development of the HFS market depends on exploiting industrial uses, especially food processing and bottled beverages. Estimates on the size of this market are based on scanty data; two sources put the potential consumption at between 220 and 500 thousand tons per year (Argento and Wardrip, 1983; Tate and Lyle, 1981). Moreover, this market is expected to grow at a estimated rate of 5% through the rest of the century (Pearson, 1984).

Indonesia has already committed itself to producing high fructose sweetners. A cassava-based factory with an annual capacity of - tons is already in operation in Malang on Java. Licenses for the construction of 4 more factories have been issued to bring total production capacity to 110 thousand tons of HFS. Nevertheless, two basic factors will largely determine the future of this industry. First, the economic viability of high fructose sweetner production will necessarily rest on the maintenance of the high domestic price level for sugar. Domestic wholesale prices for sugar in 1984 were $.57 per kg, compared to a world market price of $.15 per kg and the medium term prognosis for world price levels to rise only to about $.26 per kg. Second, licensing procedures and subsidies on capital investments will be critical in determining whether sweetner production is based on cassava or maize. The economic advantage of one crop over the other is difficult to project with any degree of certainty but the most complete cost analysis to date is that of Pearson (1984).

The Pearson concluded that maize would be a lower cost alternative than cassava in HFS production due to three principal tenets. First, there are significant economies of scale in the maize wet milling process, while in cassava these are minimal. Second, the price distortions in the world market for cassava relative to maize are assumed to persist and will in turn influence domestic profitability. Third, domestic production of maize is projected to increase significantly on the basis of an improved hybrid technology; should this technology not produce increased yields, imports will have to increase markedly to meet increases in demand for maize for both feed concentrates and HFS production.

Nevertheless, planning of the HFS industry has been based on cassava for several practical reasons. First, HFS production based on cassava is profitable under present domestic sugar prices as set by BULOG. Second, expansion of cassava production does not depend on yield increases but can be based on further area expansion in the off islands, especially those with good infrastructure as in south Sumatra. A supply response is much more assured in the cassava case. Third, capital requirements for HFS production are significantly less as a HFS production line can be added to existing cassava starch factories, as was done in the Malang case. This allows a more evolutionary and less risky approach to market development since production can initially be based on relatively small scale plants that have alternative product lines and not on major capital investments in large-scale, maize wet milling plants.

Basing HFS production on cassava allows significantly more flexibility in market development than does maize. For cassava-based HFS, factories can be located in cassava production areas and based on starch slurries from the direct root processing or alternatively can located next to major market areas and use processed starch as a raw material. Relative transport costs and control over raw material costs will determine the choice. Maize, wet milling plants will probably be located near to consumption points and will depend on steady supplies of maize from major storage facilities or imports. In this regard maize-based HFS will be competing with the animal feed industry for raw material supplies, most of which is currently supplied to the concentrate industry from BULOG stocks which are often imports (Table). Cassava's potential role in this industry will thus be based on BULOG's sugar price policy and on the relatively immediate demonstration of impact from the improved maize technology.

Gaplek in Feed Markets

Gaplek forms an integral part of cassava production and market systems in Indonesia. When properly dried, gaplek is a stable commodity and provides the farmer the option of harvesting and storing his cassava especially when there is a time premium on harvesting the cassava to plant the next crop. Moreover, gaplek, since it can be stored and transported, provides a means of integrating cassava markets. Finally, gaplek has multiple uses; it can be used directly for human consumption, can be ground into flour for noodle production, or can be a raw material source for feed concentrate production or even for manufacture of low quality starch and its derivatives such as glucose or fructose sweetners.

Gaplek is currently used principally for human food, especially by the lower income consumers in rural areas. Indonesia is also a consistent, although highly variable, exporter of gaplek to the European Community. This export market serves the very important function of setting a price floor under domestic prices for gaplek and in turn cassava in general (Unnevehr, 1982). The export market is effective in setting this price floor, even though this market rarely accounts for more than 10% of cassava production. Only twice since 1970 have gaplek exports exceeded 400 thousand tons (Table) and export levels more generally oscillate between 150 and 350 thousand tons.

Internal gaplek prices have in general followed the general rising trend in world prices (Figure), with exports being particularly responsive to the devaluation of the rupiah in 1978. A similar devaluation in 1983 has yet to produce such a response. This apparent tightening of domestic markets is especially evident in Lampung, where the gaplek export market was the engine of growth for the cassava industry in the first half of the 1970's. Gaplek exports from Lampurg stagnated after 1975 and have declined markedly since 1981. The gaplek industry has had difficulty competing with the expanding starch industry on Lumpung, even when world prices were recently relatively high. This declining trend was exacerbated by the poor crop years in 1982 and 1983.

The tightening of export supplies of gaplek have made the voluntary quotas, formalized with the EC in 1982, rather superfluous. The quota was set at 500 thousand tons in 1982, rising to 825 thousand tons by 1986 when the agreement ends. Compared to the Thai quota, which declined over the period, the Indonesian agreement was very much largesse, even though of a very gratuitous kind. There is very little potential for meeting the quota volumes, even with the 1983 devaluation. The advantages of the latter were negated by a bad crop year and the 1984 fall in the world price, brought on by the effect of the quota on the Thai cassava industry.

The current level of the gaplek export market undervalues its importance. An export price floor set in the EC not only earns Indonesia a significant economic rent but also serves to maintain price incentives should future production growth increase. New cassava production technology or further transport infrastructure development on Sumatra could bring about such growth and the export market could serve to buffer farmer prices were production growth significant. The short term problem with current strong domestic markets for cassava is to maintain sufficient pelleting and export capacity to insure the world price linkage. The medium term problem is to insure that a sufficiently large quota in the EC market is maintained to allow the cassava industry to expand without significant price instability. Certainly, in renegotiating the quota agreement, the short-term problem should not militate against the longer term gains from maintenance of export flexibility.

The maintenance of the world price export floor for gaplek, while earning significant rents for Indonesia, nevertheless is one factor inhibiting the development of gaplek as a raw material source in mixed feed. Since gaplek prices are set in the EC and maize prices are to a degree linked to the world coarse grain market, gaplek prices are often out of line with maize. Nevertheless, as table demonstrates, calorie prices of gaplek are often as not competitive with maize. Two additional factors militate against gaplek use in balanced feed rations. First, there is a preference for maize because of its carotene content, which gives the eggs and poultry meat a yellower color. Second, BULOG can be relied on for supplies when these are not available on the local market, especially since the major mills are located near to major urban areas (Table). Third, BULOG has recently brought soybean meal imports under its control, principally as a means of regulating foreign exchange. Although BULOG continues to change prices in line with world market prices, in 1983 it decided to cut imports by a half to save foreign exchange. This resulted in mills importing rapeseed and sunflowerseed meals, which are not currently controlled. Any limitation on protein supplies would give a relative advantage to maize over cassava.

The balanced feed/commercial livestock sector is not as well developed as similar industries in such countries as Thailand or the Philippines. This is principally due to a relatively late start, as the first feed factories were only established in 1972. However, the other structural features of this industry are very similar. Growth in mixed feed production has been spectacular, rising from essentially no industry in 1972 to an estimated 400 thousand tons in 1982 (Alfred C. Toepfer Company, private communication). About 85 to 90% of production is poultry rations and the commercial poultry industry has grown in close association with the feed sector (Table). This growth in the poultry/mixed feed industry has been motivated by increasing demand for meat and eggs, precipitated by rising per capita incomes during the 1970's. In sum a viable poultry/mixed feed industry has been established in Indonesia with prospects for continued future growth as reflected in the high income elasticities for meat and eggs.

A factor that may be a constraint on growth in the poultry industry, and by implication for the mixed feed industry, is the presidential decree limiting the size of layer units to 5000 birds and of broiler operations to 750 head per week. The objective of the decree is the maintainence of a labor intensive poultry industry and a more equitable distribution of income opportunities. For the feed industry, per se, the decree in effect expands their market, since the large poultry operations mix their own feed. The principal effect will be on costs of eggs and poultry meat, since the larger producers are able to achieve higher feed conversion rates and fewer losses. Mink (1984) estimates the result of such a shift to small producers will be an annual reduction of 35,000 tons in demand for carbohydrate sources.

Between 450 (World Bank, 1984) and 700 thousand (Mink, 1984) tons of maize are estimated to be used as animal feed currently in Indonesia. This represents no more than - per cent of the total maize crop. No cassava is currently used in the animal feed industry and there is little potential of entering this market as long as gaplek prices are set in the EEC. Moreover, improved hybrid varieties, the first released by Cargill in 1983, are thought to have significant potential for increasing production above domestic requirements. This yield impact however, remains to be demonstrated on a widespread scale at the farm level. Nevertheless, only with a marked change in relative prices will cassava be used in animal feed, and this appears unlikely as long as the export price floor remains effective. Given the growth potential of other markets and the social profits derived from exports, such a situation continues to be advantageous for cassava.

Pricing and Market Efficiency

The Indonesian cassava economy represents in many ways the ideal development of the crop; that is, cassava is deployed within diverse and complex cropping systems across a range of agroclimatic conditions and is fully utilized in a broad spectrum of end uses. Such full exploitation of the production and utilization potential of the cassava crop relies fundamentally on well functioning markets and in particular on integrated markets in which prices serve to allocate cassava between the range of end uses. That is, farmers are receiving a price for their cassava roots that reflects its best end use in the country. Such a situation requires that cassava prices be linked spatially across the country and linked vertically across different forms. The development of such linkages for a highly perishable, bulky commodity is difficult and is dependent on the existence either of a highly developed transport, refrigerated storage and marketing system (eg. vegetables in the U.S.) or processing of the roots to a stable, storable commodity. Since the first does not exist in Indonesia, the role of gaplek can be singled out as crucial to well integrated cassava markets in the country.

Unnevehr (1984a), (1984b) has analyzed market integration and price transmission on Java and what follows is drawn directly from that research. The key to her analysis is the concept that "cassava prices within Java are set by domestic supplies of staple foodstuffs and demand for cassava products, subject to a lower bound set by export parity ... the local demand curve for cassava has two portions - a downward sloping domestic curve and a perfectly elastic export floor." (Unnevehr, 1984a). A demand curve was estimated to test for this "kink". When East Java prices were at export parity the correlation with world market prices was 0.95. Gaplek prices at the East Java port, Surabaya, in the 1971-79 period were at export parity 79% of the time. This demonstrates the effective operation of the price floor and the fact that the export market was a principal determinant of domestic prices throughout this
period. This is seen in Figure , charting world and Indonesian gaplek prices.

Effective price transmission and adequately linked markets implies relatively competitive price formation throughout the country. This, however, does not imply that all farmers face the same price since transport and marketing costs will differ radically depending on location relative to markets and the level of development of transport infrastruture. In fact marketing and transport costs make up a very significant portion of the wholesale or retail price for both fresh roots and gaplek. Assembly costs of fresh roots for starch plants and gaplek for pelleting plants are relatively high, compared to the eventual farm level price (Table). On Lampung assembly costs alone consume half of the factory price paid for roots and 40% of the price paid for gaplek. This significantly reduces price incentives for farmers, since the complete marketing margin (farmer to retail) for alternative crops is only around 30 to 40% (Table).

The effective operation of the export price floor under domestic cassava prices throughout Indonesia, Moreover, depends critically on spatial integration of the various cassava markets. Such integration relies on two components, first, integration between fresh root and gaplek prices and, second, between gaplek prices in different markets throughout the country. In terms of the linkage between fresh root and gaplek prices, variation in fresh root prices explained over 90 percent of the variation in gaplek prices in 7 of 19 markets on Java and over 80 percent of the variation in 18 of the 19 markets (Unnevehr, 1982).

Not only were gaplek and fresh root prices strongly linked but there was also a strong linkage of gaplek prices between markets across Java, and this linkage was principally due to the operation of the export price floor. Thus, when domestic prices were at export parity the correlation coefficient of gaplek prices in the 19 different markets was greater than or equal to 0.90 for 106 of 171 potential pairs. On the other hand, when domestic prices were above export parity, only prices in 27 pairs of markets were correlated at the level of 0.90 (Table). When domestic prices were at export parity, domestic price variation of gaplek was due almost completely to variation in the export price (Unnevehr, 1982), and since there was a generalized price linkage between markets and between roots and gaplek, the operation of an effective price floor was demonstrated for Java as a whole.

When domestic prices rose above export parity, price variation was much more influenced by regional supply and demand conditions for cassava. Moreover, internal transportation costs tended to lower the export floor for more remote markets, increasing the influence of local supply and demand conditions. Thus, the number of months the prices at 19 internal markets were at export parity varied from 32 to 70% of the time, all less than the 78% at Surabaya.

Nevertheless, what is remarkable is how often domestic prices have been at the price floor. In the period 1971 to 1979, monthly prices in major markets were at export parity between a third to four-fifths of the time. Production in this period grew at an annual rate of approximately 2.8%, at a time when population growth was 2.0% and income growth was 5.3%. Normal growth in food demand for cassava (assuming a combined income elasticity of 0.1) and the rapid growth in starch production, should have put some upward pressure on cassava prices. Moreover, never more than 15% of domestic production was exported and the figure was usually less than 10%. Surpluses, at export prices, thus, were never that large. Part of the reason is that there was a general upward trend in export prices.

However, the other major factor affecting cassava prices is the domestic price of rice and over this period the real price of rice fell substantially (Figure) due to the impact of improved rice technology and import policy. Timmer (1980) finds a cross-price elasticity between cassava and rice of 0.77, indicating significant decreases in cassava consumption for a decline in rice prices. During the period of rapid expansion in rice supplies the cassava export market served a critical function of providing an effective price floor and thus maintaining incomes of cassava farmers. As Indonesia exploits most of the yield gain possible from the rice technology, domestic rice prices and rice imports are again likely to become important policy issues. Cassava, because of this price linkage to rice, allows additional flexibility in meeting rice price policy objectives. In the future, improving cassava production may be a far less expensive means of maintaining rice prices than rice imports.

Any cost reductions in transport or scale economies in assembly will tend to favor cassava over other crops. On the other hand, to assembly costs must be added processing costs. Both the gaplek and starch processing industry has been found to be socially efficient (Nelson, 1982). Only about a quarter of the export parity price for both starch and pellets is consumed by processing costs (Table). The cassava processing industry is relatively dynamic and as well permits a significant degree of diversity. Labor intensive, household starch production co-exists with capital intensive, large scale factories. All are profitable, although government tax and capital credit policies tend to favor the large-scale plants, when the household units are socially more efficient and employ significantly more labor (Nelson, 1982).

Cassava marketing systems in Indonesia have evolved in response to transport infrastructure development and changes in market demand. There has been almost no intervention by government agencies apart from the tax credits for large scale processing plants and the import tax on starch. As the evidence suggests, cassava markets function very efficiently in Indonesia, given the constraints improved by infrastructure. There is not only little need for government involvement in cassava markets, but unlike rice, any such intervention in a commodity with multiple markets would be counter productive without a comprehensive policy and this would be difficult to attain. Unlike many other countries in Asia, Indonesian cassava markets reflect national supply and demand conditions with a buffer provided by the export market. Further development of cassava in Indonesia will be relatively easy given such a well functioning marketing system.

Conclusions

Growth in the Indonesia economy has been impressive over the decade of the 1970's, continuing through to 1982. GDP growth averaged 7.6% per annum in the 1970's and was above that mark in 1980 and 1981. These growth rates were well above the average for either industrial or developing countries. Only in 1982 did the economy start to be affected by the international economic recession and GDP growth fell to 2.3% rebourding to around 4% the following year. The decline in oil prices and demand for agricultural exports led to a significant decline in the foreign exchange reserve position, culminating in a devaluation of the rupiah in 1983 and 1986 and tighter controls on imports. Future growth in the Indonesian economy is highly dependent on what happends in the petroleum export market; nevertheless, the economy is projected to grow by 5% per year through the rest of the decade (World Bank, 1984).

Such significant growth in incomes have a market impact on food demand. Extimated annual per capita consumption of rice increased from 107 kg in 1970 to 145 kg in 1983. Fortunately, rapid demand growth corresponded with the rapid adoption of short stature rice technology and rice production almost doubled in this period, even with very minor change in the land area planted to rice. Nevertheless, Indonesia remained a major net importer of rice, importing as much as 2 million tons in 1980. Growth in production of rice is expected to slow somewhat through the end of the decade, as the growth rate in yields declines. However, Indonesia is expected to remain at or near self-sufficiency in rice while continuing to maintain some capacity to import when production deviates from trend (World Bank, 1984).

Indonesia has been relatively successful in attaining self-sufficiency in the production of basic foodstuffs and in maintaining relatively stable consumer prices, especially for rice. While the government has been successful in meeting two of its food policy objectives, impact on raising farmers incomes, the third principal food policy objective, has been less widespread. This is because the income generation from the new rice technologies was directed almost exclusively toward the irrigated sector. The benefits from the new rice technology have been inequitably distributed between regions and since the bulk of the population countinues to depend on agriculture for their income, coninued neglect of the upland areas will further increase these disparities.

Two principal concerns should govern policy toward the upland sector. The first is the relative priority between development of the upland areas on Java and those on the outer islands. Java accounts for 47% of Indonesia's GDP, 62% of the population and only 7% of the land area. The soils on Java are relatively fertile, transport infrastructure is relatively well developed, and very labor intensive production systems have evolved to suit the extremely small average farm size. On the outer islands, on the other hand, the soils tend to be infertile and highly acidic and infrastructure is not as highly developed. Land is relatively plentiful. The population distribution between Java and the outer islands creates, a situation where both land and labor resources are underutilized and the transmigration projects were established to remedy this imbalance. Between 1971 and 1980 approximately 2.1 million migrants resettled in the Outer Inslands, of which one million were resettled through the transmigration program. This program had a significant impact on agricultural employment. Of the 1.8 million increase in agricultural employment in this period, 1.4 million was off Java (World Bank, 1982). Certainly any increase in area planted to crops will have to come on the Outer Islands and the government is currently attempting through agricultural research estate development, and the transmigration projects to establish a base for future growth on the Outer Islands.

The second issue is the choice of crops, where technology can be expected to raise productivity and markets are suffciently expansive to absorb the increases in production, thereby leading to increases in farmer income. Certainly cassava must be considered as a principal choice for both Java and the Outer Islands. Maize is an alternative choice on Java and tree crops are an alternative on the Outer Islands. However, cassava could have the widest potential impact of these crops, given a higher committment of resources to support research on the crop.

As a crop development of the upland areas, cassava has several advantages. Most importantly the cassava marketing system in Indonesia is probably the best developed in Asia, with the possible exception of the larger but more specialized system in Thailand. Prices efficiently allocate cassava between regions, across different and uses, and over time. Moreover, and effective price floor is provided by the gaplek export market. Efficient markets together with the multiple and uses for cassava, particularly the high consumption of gaplek and fresh cassava by the poor, allows the introduction of improved production technology to achieve the dual policy objective of increasing farmers' incomes and improving calorie intake of the rural poor. Moreover, the rapidly growing starch market, with potential under current policies for the development of high fructose sweetners, provides scope for the absorption of significant increases in production, with any surpluses up to the EEC's 825 thousand ton quota restriction being exported.

Nevertheless, the very uncertain situation in the EC market for cassava pellets will continue to affect the Indonesian cassava economy, if not in lower import quotes when these are renegotected in 1986 then in the impact on world prices and the impact that lower world prices will have on Indonesia farmers. There is some opinion (World Bank, 1984) that Indonesia will be in a surplus position in both maize and cassava by the end of the decade, with little hope of absorbing these production increases in domestic markets. For cassava the report overlooked the large and dynamic starch market, but certainly any major productivity increases will probably result in internal prices remaining effectively tied to the export price with the accompanying need to maintain some flexibility in the export market.

Certainly there are trade-off in maintaining this price linkage to the EC market. The gains are in the social profits reaped by the high export prices; the costs are that cassava cannot compete with maize in certain domestic markets, especially the animal feed market. It remains to be seen whether these domestic surpluses of secondary carbohydrate sources develop and to a large degree the advent of such surpluses will depend on what happens in the rice sector. All in all there is no need to intervene in casssava markets until major breakthroughs are made on the technology front. At that point the maize and rice situation together with cassava production costs will dictate whether the cassava price should be aligned with the domestic and presumably world maize price. Until that time there are losses in the social profit for cassava if forced to compete in domestic maize markets.

Providing resources for cassava research is a medium to long term investment and more than anything else a dynamic cassava sector provides flexibility in Indonesia's food and agricultural policy. When rice yields start to plateau out at the end of the decade, cassava can add flexibility to price and import policy for rice. Moreover, the starch, high fructose sweetner, and, when necessary, the export markets can be a basis for expanding cassava on the outer islands, agricultural areas where a well adapted cash crop for smallholders has been difficult to identify. This type of flexibility will be key for balanced agricultural and industrial development in Indonesia's future.

MALAYSIA

The agricultural economy of Malaysia, like that of Thailand, has traditionally been export-oriented. Export growth has relied on the fact that Malaysia has always been a land surplus economy, and at several points in its history even had to rely on immigration of both Chinese and Indians to meet rising labor demand in agriculture and mining . Export orientation within a land surplus economy put a premium on the development of an effective land policy. In this aspect, Malaysia differed from Thailand in that the focus of land policy was on promoting large-scale, plantation agriculture, although land availability did not preclude the development of smallholder agriculture, both for the production of rice and export crops. A focus on plantation agriculture has remained a primary component of agricultural policy to the present.

Cassava was the first of the series of export crops that have spread across Malaysian agriculture. The establishment of the first tapioca factory in Malacca in the early 1850's coincided with the rapidly expanding use of commercial steamships. The evolution in sea transport together with the opening of the Suez Canal in 1869 opened European markets to other agricultural commodities than just high valued spices. The tapioca industry expanded rapidly and relied on cassava's particular advantages as a frontier crop. The forest was cleared to feed the steam engines of the plant, while cassava was planted in a shifting cultivation sytem characteristic of a land-surplus, labor-scarce economy. This production system, which ostensibly took place within a plantation-type land concession but where the land was abandoned to lalang when soil fertility declined to unprofitable levels, gave cassava the image of a soil-depleting crop, especially compared to the rapidly increasing tree crops. Although soil depletion was due more to the shifting cultivation system than to the crop itself, this image has remained upto the present, resulting in controls on cassava expansion through restrictions on land concessions and leases. The oscillations in the export market for tapioca and starch, land policy, and competition with export-oriented, tree crops have remained the key factors influencing the Malaysian cassava industry to the present.

Production Trends

Cassava production in Malaysia has never repeated the boom period of 1860-1890. In Malacca cassava area climbed from virtually nothing to around a peak of 30 thousand hectares in 1882. In the 1870's cassava area had also began to expand into neighboring Negri Sembilan, reaching its peak areas in the 1890's (Jackson, 1968). Area planted to cassava in this early period probably did not exceed 45 thousand hectares. The cassava industry fluctuated with the prices on the world market through to the turn of the century but then got caught in a squeeze between the rapidly expanding rubber industry in Malacca and the development of an export oriented cassava industry on Java. These trends were remarkably rapid. In 1906 there was 15 thousand hectares planted to rubber in the Straits Settlement Provinces (Malacca and Province Wellesley and Penang) versus 43 thousand hectares planted to cassava. In the same year Java exported a little over 6 thousand tons of cassava products. By 1913 rubber area had expanded to 64 thousand hectares in the Straits Settlements and Javanese exports had increased to over 90 thousand tons. Cassava area in the Straits

Settlements declined to only 6 thousand hectares (Greenstreet and Lambourne, 1933).

After this major structural shift, cassava area oscillated between 10 and 20 thousand hectares over the next 70 years till the present (Table 1). The other major element in this stagnation of the cassava industry was the restrictions on land concessiones and actual planting of cassava by many of the states. Thus, Negri Sembilan prohibited planting of cassava in 1912, Perak restricted plantings in 1909, and Selangor did the same in 1925. In Kedah in 1905 cassava was allowed only as a catch crop for tree crop establishment (Greenstreet and Lambourne, 1933). Thus, in the period between the two world wars, the cassava industry shifted to Johore, where there were no restrictions on cassava, and Kedah, where it was grown as a catch crop.

The shifting nature of the cassava industry continued, since following the Second World War, and especially after the 1958 Emergency, cassava rapidly shifted to Perak, which is the locus of the industry today. Nevertheless, land policy continued to play a dominate role in the organization of production. In particular, Aw-Yong and Mooi (1973) estimated that in the mid-1960's approximately 75% of the cassava in Perak was planted illegally on unalienated state land or forest, railway, or mining reserves. As a result, shifting cultivation remained the dominant production system for cassava.

Shifting cultivation systems and the uncertainty of access to land for cassava are possibly reflected in recent trends in production (Table). In cassava area there is significant variation around a relatively stable trend of 16 thousand hectares. Yields also are highly variable, ranging from 11 to 22 t/ha., with no necessary tendency for variation in area to compensate variation in yield. Production, as a result, is highly variable. However, this year-to-year variability is not reflected in the output of cassava products. Converting starch and chip production to fresh root equivalent, shows a consistent rise in root utilization through the early seventies and a decline from the 1976 peak over the latter part of the decade (Table). A comparison of the two series suggests much more stability in the utilization series and a consistent underestimation of utilization when using the production series. Given the large percentage of illegal plantings, the production series probably does not capture all the actual area planted to cassava. On balance there is probably much more stability underlying the Malaysian cassava industry than is reflected in production statistics; on the other hand, over the last half of the decade there has been a persistent, declining trend in cassava production.

Cassava Production Systems

Cassava's principal comparative advantage vis-a-vis other crops is its adaptation to relatively marginal agro-climatic conditions and therefore its exploitation of land with a low opportunity cost. Because there is no climatic constraints on crop production in Malaysia and tree crops are well adapted to a wide spectrum of tropical soils, cassava has no particular niche to exploit in the agricultural economy and must compete with tree crops for land. Thus, of the 25% of Malaysian land under cultivation, well over 80% is planted to the three principal tree crops, rubber, oil palm and coconut. Paddy land accounts for another 10%, leaving under 10%, for all other crops. Tree crops are by far the most profitable agricultural activities, and in fact, cassava is primarily grown in those areas where farmers do not have the option of planting oil palm or rubber. Land tenure primarily influences where and the type of production system that cassava is grown under in Malaysia.

The more minor area where cassava is cultivated is as a catch crop in the establishment of oil palm or rubber. This is done principally by smallholders, although some planting of cassava as a catch crop by tree crop estates has also been reported (Lulofs, 1970). The cassava is planted for 2 or 3 seasons as a source of income until the tree crop is established. However, this is not a widespread practice and is limited to those areas which have access to cassava processing plants.

The major portion of the cassava is grown in monoculture. This is in part due to the fact that a large portion of the crop is planted on land where the grower has no usufruct rights. Aw-Yong and Mooi (1973) in a study of cassava production in Perak in the mid 1960's found that over 70% of cassava area was planted illegally. Illegal planting of cassava is done on a much more extensive basis than legal cultivation (Table). Area planted is often done on a large-scale, sometimes exceeding 50 hectares. Where virgin jungle is cleared, all work is done by hand. However, with the rising costs of labor, areas covered with lalang which have the possibility of mechanized land preparation are now probably cultivated more generally than virgin forest. This early study reports that most illegal cultivation is done within a system of shifting agriculture, where the land is planted two or three time to cassava without application of fertilizer and then a new area is opened up and brought under production. Whether the rising labor costs of opening new land has caused even illegal planting to shift to a more permanent, cultivation system is only open to hypothesis, but certainly the incentives are increasingly to shift to more continuous cropping, even within an insecure tenure situation.

Legal production, on the other hand, is concentrated in the hands of smallholders. Area planted in casssava averages less than 2 hectares and cassava is usually only one of several crops cultivated. Even in this situation cassava is often grown on rented land or on state land with temporary occupational licences. That is, there is sufficient uncertainly in tenure not to plant tree crops. Also, cassava is often a component in the initial cropping system in those areas where farmers have recently been settled but have not yet invested in tree crops. Thus, even for the legal planting, cassava is only planted in that land where investment in tree crops is risky.

Nevertheless, production systems are much more stable. Rotational systems with other annual crops are often practiced along with application of fertilizer or manures. Over the last couple decades fertilization has apparently shifted from farmyard manure and woodash (Aw-Young and Mooi, 1973) to reliance on chemical fertilizers (Tunku Mahmud, 1979). Moreover, with the rising cost of labor farmers have as well moved to the application of herbicides in order to control weeds. Rising labor costs and the competition with tree crops for land have put a premium on achieving low costs of production per ton. More intensive production methods are now more economic than extensive production methods, as the emphasis has shifted to lower labor costs and higher yields. In effect, shifting production systems have become increasingly uneconomic in Malaysia, making cassava's reputation for soil impoverishment more of an historical red herring rather ever than a point of fact.

The other major production system for cassava is plantations. In the early stages of the cassava industry these systems had their impetus in the form of land concessions allocated by the state governments. However, root production operated on a basis of shifting agriculture and it was not till the advent of rubber at the turn of the century, that plantations based on permanent production systems were established. At this stage production of cassava on a large scale declined. However, in the post-war period more permanent cassava plantations have been established, usually under government sponsorship. The motivation for plantations is usually to assure regular supplies to relatively large-scale factories. However, the operations of large-scale, cassava plantations have not met with much success. Of four plantations that have been operating in the last decade, only one is still operating. High labor and overhead costs make plantation production much more costly than smallholder production within an industry that is highly competitive, both from other domestic factories and international competition from Thailand.

Yields

Cassava is grown purely as a commercial crop in Malaysia and moreover must compete with tree crops for both land and labor. Yields are therefore, a primary determinant of cassava's economic viability in the country's agricultural economy. Not surprisingly, average yields in Malaysia are high by world standards or even by comparison to other Asian countries. National production statistics suggest an average yield in the range of 11 to 22 t/ha. As has been suggested, the reliability of these estimates are open to question. Nevertheless, the few surveys of cassava producers that have been carried out do support the higher end of this range of yield estimates. Tunku Mahmud (1979) found an average yield of 28 t/ha in the Manong area of Perak. Rahman Binti Adam (1974) found an average yield of 18 t/ha in a survey of farmers in Pahang.

The point where these survey areas reside within the overall yield distribution for the country cannot be specified. Aw-Young and Mooi (1973) suggest in Perak a very broad yield variation of between 7 and over 40 t/ha base on differences in soil and production system, where the production system as well reflects principally variation in soil fertility (Table). Nevertheless, it was not possible to associate production weights with the different strata so that average yields could not be calculated. The fact that cassava is not grown in continuous production sytems, as in other parts of Asia, contributed to the high yields obtainable in Malaysia. Other factors are the favorable rainfall and growing season, the existence of relatively high yielding varieties, and the apparently wide use of fertilizer on cassava. However, defining the gap between average yields and the potential productivity of the crops remains uncertain due to lack of reliable data on cassava.

Costs of Production and Labor Utilization

Cassava is a highly commercialized crop in Malaysia. The crop is fully marketed, usually for industrial processing. Moreover, cash costs form a high percentage of total costs, because most labor is hired, land preparation is mechanized, and input use is relatively high. Cassava farmers are thus reponsive to changes in input or output prices and likely to adopt technical innovations. Production costs and root prices are therefore principal indicators of economic incentives that cassava producers face.

Technology development and the evolution of costs have reflected the relative scarcity of labor in the agricultural economy. Where possible land preparation is mechanized, and tractor services are provided by farmers cooperatives. Moreover, herbicides have assumed increased importance in cassava cultivation in order to reduce labor costs. Weeding and harvesting are usually done on a contract basis. With this tendency to reduce labor use as much as possible, labor input is relatively low. A survey in Perak (Tunku Mahmud, 1979) found an average labor use of 62 mandays/hectare (Table). Any further reductions will require the mechanization of the harvest.

Labor costs make up just less than half of total production costs for cassava. Malaysia provides a counter example to the normal tendency for labor to make up the major portion of total production costs in cassava. Moreover, weeding is one of the more minor costs items, again running contray to normal patterns. Land preparation, fertilizer costs, and harvesting all are usually larger cost items (Table). The tendency toward labor substitution is clear in the cost structure; however, the scarcity of land forced both by government land policy and by high opportunity costs has also put a premium on yield per hectare, as is reflected in the high costs for fertilizer.

High yields, low labor input, and moderate input use, which is often subsisdized by the farmer cooperatives, result in a very low variable cost of production per ton of roots, comparable to that of Thailand. However, farm-level prices of roots are normally higher in Malaysia than in Thailand. This is principally due to the high opportunity cost of land. The annual net income for rubber was M$3651 (at a rubber price of M$2.40/kg) and for oil palm was M$5030 (at an oil price of M$1200/ton) (Tunku Manour and St. Clair-George, 1979). This compares to an average net income for cassava in Perak of M$979 (at a root price of M$74/tons) (Tunku Mahmud, 1979). High supply prices for cassava in Malaysia reflect the profitability of alternative crops, which has provided some impetus to the search for higher yields and lower production costs but is primarily reflected in the utilization of land with a relatively low opportunity cost.

Technology Development

Research of a rather sporadic nature has been carried out on cassava since at least the 1920's. The focus of this research was principally oriented to evaluation and characterization of imported clones and to appropriate fertilization of the crop. In the 1970's a cassava research program was established within the Malaysian Agriultural Research and Development Institute (MARDI). Cassava research broadened in scope at MARDI but continued to maintain traditional lines of emphasis. Germplasm evaluation was expanded to include a major crossing and selection program. The principal breeding objectives were high yield and and high starch content of roots, reflecting the demands made by the starch and chip markets. Agronomic research continued the long tradition of focusing on plant nutrition and maintenance of soil fertility. Long-term fertility trials and evaluation of nutritional requirements of cassava grown on peat soils became principal lines of investigation. The few diseases of any potential significance were incorporated into the program as secondary screening objectives.

Little direct impact of this research is yet visible on cassava yields. Fertilizer and herbicide use by farmers has signfiicantly increased but this is due as much to subsidies on these inputs as to the research that has been carried out. Breeding, on the other hand, is a longer term investment, and while some lines have been identified which give superior yields to the dominant variety, Black Twig, none of these as yet has been released as a new variety. Emphasis on increasing yields is a well justified strategy under Malaysian conditions, given the need to achieve higher returns to land. A complementary strategy, on which there has been some research, is to direct technology to low opportunity cost land areas. Peat soils have been one area where there has been some research. The other area is as a catch crop in the establishment of tree crops. Little research exists on competitive interactions between these two crops in association and the means to minimize them. Certainly shade tolerance will be a principal issue in such research.

Markets and Demand

A synthesis of production and utilization

Collection of accurate production statistics for cassava in Malaysia is hampered by the illegal nature of a significant percentage of the area planted to the crop. In consequence a suspected downward bias exists in estimates of area and production. However, since basically all the crop is sold for processing and data are collected on production of cassava starch and chips , an alternative production series can he constructed (Table). The utilization series in fact is consistently higher than the root production series. Since the downward bias in the production series can be identified, there is sufficient reason to suggest that the utilization series gives a much more accurate picture of cassava production trends in Malaysia.

The two series offer quite contrasting views of trends in cassava production. The series developed by the extension department shows little trend and very substantial variability. On the other hand, the utilization series displays a steady increase in the first half of the 1970's to a peak of almost 450 thousand tons of roots in 1976. Production then declined to about 300 thousand tons in 1980, where it has remained through 1983. The latter series, as will be shown in the following sections, explains very well trends in exports and prices. The utilization series will therefore be used as the best esimate of cassava production in Malaysia.

The Domestic and Export Market for Starch

Starch has always dominated the cassava economy of Malaysia, especially since cassava has never been a food source in the country, except among some of the tribial groups. Moreover, starch production has traditionally been overted toward export, in line with most of the rest of the agricultural economy. Finally, the history of the starch industry in

Malaysia has been one of constant movement in search of areas where cassava roots could be produced most cheaply, i.e. where competition with tree crops was least or where illegal land use was not rigidly enforced. In the post-war period the starch industry settled in Perak and the following analysis will focus on starch production in that state.

Only two starch factories existed in Perak prior to 1945. By 1968, 19 plants were operating in the state, with most of the growth coming in the 1950's, when 10 factories were set up (Table). At this point starch production depended primarily on the sedimentation method, as only two plants were using centrifuges. Production from these latter plants was higher than for the sedimentation plants (Table), even though the centrifugal plants were only operating at 30% capacity. Also, the centrifugal plants obtained an extraction rate of between 20 to 23% while the sedimentation plants averaged between 13 to 18% (Onn and Yet, 1971). With continuing problems with root supply and increasing competition from Thailand, it is not surprizing that a shake-out of the industry would occur in so competitive an environment. Thus, by 1982 only eight starch factories were operating in Perak (Table).

What is clear, however, is that this shake-out did not occur until the late 1970's. Prior to that -- and contrary to the root production statistics -- the starch industry showed steady growth in the post-war period. Starch exports increased steadily through the 1950's and 1960's and peaked in 1976 (Table). The shorter series on starch production complements these export trends and suggests that total starch production also peaked in 1976 at 68 thosand tons. Production declined from that level and has been stable at about 50 thousand tons through the 1980's. Exports, however, declined much more dramatically and Malaysia became a net importer of starch in 1981. Two factors were responsible for this reversal: rapidly increasing doemstic consumption and increased price competition from Thailand.

Domestic starch consumption in Malaysia increased very rapidly during the 1970's, rising from less than 20 thousand tons in 1971 -- Onn and Yet (1971) estimate domestic consumption at 16.3 thousand tons in 1967 to about 50 thousand tons by the end of the decade. Major users of cassava starch are monosodium glutamate and glucose producers and the textile industry. As industrialization proceeds in Malaysia starch demand is certain to continue to increase. Particularly, any future developments in either the plywood or paper industry should lead to signficant increases in consumption.

A market with signficant potential is the sweetner market. This market has expanded rapidly in Japan and Taiwan, while Indonesia is currently starting a sweetner industry. Malaysia imports about 85% of its consumption requirements of sugar, even though domestic sugar prices are maintained at levels well above world market prices in order to cover Malaysia costs of production. Sugar imports of tons in 1984 and a protected domestic sugar market offer scope for the development of a high fructuose sweetner industry based on cassava starch. Moreover, development of this industry requires relatively moderate investment, since present starch processing factories can form the basis for an integrated starch-sweetner operation. However, domestic starch production is the limiting factor in the development of this industry.

The other factor influencing recent production and export trends is increasing price competition from Thailand. This price competition is amply portrayed in Figure . Before 1976 wholesale starch prices in Ipoh, Perak were well below Thai wholesale prices. This coincided with the period of expanding starch production in Malaysia. From 1976 to 1981, Malaysia starch prices in Perak were more or less on a par with Bangkok wholesale prices. During this period, Malaysia lost export markets even though prices in general were rising. In 1981 Malaysian starch become more expensive than Thai starch and Malaysia become a net importer of starch. The situation was compounded by a falling price level. Thus, after two decades of growth, the Malaysia starch industry stagnated, caught between the high supply price for roots and the prices of imported Thai starch. For Malaysia to remain competitive in starch would require further cost reductions in the production of cassava roots.

PHILIPPINES

Like Indonesia, the Philippines is a multi-island economy; yet, unlike Indonesia, the Philippines has major population concentrations on all the major islands, although Luzon still figures as the economic center. The agricultural economy is dominated by two grains, rice and maize, and two principal export crops, coconut and sugarcane. Grain and food production in general are concentrated in the small farm sector while the export crops tend to be dominated by plantation systems, although smallholder production of copra is also important. The Philippines has an apparent comparative advantage in the production of copra and is by far the dominant exporter of this product. This agricultural structure has created something of a dual approach to policy. The export crops have to a large extent been left to the plantation companies in the private sector. There has not been, until very recently, much government involvement in either research, exports or pricing in these crops.

In the food sector, on the other hand, the situation has been just the reverse. Three themes run through agricultural policy for grains: a commitment to self-sufficiency in grain production apart from wheat, very heavy intervention in setting domestic prices, and an apparent commitment to increasing productivity in the smallholder sector. The achievement of self-sufficiency is seen as being dependent on price policy and small farm programs. Control over domestic prices is in the hands of the National Food Authority (NFA), which has authority to control imports and exports, to buy in the domestic market, and to set both support prices and ceiling prices. Trade in foodgrains and domestic prices are to a large extent administratively determined. Policy toward the small farm sector has included land reform, investment in irrigation infrastructure, and specialized credit and extension schemes.

The stage was thus appropriately set for the advent of the high yielding rice varieties. Under the Masagana 99 Program the Philippines went from a consistent net importer to a net exporter of rice in the mid-1970's. This success has led to the recent development of the Maisan 99 Program, which hopes to achieve self-sufficiency in maize in three years. Concern also runs to the large and growing wheat imports and identifying means of either controlling such imports or substituting for wheat flour.

Cassava fits well into this policy context. The crop is essentially grown by smallholders, although some plantation production does exist. Moreover, cassava can be a domestically-produced substitute for imported grains. This concern for self-sufficiency has even extended to the development of a national alcohol program based on sugarcane and cassava; however, with the recent fall in world oil prices the program has been scrapped. Nevertheless, cassava is seen as a crop that can contribute to meeting the increasing demand for carbohydrate sources. Since cassava is only a very minor crop in the Philippines and since the crop has received little government support, the question to be pursued is what difference government involvement can make in developing cassava as a commercial crop in the Philippines.

Production

Production trends and distribution:

The official production series for cassava in the Philippines is presented in Table 1. The series shows relatively stable area, production and yields from 1960 to 1974, followed by very dramatic increases in both area and yields. Such increases led to more than a tripling in production in three years and to over a quadrupling in five years. This remarkable growth immediately begs the questions of what was responsible for this sudden take-off.

An analysis of such rapid growth in production first turns to the impact on utilization patterns and market prices. As is discussed in the section on markets and demand, there is no corroborating evidence on either consumption or price levels to suggest that such production increases took place. On the other hand, alternative estimates of area and yield are limited. The agricultural census of 1971 estimated cassava area at 47,061 hectares, yields of 5.75 t/ha, and production of 270,714 tons. Even at this stage there were major discrepancies between the census estimate and the Bureau of Agricultural Economics (BAE) estimate. The major difference between the two production estimates is due to the reported area figures; the yield estimates are similar at this date. This discrepancy with the census figure raises some doubt about the adequacy of the sampling and estimation techniques for cassava estimates. This is not surprising given that cassava is such a minor crop in the Philippines.

The only data which correspond to the BAE's estimate of increasing yields from 1976 to 1979 is the Special Study Division's survey of 901 cassava farmers in the period 1977-79. Average yields for this non-random sample were 4.3 t/ha; however, this average was biased downward somewhat because the major growing area of Central Mindinao was not included in the survey. However, even this would not raise yields to the BAE estimate of 11.7 t/ha.

A regional breakdown of production and area provides insight into the regional locus of this supposed growth in cassava production (Table 2). Cassava is produced throughout the Philippines but most is produced in the southern islands. There is little production on Luzon, apart from the Bicol region lying at the southern tip of the island. The major producing areas are the Visayas region and Mindinao. The production data suggest that cassava production increased at an annual rate of 20.4% on the island of Mindinao in the period 1970-81, while increasing in the rest of Philippines at a 9.6% annual rate.

Mindinao accounted for 78% of the increase in cassava production in the period. The years 1975 and 1976 are particularly striking. Production in 1975 was 134 thousand tons and in 1976, 656 thousand tons. This increase almost doubled national production. In a single year area increased from 20 to 44 thousand hectares and yields from 6.8 to 14.8 t/ha. In just the Central Mindinao region production increased from 14 thousand tons in 1975 to 1.1 million tons in 1979. These data suggest either explosive structural change in cassava production on Mindinao or a major revision of the data. The starch industry, based on plantation systems, is concentrated on Mindinao but the data on cassava starch production suggest no major changes in the industry in 1975-1980. Thus, it appears that this major increase in cassava production in the last half of the 1970's was in major part artefact. Independent comparison of production data with the utilization data is left till the discussion of markets and demand.

Cassava production systems:

Cassava in the Philippines is grown in both plantation and smallholder production systems. There are few estimates of the percentage of cassava grown in these two systems. However, plantation systems are associated only with starch mills, and at least three factories on Mindinao and one in Eastern Visayas operate estates. As much as 6,500 hectares may be grown in plantation systems. This would imply that the greater portion of cassava is grown by smallholders. These systems will be considered in most detail.

Cassava, while it is grown throughout the Philippines, has never achieved the status of a major commercial crop, even on a regional basis. Maize is the most prominent upland crop for smallholders. The reason for this follows principally from the relatively favorable agro-climatic conditions that exist throughout the Philippines and the relatively universal distribution of paddy lands across the different regions. A short maturity crop which produces relatively consistent yields under upland conditions fits better than a long maturity crop in smallholder systems, where rice production requires substantial resources during critical periods of the year.

In general shortage of rainfall is not a limiting factor in cassava production nor for the production of other upland crops. Because of cassava's better adaptation to poorer soils, cassava is often found on the more infertile hillside areas. Cassava is planted throughout the year and the only constraint on planting time is conflict with rice production activities. Such constraints are accentuated because very little hired labor is used in cassava production. In the Special Studies Division (SSD) survey about 75% of labor use in cassava comes from family labor (Table 3).

Cassava producers, according to the SSD survey, operate farms of a little over 3 hectares, of which only .6 of a hectare is devoted to cassava. Rarely are plots of over 2 hectares planted and of the 916 farmers in this survey, only about 40% actually owned their land. Yet even on cassava producing farms, only about 11% of total cash income was derived from cassava. Other crop sales accounted for far more income than cassava, even though over 80% of the cassava that was produced was sold. Cassava was thus grown as a minor cash crop by essentially small-scale producers on land not typically suited for other crops.

Land is typically prepared by animal traction, although some small plots may be prepared by hand. Because of the relatively high rainfall the land is either furrowed prior to planting or ridging is done at the time of the first weeding, usually by interrow animal cultivation. Ridging is apparently necessary to control root rot as the crop matures. This type of weeding limits any type of intercropping, and cassava is usually found planted in monoculture.

Although a substantial range of varieties are found in the Philippines --the SSD survey found 22 different varieties--, about half the farmers in the survey grew a variety named "white", while two-thirds of farmers grew either "white" or "yellow" (Table 4). These varieties are apparently selected for their good eating quality.

The one peculiar feature of cassava production systems in the Philippines is the very low labor input devoted to weeding (Table 5). This partly reflects the use of animal cultivation but animals can be used at most twice for weeding and are often ineffective at controlling weeds within the rows. Moreover, weed control would be expected to be a problem under such relatively high rainfall conditions. Low labor input for weeding thus reflects other factors, including the reliance on family labor, competition with other crops for labor resources, and the relatively low commercial status of cassava.

This same phenomenon applies to other input use. In the survey only 18 of 916 farmers or 2 percent used fertilizer on their cassava plots. For those farmers who did apply fertilizer the average application rate was about 125 kg/ha of chemical fertilizers. For smallholder cassava production cash expenses were kept to very low levels, which may reflect the risky nature of marketing the crop.

The riskiness is as well reflected in harvesting patterns. Cassava in general in the Philippines can be harvested anytime after six or seven months. Farmers in general harvest in small lots, partly for home consumption but principally as a means of insuring disposal at a remunerative price in the market. Substantial labor is as well expended on trimming, cleaning and packing the roots for sale. At least one study has shown that there is no loss in yield when harvesting in small lots between 6 and 9 months as compared to a single harvest at nine months (Villamajor, 1980).

Cassava plantation systems in the Philippines are normally in the range of one to 1.5 thousand hectares in size. Planting and harvest are staggered to provide a continuous supply of cassava to the starch factories. This production is as well supplemented by purchases from smallholders. However, in such large estates it has been difficult to achieve any significant economies of scale in cassava production. The only significant changes are that land preparation is done by tractor rather than by animal traction and that herbicides are used in weed control. The rest of the operations are performed by hand labor, usually on a piece rate by farmers contracted in the area. A 1978 survey of starch plants suggested that the higher overhead costs resulted in substantially higher own production costs as compared to purchased prices from local farmers - 249 pesos/t versus 174 pesos/t (Villanueva and Laguna, 1979).

Yields:

Compared to standards elsewhere in Asia, cassava yields in the Philippines are low, even though agro-climatic conditions are in general more favorable. The 1977-79 survey of 916 smallholder found an average yield of 4.02 t/ha (Table), a figure comparable to the pre-1975 BAE estimates of around 5 t/ha. There was some variation in yields between regions but in general yields were uniformly low throughout the Philippines. The immediate question is why, especially if agro-climatic constraints (except for soils) are not an issue.

Since the Philippines has had no cassava research program until just recently, a potential cause of low yields may be the lack of well adapted, high yielding varieties. The principal evidence that may be brought to bear on this hypothesis is that the first varietal releases by the Institute of Plant Breeding (Lakan 1 and Data 1) were selections that went by the more common names of golden yellow and Hawaii 5. These varieties were already being grown by farmers (Table 4), and yet the yield trials prior to release of these varieties gave an average yield of 42 t/ha for Datu 1 and 32 t/ha for Lakan 1.

Lack of adequate cultural practices thus appears to be the principal constraint on yields. Two principal factors appear to be involved: lack of appropriate soil fertility management and insufficient weed control. As in other parts of Asia (except India) diseases and pests do not appear to be a major problem in cassava, apart from the occasional incidence of cassava bacterial blight. One other possible limiting factor is lodging, given the frequency of high winds in the Philippines. Of these factors the very limited labor input in weed control is probably the major constraint on higher yields. Overcoming this constraint requires a closer study of labor utilization on the farm and the value of the production gain from further labor inputs in weeding of cassava.

Yields on plantations are considered to be substantially higher, although there are practically no published reports of yield levels on estates. One estate on Mindinao reports average yields of 18 t/ha (field notes, 1982). There is continuous planting of cassava on this estate and apparently there has been problems in maintaining yield levels. Yields on newly opened land without fertilizer averaged about 30 t/ha. Yields have declined from this level and stabilized around the 18 t/ha average, while at the same time fertilizer application increased from zero to 400 kg and finally to 600 kg/ha. On another estate in Eastern Visayas the maximum yield obtained in large fields was 29 t/ha on former rice land without fertilizer application (field notes, 1982). On this same estate as a whole average yields are in the neighborhood of 20 t/ha, with the flat, former sugarcane land averaging 25 t/ha and the hilly areas averaging 10-15 t/ha.

Cost of production and labor utilization

If cultural practices are a principal constraint on yields, this should be reflected in low rates of labor utilization. Labor input, in fact, is very low (Table 5), even by Thai standards where land preparation is performed by tractor. At an average of 53 mandays/ha the cassava plots can only be quite extensively managed, unless purchased inputs that substitute for labor are used, and this is not the case. The extensive nature of cassava cultivation is particularly reflected in labor expenditure for weeding. In more usual labor profiles for cassava, weeding usually forms the largest single activity. In the Philippines most of the labor is utilized in land preparation and planting and secondly in harvesting and marketing. Little labor is expended on maintenance of the cassava crop.

The impression is that resources with a low opportunity cost are principally employed in cassava, family labor and animal power in the slack seasons and either marginal land or "excess" land which cannot be planted to more labor intensive crops given the stock of family labor. Scarce resources such as capital are used only when absolutely necessary. Cassava is able to yield under such extensive conditions, although not at high levels. If this is so, then the costs of production derived by the SSD may be overestimated since family labor and land were costed at average market prices.

Just less than 80% of variable production costs is made up by labor charges (Table 6); of the wage bill 70% in imputed to family labor. The rest of variable costs are principally delivery and transport charges and, for the 19% of farmers who were share tenants, the payment in kind to landlords. The other principal cost is the interest charged against fixed assets devoted to cassava. In the SSD study land was not costed at its rental value but rather as an interest payment (12%) on its value. This interest charge to land forms the other major cost component. For per hectare production costs there is a certain stability in total cost across the different regions.

What is substantially more variable between regions is yield levels, and this results in a substantial variability in per ton production costs from 160 pesos/t in Western Mindinao to 338 pesos/t in Bicol. In fact, four of the nine region were producing cassava at a higher production cost per ton than farmers were receiving as a market price (Table 6). However, in all cases except region VIII cash income was greater than cash expenses. Costing indigenous farm resources at their opportunity cost could make cassava profitable in these other regions as well. However, what is striking is that farm-level prices to a substantial degree reflected production costs and that profit or loss depended critically on yield level. A yield less than 3.5 t/ha was just not remunerative, at least when costed at market prices.

Technology development:

Designing appropriate technology for cassava in the Philippines will be no easy task, since the process is dependent on answers to several unknowns. The basic question is why cassava is grown in such extensive production systems when the average farm size of cassava producers in just over 3 hectares. If cultural practices are the principal constraint on yields, modifying cultural practices is going to require either providing farmers with further incentives to grow cassava (either higher prices or more assured markets) and/or relieving what may be significant resource constraints within the farm. Answer to these questions can only come from a more extensive study of cassava within the complete farm system. Moreover, although cassava is clearly a commercial crop in these systems, what is not clear is the type of market toward which increased production can be directed. The two issues of farming systems and markets together define the appropriate design parameters for the development of improved technology.

There had been little research on cassava in the Philippines until the formation in 1977 of the Philippines Root Crop Research and Training Center

(PRCRTC). The center is located on the campus of the Visayas State College of Agriculture and besides a staff of 15 researchers, the center draws on the staff of the College to assist on research projects. Besides cassava the center does research on sweet potatoes, yam, and taro. There is no cassava program as such, since the different disciplines divide their time between the different root crops, except for a breeder whose sole responsibility is cassava breeding. Research on cassava extends from breeding through crop protection and management to post-harvest utilization.

The center in its few years of operation has principally been involved in defining research strategy and research priorities between root crops. Research by each discipline is defined on a project basis, which can be influenced by outside funding, especially the funding from the Philippine Council for Agriculture and Resources Research (PCARR). Policy development can have a marked influence on research direction, such as was the case with the abortive alcohol program.

The center still is in the process of completing the development of a fully structured breeding, selection and varietal testing program. A germplasm bank has been assembled and evaluated and at least three selections have been suggested as recommended varieties for release (Radix, 1980). A crossing and selection program has been started. The breeding focus is on higher yield, with starch content being a secondary objective. This program is complemented by some cassava breeding which is done at the Institute of Plant Breeding at the University of the Philippines at Los Baños. A varietal testing system is in the process of being structured with the input of PRCRTC, IPB-UPLB, and the Bureau of Plant Industry. Trials will be carried out on six different experimental stations.

Definition of the potential yield gap that may be exploited remains as yet relatively undefined. The yield data on the first three selections released by PRCRTC (two are already grown by farmers) show the almost traditional yield of promising varieties under experimental conditions of over 40 t/ha (Table 7). Defining what potential yield levels are at the farm level is more difficult, as well as the even more critical question of how to increase farm-level yields within farmer resource availabilities. What probably can be said is that a target of 15 t/ha is realistic, which for the Philippines amounts to a tripling in average yields.

Markets and Demand

A synthesis of production and utilization:
The BAE cassava production series raises several questions about the accuracy of the estimates, particularly when they are compared to alternative production or yield estimates. The other test of the production series is a comparison with data on utilization of cassava. Two studies have attempted to reconcile production and consumption data for cassava. M. E. Constantino (1979) compiled known estimates of cassava consumption and found that between 1971 to 1976 these consumption estimates accounted for between only 50 to 80% of estimated supply (Table 8). The total consumption estimate of 252 thousand tons in 1971 compares favorably with the agricultural census estimate of 271 thousand tons. She reconciled

the two series by accepting the production series and assuming human consumption as the residual. Per capita consumption thus increased dramatically. This, however, is not supported by SSD estimates for human consumption of cassava.

The Policy Analysis Staff in the Ministry of Agriculture adopted a different tactic. Area estimates were assumed reliable and yields were re-estimated based on long-term trends (Table 9). Per capita consumption figures were estimated on the basis of a consumption function. The production series, human consumption series, and starch series were then put together and feed use was estimated as a residual. The results shows rapidly rising feed use of cassava in the period 1975-81. There are no other corroborating data that feeding of cassava on-farm has increased dramatically nor that major increases in the use of dried cassava in concentrates has occurred.

There is thus no corroborating evidence for the BAE's rapid rise in production since 1975. Real farm level prices in the period 1975-80 were very stable, and they were only slightly lower than during the first half of the decade. All things considered, it is probably best to base the production estimate on known consumption data. This is attempted by region (Table 10). These regional consumption estimates assume no inter-regional trade in fresh roots. Given the bulkiness and perishability of cassava roots, this is a reasonable assumption. The SSD production and marketing survey, in fact, found very little inter-regional trade, except on Luzon where there was movement of cassava from regions I, III and IV to Manila.

In the development of the consumption estimates several assumptions were made concerning wastage, on-farm feeding of cassava, and production of chips. Waste was assumed to be a straight 15% of total consumption. On-farm animal feeding followed in part from the results of the SSD survey, which found that about 5% of production was used in on-farm feeding and that this occurred essentially off-Luzon. It was assumed that 10% of small-holder production in Mindinao and Visayas was fed to swine on farms. Production of dried chips was more difficult, since there is essentially no data on this consumption form. The SSD survey found production of cassava chips in only Central Visayas and Western and Northern Mindinao. These areas were in general areas without access to a starch plant and with ready access to either Cebu City or Cagayan de Oro, cities where either flour or concentrate mills are located. Chip production in these three regions was assumed to be 25% of total small-farm production.

The regional utilization estimates more or less follow the regional distribution of production as presented in the 1975 BAE production statistics, except for the Bicol region in southern Luzon. Up to 1976 the Bicol region was always represented in the production statistics as the major producing region in the Philippines. Yet, on the consumption side there is no evidence to suggest what this production is utilized for, although there is occasional mention of chip production in Bicol. This region remains something of a question mark as far as cassava production and utilization are concerned.

The utilization estimate suggest that cassava is grown throughout the Philippines but that production is larger in the southern islands than on

Luzon. For most regions there is little alternative to the fresh market for human consumption. Generally where production is larger there is access to alternative markets, and the analysis now turns to a closer look at cassava markets.

Cassava for direct human consumption:

Where cassava is consumed as a food source in tropical Asia, it is usually in areas where there is a "shortfall" in rice availabilities, either because of limited purchasing power and/or insufficient production levels. Cassava has not been incorporated as a major component in the Philippine diet because rice production is in general relatively evenly distributed throughout the islands, and in regions where rice supplies are short, grain supplies are supplemented by maize (Table 11). Moreover, consumption of wheat products has steadily increased in the post-war period and has reached quite significant levels in urban areas.

Root crops are generally of minor importance in the diet, and cassava, in fact, is less important than sweet potatoes as a food source. At an average annual consumption of around 4 kg/capita, cassava is consumed more as a vegetable crop then as a basic staple. Cassava can go through quite elaborate processing in the home and often the fresh root is milled fresh and used to produce a type of cake. In the larger cassava consuming areas in Visayas and Mindinao, there is a certain seasonality to consumption, quite directly related to price changes (Table 12). On Mindinao cassava consumption is usually highest in the third quarter of the year and on Visayas in the first quarter. In both areas prices reach their seasonal low in these periods.

Nevertheless, low per capita consumption levels and cassava's role as a vegetable crop often implies a certain elasticity in demand. However, the limited available data suggest that per capita consumption declines with income and that over time cassava consumption has also declined (Table 13). In the best of circumstances it is difficult to build a relatively expansive production base purely dependent on the fresh food market. Given the long history of cassava in the Philippines, it is highly unlikely that cassava will ever develop as a major staple. In part this was because agroclimatic conditions were not poor enough to favor cassava in any part of the Philippines; maize could always be grown as a secondary staple to rice. Developing cassava as a major commercial crop will thus depend on the development of other alternative markets for cassava.

The starch market:

The principal existing alternative market for cassava in the Philippines is for starch production. Cassava starch production through the last decade has been stagnant (Table 14). At the same time net imports of cassava starch, while never large, have declined to relatively insignificant levels. Viewed in isolation these trends would appear to imply a relatively stagnant market for starch; yet while cassava starch production has been stationary, maize starch production has been increasing at a relatively rapid pace (Figure 1), indicating quite substantial growth in total starch demand. The issue then is why cassava starch has lost a significant market share to maize starch.

The major part of the cassava starch industry is located on Mindinao, together with part of the maize starch industry. The industry is by nature large-scale and in 1978 consisted of seven plants with a combined annual capacity of 90.2 thousand tons of starch [1]. In 1981 an additional plant with a capacity of 11.3 thousand tons came into operation. What is clear is that the industry is operating well below capacity and in large-scale processing plants this is bound to profoundly affect returns on capital investment.

The cassava starch industry must operate within two major constraints. First, the price of cassava starch is currently set by the price of maize starch and this price is largely determined by the price of the raw material and, to a lesser extent, the prices of the relatively high-valued by-products of maize wet milling. Second, the industry is constrained by the availability of cassava roots. As is not the case with maize, the cassava processing plants must rely on a continuous harvest of roots rather than on stored supplies or imports. At least for the starch industry there appears to be a distinct seasonality to cassava supplies. Table 15 shows the monthly production of five of the seven starch mills operating in 1978. Only two of the five plants could operate the year round and for these two plants production in the first part of the year was about half of the production in the latter part. This coincides to a large extend with the seasonality in the human consumption of fresh roots.

The rationale of plantation production is to plan supplies in relation to processing needs. Ironically, the two plants which remained closed for the longest period during the year were exactly those which relied principally on their own production from their estates. The other plants relied to a large extent on purchases of smallholder production (Table 16). Moreover, according to the companies' own estimates, it was cheaper to buy cassava from smallholders than to produce the roots in estates. Without further efforts at mechanizing cassava production, the evidence suggests that it is very difficult to achieve economies of scale in cassava production, even with such a large yield margin between smallholder and estate production in the Philippines.

Another factor which may contribute to the seasonal undercapacity in operation of cassava starch plants is an apparent price squeeze due to seasonality in maize prices. Cassava starch prices tend to be lowest in the first half of the year rather than in the peak processing period during the second half of the year. The mills appear to be caught in a squeeze between high root prices and low maize, and therefore maize starch, prices. The squeeze between input and output prices and the limited root availability in the first half of the year put severe constraints on the ability of the industry to operate at full capacity.

Even for large-scale plants the costs of producing cassava starch depends principally on the cost of the root. Fuel is another large cost

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1/ There is reported cases of household production of cassava starch. There are no data to suggest how large such production is but it is assumed to be minor.

component in large-scale plants. As can be seen in Table 17, the costs of production are not substantially different from the selling price. Small changes in the root purchase price would thus substantially affect the profitability of cassava starch production.

As in most countries, the market for starch is not understood in any detail. One survey of 64 industrial users showed a relatively broad use in both food and industrial uses (Table 18). If the total cassava starch production figures are correct, this sample would appear to account for about one-third of total consumption. The use of cassava starch in monosodium glutamate production used to be a substantial part of end demand. About 1972 m.s. producers invested in new equipment which utilized the cheaper molasses as the raw material, eliminating most of this demand for cassava starch. Constantino (1979) also estimates that about 30 to 35% of cassava starch goes into the manufacture of tapioca pearl.

The potential growth in the starch market has not been studied. The consensus in the cassava starch industry is that demand is currently not a major constraint. This is not reflected in imports, but low import levels can mostly be attributed to a 70% ad valorem duty. Three additional cassava plants with a total annual capacity of 90,000 tons of starch are either under construction or in the advanced planning stage. This would appear to indicate an expected continued growth in demand for cassava starch. Yet, such investments seem somewhat superfluous in an industry that is only operating at 30 to 40% capacity.

Data available on the starch industry would thus seem to raise more questions than they answer, and, moreover, they produce a quandary as to planning the future direction of cassava development. That is, the first constraint on the expansion of the cassava starch industry is the limited capacity to produce sufficient cassava roots at a competitive price. Indications are that smallholder production is both a more economical as well as socially preferable means of increasing cassava production. Yet the nagging question remains that if smallholder productivity and production are increased, is starch demand sufficient to absorb major increments in production? Clearly, the export market will not be an option for surplus starch production.

The starch processing capacity that is now in place represents about double current national production of cassava roots. Since cassava plants will now be distributed through most regions in the Philippines, the starch industry could provide the basis for major expansion in cassava production, given an increment in farm productivity. The starch industry thus provides an initial base on which to develop cassava production [2]/. However, this

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[2]/ Planning is critical to these large-scale plants. The farmers in the Bohol region were contracted to supply a new, 60,000 ton plant on that island. For such a large plant production was increased by a major increment over previous levels. The plant did not open as projected and farmers had to chip their production and sell at prices which were less than half of the previous year's level. The plant's ability to contract for the next few year's production has now been badly compromised.

market does not provide the certainty for major expansion in cassava production, nor, since large-scale plants are the rule, does every farmer have access to this market. Analysis of other market alternatives would thus appear warranted.

The dried chip market:

Gaplek-type, dried chips are produced in the Philippines but production has never been large enough or sufficiently continuous to allow the development of a broad-based market. Chip production is based in the Visayas and Mindinao areas and principally serves as a means of venting fresh root surpluses where there are constraints on access to fresh markets. Prices tend to be cheaper than their fresh root equivalent and chips are absorbed as cheap substitutes in industries such as feed concentrates, starch (for making glucose), and flour (for noddles and non-leavened bakery products). In general, prices are too low at current yields to provide incentives for increases in chip production. Currently, chips are the market of last resort for roots that need to be harvested or once harvested, have no ready market. Producing roots just for the chip market, however, does not cover total costs of root production.

However, the question is what would be the potential market for cassava chips if root yields were increased? Development of a broader based chip market would relieve the uncertainty about the starch market. Like a host of other tropical, wheat-importing countries, the Philippines has for a long time had a law which required that wheat flours be substituted with domestically produced flour up to a minimum of 10%. Cassava flour was assumed to be the alternative flour with the most promise. The law prompted the establishment of at least one cassava flour mill on Luzon. The mill never operated at capacity and it was never possible for the wheat flour industry to meet the requirements of the law, since sufficient cassava flour at a remunerative price was never available. As with similar laws in other countries, the market was potentially large (Table 19) but cassava flour could not be produced at a competitive price.

The composite flour market offers potential if cassava chip prices can be reduced but experience has shown that basing a cassava chip industry on mixed feeds presents far fewer organizational constraints (as well as quality problems) than developing cassava chips for a composite flour industry. In the last decade there has been a structural change in the poultry industry, as production has shifted from small-scale units to large, vertically integrated commercial operations. Meat production from these operations has tripled in the last decade (Table 20). Such structural change has spawned rapid growth in the feed concentrate industry and the production of mixed feeds has increased at an annual rate of 12.2% over the last decade (Table 21). Of total production of the mixed feed industry, 70% goes to poultry while the other 30% is swine feed (Table 22). A principal feature of the industry, however, is it locus on Luzon, where 90% of mixed feeds are produced. Since the locus of cassava chip production is in the South, inter-island transport costs will be a major cost component affecting the farm-level chip price.

Growth in industrial demand for maize has caused a fundamental change in the structure of the maize market (Table 23). Although maize production has increased at the very respectable rate of 4.3% per annum over the last decade, increased use of maize for feed and for starch have resulted in a reduction of supplies going to human consumption and a continuing, if not rising, level of imports. Moreover, maize production has stagnated over the past three to four years, raising concerns that imports will have to increase even further. The Philippines is currently pursuing a self-sufficiency program in maize, along the lines of their successful rice program. Maize yields at less than one ton per hectare are low and the heart of the Maisan 99 program is a tropical maize technology, in particular a hybrid maize resistant to downy mildew.

There are two scenarious that follow from the success or ineffectiveness of the new maize technology. If the technology should succeed, planners in the Ministry of Agriculture hope to move the Philippines into a net export position in maize. Expansion in cassava chip production is designed to be used domestically and to release further maize supplies for export. If such exports are to be handled by the private sector and not the National Food Authority (NFA), then domestic price levels will have to be brought in line with world prices from their present position above world prices. In turn, cassava chip prices would have to be brought into line with world maize prices. However, Thailand has found the social profit to be higher by exporting dried cassava to Europe and using domestically produced maize in its concentrate industry. Were the Philippines to develop a competitive cassava chip industry and assuming that the EEC does not renegotiate the tariff binding on cassava, the Philippines would gain more by exporting cassava than maize.

The other scenario is that the tropical maize technology proves ineffective in the face of continued increases in demand. Without an alternative carbohydrate source, policy makers have to decide between increased maize imports or higher prices (or a price squeeze, since price ceilings on food commodities are maintained) for poultry products. Development of a cassava chip industry which services the feed concentrate industry would thus provide a sort of insurance against continued stagnation in maize yields with no risks, since the chips could always be exported.

However, development of the cassava chip market will not be easy and raising farm level yields will probably be the easiest component in the expansion of the chip market. A cheap drying technology will be a critical constraint. It is not clear how and whether this can be solved under the generally high rainfall and humidity conditions prevalent in the Philippines. Possibly, the locus of cassava production could be shifted to the drier areas on Luzon or coconut and rice drying units could be adapted to cassava. Second, internal transport costs will play a critical role in determining cassava's ability to compete. Inter-island transport is relatively expensive for a bulky commodity like cassava chips, and with most of the cassava production area in the south and the feed industry on Luzon, transport costs will capture a not unsubstantial portion of the output price. This, however, may be counterbalanced by a recent trend to locate new feed mill capacity in Visayas and Mindinao. Finally, given the Philippines' policy focus on improving the welfare of the rural poor, development of the cassava crop will take place within the smallholder sector rather than within a plantation system. Such a focus would require substantial institutional support to develop production and processing systems and market linkages.

A national cassava production program has been formulated by the Ministry of Agriculture. The plan focuses on raising cassava yields in all regions in the Philippines. Where starch plants are already in operation, increased production will be directed at servicing the plant. For those cassava production regions that lie outside the effective transport radius of a starch plant, increased production will be chipped and dried. Production credit and loans for financing of chipping and drying capacity will be extended through farmers associations. The credit will also be extended only on the basis of a marketing contract between the association and an accredited buyer, either a starch or feed mill or the National Food Authority. The program, as currently conceptualized, focuses on both production and marketing and foresees the principal market to be for use in feed concentrates.

Pricing and market efficiency:

Apart from the supply areas of the starch plants, prices for cassava are principally determined by demand in the fresh food market. Cassava is a vegetable and not a staple food in the Philippines. Retail prices are high and do not follow staple grain prices (Table 24). The ratio of retail, milled maize prices to retail cassava prices over the period 1970-79 varied from 1.4 to 2.4 and varied dramatically from year to year. For prices of fresh cassava and milled maize to be equal on a caloric basis the ratio should be around 3.5. Calories derived from cassava are just too expensive to be considered a staple.

However, this high retail price for cassava is not translated into high farm-level prices. Farm prices make up as little as 30% of the eventual retail price (Table 25). These marketing margins are somewhat typical for cassava consumed in urban areas, where transport from farm to urban center is relatively expensive. However, the SSD surveyed 222 cassava middlemen throughout the Philippines and found the gross margins between farmer and wholesaler as well as between wholesaler and retailer to be much smaller than that reflected in the average price data (Table 26). Moreover, actual marketing costs (without accounting for losses) were low. There is thus some doubt as to the extent to which the gross margins, as reflected in the BAE price data, can be generalized to cassava market channels. Nevertheless, margins for fresh cassava remain high.

To evaluate whether cassava is going to compete with grains in alternative markets, the relevant price is the farm, and not the retail, price. The price ratio between maize and cassava at this level is much more favorable (Table 24). Accepting a minimum price equivalent ratio of 3.1 [3]/, farm-level prices were very nearly competitive with maize between 1972 to 1978. This would be expected if cassava starch or chips were to be competitive with maize-derived products. Cassava root prices have remained

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[3]/ The ratio assumes a conversion of roots to chips of 2.5:1 and that dried cassava is competitive at 80% of the maize price.

distinctly uncompetitive since 1979, at least on average. Moreover, as would be expected, root prices are much lower in the southern regions as compared to Luzon, by as much as half (Table 27).

Cassava root prices are only just marginally competitive with grain prices in the Philippines and at present yield levels these prices are not sufficiently high enough to draw forth the supplies that are needed to service alternative markets. The fresh market can operate at higher price levels and is thereby the principal demand factor in the market. However, there is very limited capacity to absorb additional supplies. With yield increasing technology price determination in the cassava root market will have to be linked to the coarse grain markets. The fresh root market is small enough that making this transition, that is driving prices downward in the fresh market, should be easily accomplished. As a broader based, chip market becomes established, market efficiency and better market integration between regions should be vastly improved.

Conclusions:

The Philippines was the first country in Asia to receive cassava from the New World. Cassava was brought by the Spanish from Mexico in the 17th century. Cassava never established itself as an alternative carbohydrate staple to rice. Given the generally favorable rainfall and soil conditions, this role was captured by maize. Moreover, maize, while at first being grown as a cheap foodgrain alternative to rice, provided the raw material base for the development of both a starch and feed concentrate industry. A large and growing domestic market for carbohydrate sources for industrial uses now exists. The issue is whether maize or cassava has a better competitive advantage in servicing the continued internal growth in demand for carbohydrate sources. To complicate the issue this competitive advantage will be defined by technologies not yet in place [4]/.

Current farm-level yields in the Philippines are unreasonably low. The potential yield gap that can be exploited is therefore much larger than in other Asian countries. Moreover, a sort of vicious circle is seemingly operating, in which farmers do not intensify cultural practices because marketing is so risky and alternative markets do not develop because cassava is not competitive at current yield levels. A closer study of cassava within current farm system is needed to identify the types of technology required to raise cassava yields. Increasing productivity, however, must be simultaneously linked to market development. In this regard the national cassava production program has formulated the requisite links between technology extension, credit, and marketing contracts.

Nevertheless, if a broad based cassava market is to develop, it will depend on the ability to produce cassava chips. Drying technology is potentially the major constraint on future development of cassava. Various

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[4]/ A third source of production growth is continued expansion in area planted to maize on Mindinao rather than yield increases on current production area. However, differential changes in yields between maize and cassava would as well influence the potential for area expansion in maize.

alternatives will have to be tested under various climatic conditions and costs will need to be assessed. Given drying constraints and relatively high inter-island transport costs, consideration of pelleting in southern production areas should be considered at an early stage. The future of cassava in the Philippines is thus partly dependent on the success of the Maisan 99 program but will principally rest on a systematic assessment of the potential of new production and processing technology. Cassava in the Philippines thus has the difficult task of proving its potential.

Table . Philippines: Production and Trade of Cassava Starch, 1968-80.

Year	Production (t)	Trade	
		Exports (t)	Imports (t)
1968	22,044	-	1,201
1969	18,204	-	350
1970	22,771	193	10
1971	29,277	-	404
1972	27,867	-	3,722
1973	15,616	-	2,211
1974	18,375	-	4,229
1975	17,425	-	4,220
1976	17,391	1	2,004
1977	16,576	3	5
1978	17,024	3	3
1979	17,371	1	5
1980	N.A.	14	4

Source: National Census and Statistics Office.

Table . Philippines: Cassava Varieties Reportedly Grown on 916 Farms, 1976-1979.

Region	White	Yellow	Red	Native	Golden Yellow	Hawaiian	Java Brown	Other[1]
	Variety							
Ilocos	105	-	-	-	-	-	-	3
Central Luzon	36	36	-	1	-	-	-	5
Southern Tagalog	29	-	-	14	29	-	-	13
Bicol	13	-	86	-	9	6	-	27
Western Visayas	27	8	-	57	-	-	-	46
Central Visayas	35	45	-	-	-	-	8	10
Eastern Visayas	61	41	-	7	-	-	-	-
Northern Mindinao	48	42	-	-	-	-	-	5
Western Mindinao	72	-	-	-	37	7	3	7
Total Farms	426	172	86	79	75	13	11	116
% Farms	44	18	9	8	8	1	1	11

1 Includes 15 other varieties

Source: E.B. Mejia, et. al., "Cassava Socio-Economic and Marketing Study, Philippines," Special Studies Division, Ministry of Agriculture, No. 79-26, October 1979.

Table . Philippines: Nominal Prices Received by Farmers, Wholesale and Retail Prices, by Region, 1979 and 1980.

REGION	1979			1980		
	Prices Received (Pesos/kg)	Wholesale (Pesos/kg)	Retail (Pesos/kg)	Prices Received (Pesos/kg)	Wholesale (Pesos/kg)	Retail (Pesos/kg)
PHILIPPINES	0.37	0.74	1.19	0.44	0.85	1.28
Ilocos	0.60	1.20	1.26	0.75	-	1.29
Cagayan Valley	0.50	0.60	1.54	0.56	-	1.34
Central Luzon	0.56	0.65	1.02	0.48	0.69	1.11
Southern Tagalog	0.44	0.93	1.00	0.49	0.91	1.01
Bicol	0.38	0.64	1.09	0.42	0.69	1.07
Western Visayas	0.38	0.62	1.15	0.47	0.87	1.53
Central Visayas	0.30	0.52	0.91	0.36	0.53	1.15
Eastern Visayas	0.40	-	0.88	0.48	-	0.95
Western Mindanao	0.29	0.76	0.96	0.44	0.99	1.18
Northern Mindanao	0.34	0.61	0.86	0.43	0.80	1.05
Southern Mindanao	0.37	0.63	1.09	0.38	0.79	1.30
Central Mindanao	0.39	0.78	0.95	0.50	0.84	1.00

Sower: Bureau of Agricultural Economics.

Table . Philippines: Supply and Utilization of Cassava as Estimated by M.E. Constantino, 1971-77.

	1971 (000t)	1972 (000t)	1973 (000t)	1974 (000t)	1975 (000t)	1976 (000t)	1977 (000t)
Supply							
Production	424.7	450.4	444.7	480.0	684.5	794.4	1011.1
Imports	2.0	18.6	13.8	21.3	21.0	10.0	-
Total	426.8	468.9	458.5	501.3	705.5	804.4	1011.1
Demand							
Starch	148.4	157.9	91.9	113.1	108.2	97.0	103.6
Animal Feed	18.3	19.4	19.1	20.6	29.4	34.1	42.5
Available for							
Human Consumption[1]	260.1	291.7	347.5	367.5	567.8	673.3	865.1
Human Consumption[2]	86.2	125.3	195.2	282.0	237.2	253.0	231.0
Total 1	426.8	468.9	458.5	501.3	705.5	804.4	1011.1
Total 2	252.8	302.6	306.3	415.8	374.9	384.1	377.1

[1] Calculated as a residual.

[2] Calculated from SSD food consumption surveys.

Source: M.E. Constantino, "Cassava Market Study and a General Strategy of Implementation for the Cassava Program, unpublished M.B.A. thesis, Asian Institute of Management, 1979.

Table . Philippines: Cassava Varieties Selected for Release by the Philippine Root Crop Research and Training Center

Variety	Months to harvest	Yield (t/ha)	Dry matter (%)
PR-C13	10-12	42	34
PR-C24	8-10	43	39
PR-C62	10-12	46	33

Source: The Radix, Volume 2 (1), Jan-June 1980

Table . Philippines: Area, Production and Yield of Cassava, 1960-1981

Crop Year	Area (ha)	Production (tons)	Yield (t/ha)
1960	79,460	442,413	5.57
1961	100,310	546,611	5.45
1962	92,980	494,805	5.32
1963	80,280	457,769	5.70
1964	93,540	596,156	6.37
1965	93,280	645,720	6.92
1966	89,700	614,386	6.85
1967	86,520	528,727	6.11
1968	83,880	481,928	5.74
1969	85,690	482,327	5.69
1970	82,620	442,223	5.35
1971	81,820	427,055	5.22
1972	82,680	439,697	5.32
1973	87,420	444,710	5.09
1974	96,710	480,015	4.96
1975	119,310	684,507	5.74
1976	144,650	1,153,958	7.98
1977	179,270	1,710,767	9.54
1978	181,770	1,781,961	9.80
1979	192,360	2,253,824	11.72
1980	204,190	2,277,338	11.15
1981	211,370	2,255,115	10.66

Source: Bureau of Agricultural Economics, published in National Economic and Development Authority, Philippine Statistical Yearbook, Manila, 1981.

Year	Ilocos	Cagayan Valley	Central Luzon	Southern Tagalog	Bicol	Western Visayas	Central Visayas	Eastern Visayas	Western Mindinao	Northern Mindinao	Southern Mindinao	Central Mindinao
Area (000 ha)												
1972	1.2	1.6	1.0	5.7	15.4	5.3	13.0	10.2	11.1	4.1	4.2	9.9
1973	1.2	1.7	1.0	6.2	16.4	4.5	14.6	10.7	12.2	5.5	9.5	3.9
1974	1.9	0.7	0.9	5.8	25.8	4.3	25.7	16.9	1.1	6.2	4.0	3.5
1975	1.9	1.2	0.8	7.2	33.4	5.3	25.9	23.8	1.3	7.7	5.9	5.0
1976	1.9	1.0	0.9	8.2	27.3	7.8	23.9	29.3	10.2	12.8	6.6	14.6
1977	2.1	1.1	1.1	8.5	27.7	10.7	28.6	31.0	20.4	13.8	7.5	26.6
1978	2.2	1.0	1.1	8.2	27.8	10.2	28.6	24.4	23.9	16.0	9.3	29.6
1979	2.3	1.0	1.1	7.9	28.8	10.7	29.6	25.9	22.9	23.4	9.0	29.0
1980	2.4	0.9	1.5	8.5	32.4	11.5	30.7	28.3	23.3	26.4	8.8	29.4
1981	2.3	0.9	1.6	8.4	33.3	12.0	38.0	27.4	25.8	24.1	8.5	29.2
Production (000 t)												
1972	9.7	14.7	5.0	33.7	63.3	25.4	39.7	57.0	7.8	25.5	37.7	56.2
1973	10.4	14.6	5.6	38.9	61.3	22.2	33.1	53.5	78.0	47.8	60.3	19.2
1974	9.8	6.8	4.2	54.9	139.4	23.9	54.0	52.5	5.9	56.7	41.5	30.5
1975	11.1	6.1	4.6	54.2	237.6	30.3	85.2	120.8	8.5	77.0	34.7	14.2
1976	18.3	3.1	2.9	42.3	220.6	39.2	86.9	84.3	190.9	50.8	40.9	373.8
1977	16.3	3.3	2.2	46.1	230.6	42.2	92.8	98.2	349.9	56.9	40.7	732.5
1978	16.3	2.7	2.3	44.0	269.8	30.8	94.8	114.2	333.8	67.9	42.5	762.8
1979	17.4	5.1	3.5	40.6	308.7	44.6	116.5	116.0	297.0	129.5	48.0	1126.9
1980	18.4	3.9	4.5	43.1	293.0	60.8	89.5	126.9	303.6	153.2	53.6	1125.2
1981	16.8	4.4	4.6	44.0	287.0	64.3	75.3	133.5	325.0	135.3	47.2	1117.8
Yield (t/ha)												
1972	7.91	9.29	5.00	5.93	4.12	4.76	3.06	5.60	0.70	6.15	8.99	5.66
1973	8.36	8.36	5.44	6.31	3.72	4.93	2.26	5.00	6.40	8.69	6.35	4.89
1974	5.26	9.45	4.73	9.45	5.40	5.61	2.09	3.11	5.58	9.09	10.42	8.59
1975	5.79	5.15	5.85	7.56	7.11	5.66	3.29	5.07	6.67	10.04	5.93	2.81
1976	9.29	3.15	3.36	5.16	8.06	5.02	3.63	2.87	18.66	3.96	6.17	25.65
1977	7.65	2.95	2.02	5.40	8.27	3.95	3.24	3.16	17.14	4.11	5.42	27.50
1978	7.51	2.58	2.03	5.34	9.71	3.02	3.31	4.67	13.95	4.23	4.58	26.25
1979	7.46	5.13	3.16	5.13	10.70	4.17	3.93	4.47	12.96	5.54	5.31	38.07
1980	7.71	4.32	2.93	5.06	9.03	5.29	2.91	4.47	13.02	5.81	6.08	38.29
1981	7.31	5.10	2.88	5.27	8.61	5.36	1.98	4.87	12.60	5.62	5.54	38.30

Source: Bureau of Agricultural Economics

Table . Philippines: Per Capita Consumption[1] of Cassava and Prices[2] by Quarter and Region, 1973-76.

Region	Jan-March		April-June		July-Sept.		Oct-Dec.	
	Consumption (kg/capita)	Price (pesos/kg)	Consumption (kg/capita)	Price (pesos/kg)	Consumption (kg/capita)	Price (pesos/kg)	Consumption (kg/capita)	Price (pesos/kg)
I	1.4	0.53	1.5	0.53	1.8	0.62	1.4	0.51
II	1.9	0.53	1.0	0.60	1.7	0.50	1.8	0.55
III	1.9	0.52	1.5	0.61	2.1	0.53	2.4	0.53
IV	2.3	0.41	1.9	0.45	2.3	0.54	2.2	0.54
V	3.9	0.43	2.8	0.44	4.1	0.48	3.2	0.54
VI	2.6	0.47	3.2	0.70	2.1	0.49	2.9	0.48
VII	8.1	0.31	5.2	0.47	3.5	0.41	4.6	0.53
VIII	5.9	0.34	4.8	0.64	5.4	0.38	2.8	0.81
IX	6.1	0.31	4.5	0.66	10.9	0.29	4.7	0.42
X	4.8	0.40	4.4	0.77	5.1	0.37	4.7	0.46
XI	5.4	0.38	5.1	0.33	4.0	0.36	4.2	0.40
XII	5.5	0.43	5.8	0.41	11.5	0.35	3.9	0.42

[1] Per capita consumption expressed on an annual basis.

[2] Constant 1972 prices.

Source: Calculated from unpublished consumer food consumption surveys carried out by the Special Studies Division, Ministry of Agriculture.

Table . Philippines: Per hectare Production Costs, Yields, and Costs per Ton, 1977-79.

Cost Item	Region I	III	IV	V	VI	VII	VIII	IX	X	Average
	---(pesos/ha)---									
Variable Costs										
Labour										
Hired	29.1	26.6	103.5	124.8	28.0	181.6	167.0	113.3	75.1	98.8
Food	10.4	1.0	-	2.1	10.3	10.1	56.9	51.8	9.2	15.6
Family	288.2	322.6	280.2	363.4	165.9	179.2	267.9	368.8	266.2	282.8
Land Preparation										
Tractor	15.6	-	-	-	-	32.0	-	-	-	7.0
Animal	1.5	-	-	0.5	0.9	5.6	2.7	23.5	3.4	4.2
Planting Material	-	-	-	0.6	-	-	-	-	-	0.1
Fertilizer	0.1	3.4	-	0.2	0.9	-	-	-	-	0.1
Landlord										
In kind	28.5	8.7	16.8	17.2	14.9	31.3	33.2	13.1	52.8	23.3
Cash	232.2	-	-	-	-	-	-	12.3	4.6	30.7
Transport	41.9	73.2	-	-	3.6	19.6	.2	18.9	35.9	21.1
Interest (Working Capital) 1/	40.9	18.8	14.1	16.8	7.9	19.4	28.3	27.7	22.4	21.7
Sub-total	688.2	444.2	414.6	524.8	232.2	479.6	556.1	629.4	469.7	505.5
Fixed Costs										
Depreciation	19.2	28.2	24.2	20.4	12.5	30.2	15.5	11.0	8.2	18.9
Repair	5.7	21.3	13.9	2.9	16.5	3.4	3.6	6.1	21.1	9.1
Interest 2/	322.1	470.9	447.5	293.5	344.6	386.1	227.3	217.7	271.7	325.2
Sub-total	347.0	520.4	485.6	316.8	373.7	419.7	246.3	234.8	301.0	353.1
Total Costs	1035.1	964.6	900.1	841.5	605.8	899.3	802.4	864.2	770.7	858.6
Yield (t/ha)	6.19	5.84	3.36	2.49	2.21	5.46	2.16	5.39	4.03	4.02
Cost per ton	167.2	165.2	267.9	338.0	274.1	164.7	317.5	160.3	191.2	213.6
Farm Price	250	260	190	230	250	190	300	240	220	230

1/ Interest on cash expenses with interest rate of 12%

2/ Land costs for land owners included as interest on land value, i.e. implicit land rent is 12% of land value.

Source: E.B. Mejía, et.al., "Cassava Socio-economic and Marketing Study, Philippines," Special Studies Division, Ministry of Agriculture, No. 79-26, Oct. 1979.

Table . Philippines: Labor Use, Farm Size and Average Cassava Area in Cassava Production Systems, 1977-79.

	Region									Average
	I	III	IV	V	VI	VII	VIII	IX	X	
Labor Utilization (man days/ha)										
Land Preparation	11.6	20.0	21.9	27.0	10.8	10.8	22.4	16.9	16.3	17.6
Furrowing	2.8	2.2	1.1	3.9	0.2	2.0	3.4	2.6	1.5	2.2
Planting	10.4	6.1	10.5	7.3	5.0	8.5	10.2	8.8	6.8	8.1
Weeding	3.6	5.2	11.1	14.9	2.9	5.9	14.0	19.2	6.3	9.5
Harvesting	5.9	6.3	15.7	7.8	5.3	27.8	8.7	9.2	7.5	9.8
Packing and Transport	6.7	4.2	4.6	1.9	2.0	1.8	3.9	5.7	10.0	4.4
Peeling and Drying	-	-	-	-	-	8.3	-	4.2	1.0	1.3
Total	41.0	44.0	64.9	62.8	26.2	65.1	62.6	66.6	49.4	52.9
Farm Size (ha)	2.25	2.25	2.93	3.72	4.29	2.82	2.38	3.15	2.50	3.03
Cassava Area (ha)	0.65	0.54	0.60	0.79	0.49	0.85	0.47	0.58	0.52	0.61

Source: E.B. Mejia, et.al., "Cassava Socio-economic and Marketing Study, Philippines" Special Studies Devision, Ministry of Agriculture, No. 79-26, Oct. 1979.

able . Philippines: Annual Costs of Production of Cassava Starch for a Factory with a Capacity of 20 t/day of Starch, 1978.

Cost Item	Total (ooo Pesos)	Per ton of starch (Pesos)
ariable Costs		
Cassava Roots	6300	1050
Labor	108	18
Fuel	1692	282
Gunny Bags	420	70
Interest on Working Capital	96	16
Transport (delivered ex-factory)	960	160
Total Variable Costs	9576	1596
ixed Costs		
Depreciation	1002	167
Interest on Fixed Capital	1200	200
Total Fixed Capital	2202	367
otal Costs	11,778	1963
elling Price		2100-2400

ource: M.E. Constantino, "Cassava Market Study and a General Strategy of Implementation for the Cassava Program," unpublished M.B.A. Thesis, Asian Institute of Management, 1979.

Table . Philippines: Average Monthly Consumption of Cassava Starch by Type of Final Product for a Sample of Firms, 1978.

Final Product	Number of Firms	Quantity (t)	Percent (%)
Kropeck	22	97	19
Noodle	23	41	8
Glucose	2	175	34
Adhesive	3	4	1
Cardboard	12	46	9
Monosodium Glutamate	1	113	22
Detergent	1	38	7
Total	64	512	100

Source: C.D. Villanueva and R.S. Laguna, "An Intensive and Critical Survey of Existing Industrial Processing of Root Crops and Projection for the Next Decade," PRCRTC Annual Report, 1979.

Table . Philippines: Type of Labor Used in Cassava Production by Region (man days/ha).

Region	Hired, paid in Cash	Hired, paid in Kind	Operator	Family	Exchange	Total
Ilocos	3.7	-	24.4	11.6	0.2	39.9
Central Luzon	4.5	-	28.0	11.5	15.0	59.0
Southern Tagalog	15.0	-	24.9	25.9	-	65.8
Bicol	14.2	-	24.0	25.0	0.3	63.5
Western Visayas	3.5	0.3	14.1	8.0	0.3	26.2
Central Visayas	12.2	21.8	17.5	13.7	-	65.2
Eastern Visayas	22.8	-	26.6	10.3	3.2	62.9
Eastern Mindinao	14.9	-	39.0	16.8	1.3	72.0
Northern Mindinao	8.5	-	29.9	10.2	0.8	49.4
Average	11.1	2.8	24.8	15.6	0.7	54.9

Source: E.B. Mejía, et. al., "Cassava Socio-economic and Marketing Study, Philippines," Special Studies Division, Ministry of Agriculture, No. 79-26, Oct. 1979.

Table . Philippines: Estimates of Supply and Distribution of Cassava by Region, 1975.

Region	Per Capita Consumption (kg/capita)	Total Human Consumption (t)	Starch (t)	Dried Chips (t)	Animal Feed (t)	Waste (t)	Total (t)
Ilocos	1.5	4,904	10,370	-	-	2,695	17,969
Cagayan Valley	1.9	3,673	-	-	-	648	4,321
Central Luzon	1.6	6,736	-	-	-	1,189	7,925
Southern Tagalog	2.3	11,992	-	-	-	2,116	14,108
Bicol	7.6	24,274	-	-	-	4,284	28,558
Western Visayas	5.5	22,803	18,000	-	4,420	7,981	53,204
Central Visayas	7.5	25,402	-	12,701	5,080	7,621	50,804
Eastern Visayas	13.7	35,620	-	-	4,749	7,124	47,493
Western Mindinao	10.0	20,480	-	10,240	4,096	6,144	40,960
Northern Mindinao	8.2	18,975	15,000	13,800	5,520	9,405	62,700
Southern Mindinao	4.9	13,304	-	-	1,774	2,661	17,739
Central Mindinao	11.0	22,770	47,340	-	6,665	13,549	90,324
Manila	2.5	12,425	-	-	-	-	12,425
Philippines	5.4	223,358	91,710	36,741	32,304	65,417	449,530

Source: CIAT estimates.

Table . Philippines: Sources of raw material and unit costs of cassava roots purchased by five starch factories, 1978.

Firm	Own Plantation		Farmer		Middleman	
	Percent (%)	Unit Cost (Pesos/kg)	Percent (%)	Unit Cost (Pesos/kg)	Percent (%)	Unit Cost (Pesos/kg)
1	-	-	60.0	0.23	40.0	0.23
2	90.9	0.28	9.1	0.18	-	-
3	15.0	0.18	85.0	0.18	-	-
4	10.0	0.24	90.0	0.16	-	-
5	88.6	0.37	1.2	0.15	10.2	0.60 1/
Average	18.2	0.25	78.3	0.17	3.5	0.28

1/ Gaplek

Source: C.D. Villanueva and R.S. Laguna, "An Intensive and Critical Survey of Existing Industrial Processing of Root Crops and Projection for the Next Decade," PRCRTC Annual Report, 1979.

Table . Philippines: Monthly Production of Starch by Five Starch Factories, 1978.

Month	Firm 1 (t)	Firm 2 (t)	Firm 3 (t)	Firm 4 (t)	Firm 5 (t)	Total (t)
January	-	203.2	1,098.8	656.9	-	1,954
February	-	-	741.0	283.9	-	1,025
March	42.8	-	576.4	399.9	-	1,019
April	123.3	-	437.7	350.9	-	912
May	173.3	-	678.5	258.9	-	1,111
June	180.8	-	753.2	242.5	69.1	1,246
July	166.1	-	707.6	412.7	239.8	1,526
August	195.7	-	1,028.5	689.1	113.6	2,027
September	171.1	-	1,091.8	644.6	118.9	2,026
October	166.3	81.1	1,110.6	683.7	159.5	2,201
November	161.7	161.3	1,272.0	671.5	165.9	2,432
December	76.7	129.0	1,121.7	704.7	140.4	2,172
Total	1,458.0	574.7	10,612.9	5,999.2	1,007.1	19,652

Source: C.D. Villanueva and R.G. Laguna, "An Intensive and Critical Survey of Existing Industrial Processing of Root Crops and Projection for the Next Decade," PRCRTC Annual Report, 1979.

Table . Philippines: Nominal and Real Prices of Cassava at Farm, Wholesale and Retail Level, 1970-80.

Year	Farm (pesos/kg)	Wholesale (pesos/kg)	Retail (pesos/kg)
Nominal			
1970	.12	.19	.32
1971	.15	.24	.38
1972	.15	.29	.46
1973	.21	.32	.53
1974	.29	.40	.70
1975	.29	.41	.71
1976	.28	.43	.71
1977	.30	.53	.80
1978	.32	.57	.74
1978	.37	.74	1.19
1980	.44	.85	1.28
Real (1975 prices)			
1970	.25	.40	.67
1971	.27	.43	.69
1972	.25	.48	.76
1973	.30	.46	.76
1974	.31	.43	.76
1975	.29	.41	.71
1976	.26	.40	.67
1977	.26	.46	.70
1978	.26	.46	.60
1979	.25	.51	.81
1980	.25	.49	.74

Source : Bureau of Agricultural Economics.

Table . Philippines: Marketing Margin for Fresh Cassava Root for Various Types of Middlemen, 1977-79.

Middleman	Average Buying Price (Pesos/kg)	Average Selling Price (Pesos/kg)	Gross Margin (Pesos/kg)	Marketing Cost (Pesos/kg)	Net Return (Pesos/kg)
Contract Buyer	0.23	0.32	0.09	0.04	0.05
Agent	0.23	0.28	0.05	0.02	0.03
Assembler-wholesaler	0.16	0.27	0.11	0.09	0.02
Wholesaler	0.28	0.35	0.07	0.04	0.03
Wholesaler-retailer	0.33	0.42	0.09	0.04	0.05
Retailer	0.29	0.40	0.11	0.03	0.08

Source: E.B. Mejía, "Cassava Socio-economic and Marketing Study Philippines,"Special Studies Division, Ministry of Agriculture, No.79-26, October 1979.

Table . Philippines: Supply and Utilization of Cassava as Estimated by the Policy Analysis Staff, 1969-1980.

Year	Supply			Demand			
	Production (000t)	Imports (000t)	Total Supply (000t)	Feed and Waste (000t)	Starch (000t)	Food Use Total (000t)	Food Use Per Capita (kg)
1969	490	2	492	53	111	328	9.2
1970	448	-	448	41	137	270	7.3
1971	426	2	428	26	173	229	6.1
1972	440	21	461	17	165	279	7.2
1973	489	16	503	34	97	372	9.3
1974	545	24	569	75	112	382	9.3
1975	643	23	666	167	103	396	9.4
1976	750	11	761	247	107	407	9.4
1977	859	-	859	344	102	413	9.3
1978	910	-	910	380	104	426	9.3
1979	928	-	928	394	110	424	9.0
1980	948	-	948	402	112	434	9.0

Source: Policy Analysis Staff, Ministry of Agriculture

Table . Philippines: Prices of Cassava and Shelled Yellow Maize at the Farm and Retail Level, 1970-1980.

Year	Maize (pesos/kg)	Cassava (pesos/kg)	Maize / Cassava (%)
Farm-level			
1970	0.33	0.12	275
1971	0.49	0.15	327
1972	0.54	0.15	360
1973	0.56	0.21	267
1974	0.91	0.29	314
1975	0.94	0.29	324
1976	0.94	0.28	336
1977	1.00	0.30	333
1978	0.97	0.32	303
1979	1.01	0.37	273
1980	1.14	0.44	259
Retail			
1970	0.47	0.32	147
1971	0.80	0.38	211
1972	0.80	0.46	174
1973	0.90	0.53	170
1974	1.24	0.70	177
1975	1.44	0.71	203
1976	1.43	0.71	201
1977	1.48	0.80	185
1970	1.50	0.74	203
1979	1.60	1.19	134
1980	1.79	1.28	140

Source: Bureau of Agricultural Economics.

Table . Wheat Imports and Production of Wheat Flour, 1970-80

Year	Imports of Wheat (000 t)	Flour Production (000 t)
1970	494.9	387.0
1971	588.2	418.6
1972	711.8	417.9
1973	503.8	400.3
1974	478.3	346.1
1975	518.0	396.5
1976	703.6	464.5
1977	651.1	482.9
1978	675.0	N.A.
1979	704.8	N.A.
1980	785.7	N.A.

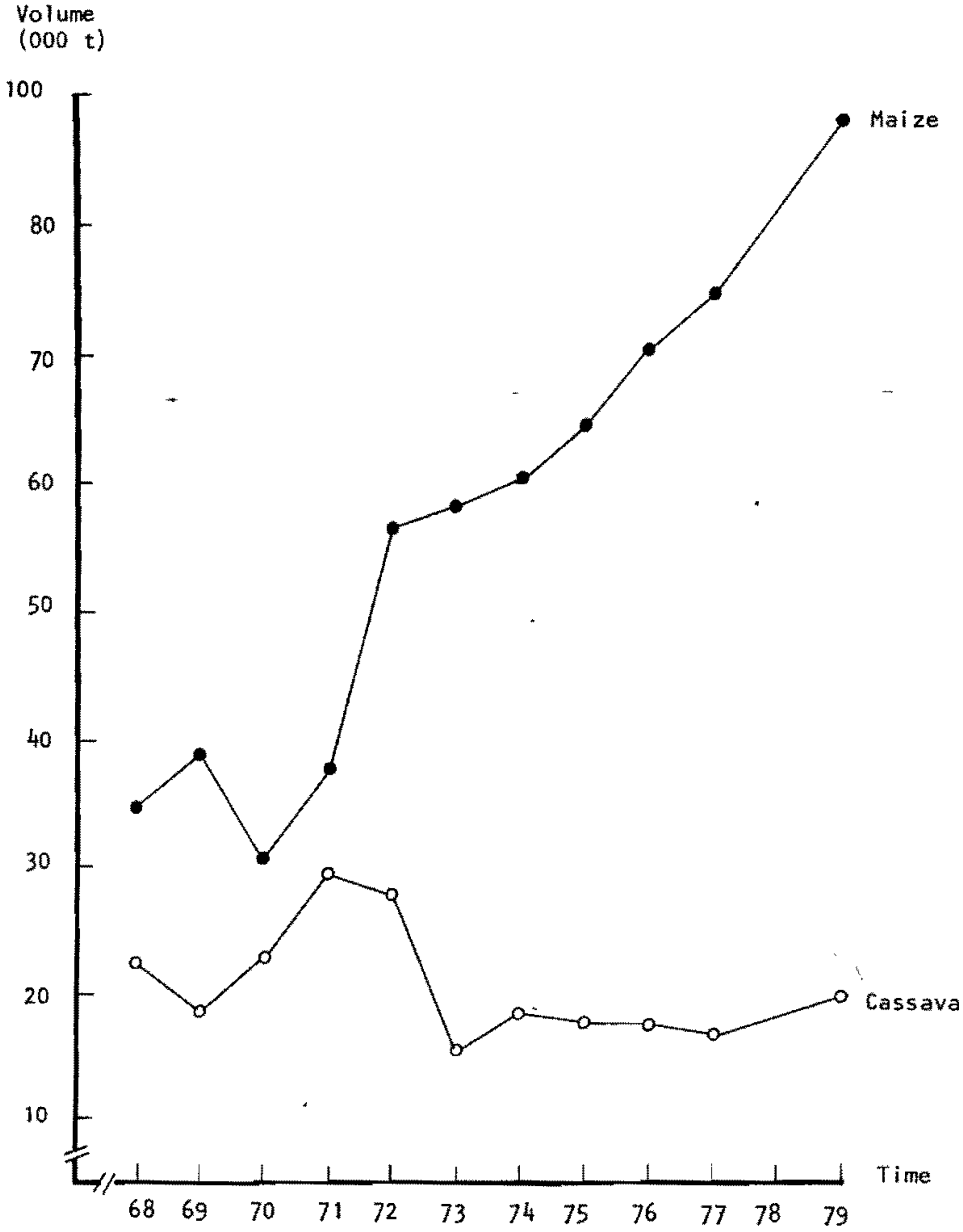
Sources: National Economic and Development Authority, "1980 Philippine Statistical Yearbooks," Manila, 1980.

Table 3.37 Philippines: Supply and Utilization of Maize, 1970-1980.

Crop Year	Production (000 t)	Imports (000 t)	Utilization: Food Consumption (000 t)	Feed (000 t)	Starch (000 t)	Seed (000 t)
1970	2005	31	1248	669	52	39
1971	2013	193	1250	750	73	40
1972	1831	90	1259	680	89	38
1973	2289	94	1337	750	92	45
1974	2568	159	1712	850	96	50
1975	2767	54	1835	900	103	53
1976	2843	160	1669	1150	112	54
1977	2855	134	1647	1230	119	52
1978	3167	56	1600	1338	122	54
1979	3176	94	1657	1580	136	56
1980	3170	351	1604	1699	146	55

SOURCE: Bondad, et.al., 1981.

Figure 3.12. Philippines: Production of Maize and Cassava Starch, 1968-1979



SOURCE: Constantino, 1979

Table 3.36. Philippines: Volume of mixed feed production by type and region, 1978

Type of feed	Location: Philippines	Luzon	Visayas	Mindinao
Poultry				
Production (000 t)	598.4	556.7	41.7	neg
% of total by region	100.0	93.0	7.0	-
% of total by feed type	69.0	70.0	75.0	-
Hog				
Production (000 t)	262.5	225.1	13.7	22.6
% of total by region	100.0	86.0	5.0	9.0
% of total by feed type	30.0	28.0	25.0	100.0
Other				
Production (000 t)	12.6	12.3	0.3	-
% of total by region	100.0	98.0	2.0	-
% of total by feed type	1.0	2.0	-	-
Total				
Production (000 t)	873.5	795.1	55.7	22.6
% of total by region	100.0	91.0	6.0	3.0

Source: Lincageo-López, 1979.

Table 3.35. Philippines: Production of Mixed Feed, 1968-1979

Year	Total Production (mt)
1968	263,744
1969	357,881
1970	314,415
1971	285,143
1972	312,341
1973	387,680
1974	421,266
1975	654,665
1976	625,345
1977	756,877
1978	873,499
1979	935,900
Annual Growth Rate	12.2%

Source: Lincangeo-López, 1979

Table 3.34 Philippines: Poultry Stock and Slaughter in Commercial Operations

Year	Poultry Stock (000 head)	Slaughter (000 head)
1970	46,448	34,576
1971	52,526	42,221
1972	52,555	42,276
1973	44,373	32,777
1974	60,609	48,728
1975	69,851	60,928
1976	77,877	64,768
1977	90,315	71,622
1978	103,528	87,813
1979	117,964	101,353
1980	125,362	110,480

Source: Bondad, et.al., 1981.

Table 3.33. Philippines: Cassava Consumption by Income Strata over time, 1973-1979.

Year	Income Strata				
	Less than 400 (kg/capita)	400-799 (kg/capita)	800-1499 (kg/capita)	More than 1500 (kg/capita)	Average (kg/capita)
1973	6.5	4.4	4.3	3.2	4.9
1974	8.9	6.1	6.7	6.7	6.9
1975	8.2	4.9	6.5	3.6	5.2
1976	8.5	5.0	5.7	4.0	5.6
1977	-	-	-	-	5.2
1978	-	-	-	-	3.6
1979	-	-	-	-	3.1

SOURCE: Special Studies Division, Ministry of Agriculture.

Table 3.32. Philippines: Annual, Per Capita Food Consumption Patterns by Region, 1977-1980.

Region	Rice (kg/capita)	Maize (kg/capita)	Wheat (kg/capita)	Cassava (kg/capita)	Sweet Potatoes (kg/capita)
Ilocos	139.8	1.3	7.7	1.6	6.2
Cagayan Valley	101.2	20.4	6.9	1.8	5.7
Central Luzon	120.1	1.6	8.8	0.2	2.0
Metro Manila	103.4	1.6	17.3	0.4	2.0
S. Luzon	118.0	1.3	10.8	1.6	2.6
Bicol	114.0	3.0	7.5	4.9	15.6
W. Visayas	120.7	7.5	6.0	6.0	4.3
C. Visayas	45.6	83.2	7.1	7.6	6.7
E. Visayas	104.7	19.9	7.4	5.4	15.9
W. Mindinao	82.0	25.0	6.2	5.1	8.5
N. Mindinao	77.5	54.9	6.9	2.9	6.4
E. Mindinao	101.4	28.7	7.0	1.8	7.1
C. Mindinao	113.4	12.7	8.0	9.5	7.4
Philippines	105.8	17.7	8.5	3.5	6.5

Source: Aviguetero, et.al., 1981.

Thailand

Production Trends

Cassava is the most recent of Thailand's commodity booms, which is not to say that cassava is a recently introduced crop. The exact date of introduction to Thailand is not known, but cassava was apparently being grown as a food crop in the 18th century. However, unlike countries such as Indonesia and the Philippines, Thailand was always able to meet its starchy staple requirements solely through rice. Cassava, thus, never became more than a speciality food in the country. The genesis for growth in the crop has always been non-food markets, principally directed to export. The initial development of such a market was in the 1930's, when cassava pearl was produced in the South for export through Malaysia (Scheltema, 1938)[1].

The Thai cassava industry was based on the starch export market up to about 1960. World War II briefly curtailed this market in Southeast Asia in the late 1940's, but following the war modern processing machinery was introduced into Chonburi in the eastern region. A healthy starch industry was operating in this region by the mid-1950's, supplanting the starch industry in Indonesia and in the south of Thailand. However, it was starch wastes that became the basis for the real expansion in the crop, when a West German importer in 1956 introduced cassava waste as an animal feed to Germany (Philips, 1974; Titapitnatanakun, 1979). Low freight rates in this period, its lack of alternative uses, and high feedgrain prices in Germany made cassava waste particularly price competitive in Europe. Since cassava waste was a by-prduct of starch manufacture shortages resulted and led to the importation of cassava meal starting in 1960. With the introduction of the Common Agricultural Policy in 1962, and the fact that cassava was overlooked in the development of the variable levy system for grains the Thai cassava industry shifted to animal feed as its principal market. Cassava chips became the dominant export in 1964, native pellets in 1969 and hard pellets in 1983.

Thai agriculture moved directly from essentially a subsistence economy to an export oriented economy in the 1850's, with the signing of the Bowing Treaty that removed a ban by the Thai king on exports of rice. The agricultural sector has continued to respond principally to export opportunities and in turn to the vagaries of world market demand. The rise and collapse of the kenaf industry is indicative of this process. Growth of cassava production in Thailand also has been largely determined by external demand for the commodity, and growth in cassava production has been impressive indeed. Thailand has gone from a relatively minor producer of cassava in the 1950's to the second largest (if not the largest)producer of cassava in the world.

Production of cassava has increased from around 400 thousand tons in the mid-1950's to almost 20 million tons in 1984/85 (Table). This represents a sustained growth rate of 16% per annum for over 25 years. These sharp increases in production have been based exclusively on

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1 Thai export statistics for cassava do not start until 1953 and the only suggestion of such an industry is Malaysia import statistics.

expansion in area planted and have been concentrated in a relatively limited number of regions within the country. Production has continued to expand in the old starch producing region of Chonburi and Rayong. However, the bulk of cassava production has shifted from this zone to the Northeast. Whereas the Northeast made up less than 10% of the total up to 1969, by 1979 the Northeast was producing over 60% of total cassava. This represented a shift to relatively drier production conditions and movement from the red-yellow podzolic soils to the more acidic latosols. Cassava in part displaced kenaf in the Northeast and in part was planted on newly cleared forest areas.

Cassava has grown from a relatively minor crop in the 1950's to be the second most important crop after rice in terms of production volume (as measured on a dry weight basis) and in terms of foreign exchange earned. As in previous commodity booms, rapid production increases have been based on area expansion led by demand in international markets. Capacity and growth in domestic markets would never have generated the growth rates that have occured in cassava and the other major agricultural commodities. To understand the cassava industry in Thailand, the analysis thus first reviews the factors on the production side that formed the basis for such high growth rates and then turns to an analysis of the demand side, which must necessarily consider the changing nature of the international cassava market.

Cassava Production Systems

Agricultural development in Thailand has been based on exploitation of an agricultural frontier and reliance on international markets as a surplus vent. Unlike Malaysia, access to new land has been relatively uncontrolled, although a ceiling on the size of land holdings fomerly in the public domain was set at 8 ha. in 1936. With the expansion in international markets following World War II, planted area expanded rapidly, in many cases at the expense of forest lands. A satellite census showed that forest land had been reduced from 57% of total land in 1961 to 37% in 1974, a loss of 10 million hectares in 13 years (Bertrand, 1980).

Whereas the pre-war expansion was based principally on rice, for which there was already a large production base, diversification into upland crops has been the hallmark of post-war agricultural growth. Crops such as maize, sugarcane, mung been, kenaf, and cassava have expanded rapidly from relatively small production bases. The final component of this extensive growth pattern was relatively rapid mechanization of the agricultural sector, based on either animal or mechanical equipment. Thus in 1963, 68% of farms were using animal traction and 14% were using mechanical power or some combination of animals and tractors. By 1978 33% of farmers were utilizing tractors.

Cassava production systems, therefore, must be understood essentially in the context of rapid expansion of previously uncultivated land. Certainly, in the Northeast there was some substitution for kenaf, whose area by 1981 had declined by about 330 thousand hectares from its peak in 1967. However, cassava area in the Northeast increased by over 780 thousand hectares in the same period, at the same time as maize production also expanded quite dramatically. Given cassava's adaptation to the drier growing conditions of the Northeast and the profit levels as maintained by

EC grain prices, the crop expanded rapidly, principally by opening up new land. The process obviously introduces a dynamic element into characterizing cassava production systems, especially in terms of adaptation of management practices, as farmers learn the responsiveness of a new crop and the effects of continuous cassava cultivation on soil fertility.

Using the agricultural census of 1963 and 1978 as reference points, cassava expansion was based on a sizeable increase in the number of cassava growing farms (from 58 to 450 thousand) and in an increse in the average size of cassava plantings per farm from 1.4 to 2.1 ha. In 1978 21% of the farmers in the Northeast grew cassava, and in most instances probably depended on cassava as their principal source of income. By 1978 the modal farm size stratum for cassava farmers was between 3.2 and 6.4 ha (Table). This is large by overall Asian standards but still relatively small given the agro-climatic potential of most growing areas. Moreover, such a farm size has supported a market for tractor hire services but not actual tractor ownership. The adoption of tractor hire services has in turn released grazing land, formerly needed to support draft animals, for cultivation.

Given the very dynamic nature of the upland sector, especially in the Northeast, the degree of competition between cassava and other upland crops is difficult to define. If crop area data are disaggregated by agroeconomic zone (Table), certain hypotheses at least emerge. In the old cassava growing area of Chonburi and Rayong (agroeconomic zone 15), cassava made up 40% of total farm area, with the only other upland crop being sugarcane. Cassava dominates this zone so thoroughly that it appears blanketed by monoculture cassava. In the Northeast the situation is more diverse. In agroeconomic zones 1 and 5 cassava potentially competes with maize and kenaf. In agroeconomic zone 3, cassava competes only with kenaf. In none of these latter zones does cassava dominate the agricultural economy. Moreover, only in agroeconomic zone 5 do maize and cassava production areas really overlap. In the two largest maize producing zones, only very little cassava is produced. In general in the Northeast there is still significant scope for expansion of cassava area, if not at the expense of other crops then in terms of currently under-utilized land already in farms or in the public domain.

The rainfall pattern in the Northeast and Central Plain is unimodal, with a dry season from November to April and a wet season of varying intensity for the rest of the year, as reflected in averge annual rainfall from 900 to 3000 mm. Moreover, moving to the Northeast rainfall becomes more variable and uncertain. Since most of the cassava is solar dried, this rainfall pattern creates a trade-off between optimum drying period and optimum planting period. The drying season starts in November and farmers rarely leave the cassava in the ground for longer than 12 months, though it could be left much longer. Where rainfall is more secure, that is the Rayong and Chonburi area, farmers plant in the dry season as well as the wet season. Further to the northeast, farmers tend to plant exclusively in the March to June period, that is at the beginning of the rainy season (Figure). Experimental trails have shown that planting at the beginning of the rains gives significantly higher yields (Sinthuprama, 1980).

Given a eight-to-twelve month growth cycle, planting in the November-December period and harvesting in the same period coincides better with market demand. Prices are at their seasonal high in the September-November period before declining to their seasonal low in March-April. Also root starch content is much higher at the beginning of the dry season, resulting in a further price premium. There is greater demand for roots at this period, because of the significant increase in through-put, and thereby lower costs, in the chipping plants due to shorter drying periods. Nevertheless, there is only a moderate increase in roots sales in the dry season (Table), as harvest occurs throughout the year.

Cassava production systems, in and of themselves, are relatively simple. The land is prepared either by animal traction or by tractor hire services, with the latter being increasingly common. The cassava is planted either horizontally (sandy soils) or vertically (loamy soils) depending on the potential drought risk of the soil. Planting material comes from recently harvested plants, keeping stake storage time to a minimum. Cassava is grown in a very strict monoculture system, in that no other crop species are interplanted and a single variety tends to dominate thoughout Thailand, Rayong 1. In weeding hand labor is employed, with some animal interrow cultivation. Nevertheless, in the these activities labor use is kept to the minimum necessary to adequately maintain the crop.

The most critical issue in the rapid expansion of cassava production and the resultant extensive production systems is the mainteanance of soil fertility. In general fertilizer application is low in Thailand, when compared to other Asian countries. Fertilizer prices are not subsidized in Thailand and are generally applied to those crops in which marginal returns are highest. Of the major crops, sugarcane has the highest application rate, followed by rice. According to the 1978 census, rice consumes fully two-thirds of fertilizer availabilities. Sugarcane, vegetable and tree crops consume an additional quarter, leaving less than 10% or less than 70 thousand tons available for all other major field crops.

Fertilizer application on cassava is low. In 1973/74 average fertilizer application per cultivated hectare of cassava was only 6.9 kg/ha. On that area where fertilizer was actually applied (16% of cultivated area), rates were 43 kg/ha. Recommended application rates are about 15 times this level. By 1980/81 average application rates remained at the same level (Table). As would be expected, fertilizer application is much higher in the old production zones around Chonburi and Rayong, while in many areas of the Northeast fertilizer use on cassava non-existent. The very low fertilizer use in cassava raises two critical issues. First, has continuous cassava cultivation with only minimal levels of fertilizer use resulted in a declining yield trend? Second, what would be the yield gains were fertilizer application to increase? To answer partially these issues, the analysis turns to an evaluation of cassava yields.

Yields

Average cassava yield levels of 13 to 14 t/ha in Thailand are high, even by Asian standards. Only India consistently has higher yields than Thailand. Moreover, Thailand has been able to maintain this level of productivity through the period of rapid expansion in the crop. The national statistics suggest that yields have declined somewhat since 1960. In the early sixties average yields were around 17 t/ha and declined quite rapidly to 14 t/ha by the late sixties. Yields have remained at about this level ever since, having fallen below 13 t/ha only once. These relatively high yields have been a significant part of Thailand's dominance of the international trade in cassava.

The difference in agro-climatic conditions between the Northeast and the Central Plain is only partially reflected in yield differences. The older production regions on average maintain a one-to-two ton yield advantage over production areas in the Northeast. However, yields have shown something of a rising trend in the Northeast, especially if extended back to 1960. Yield trends in the Central Plain, on the other hand, initially declined in the 1960's and over the past half decade have been remarkably stable at around 15 t/ha. Yield levels as expressed in the aggregate production statistics thus present a picture of relative stability and give no indication of progressive soil exhaustion.

The micro-level data are only suggestive of the factors underlying the dynamics of cassava productivity. To start with, average yields of cassava mask a very wide yield dispersion. The yield distribution is skewed, with the largest segment of farmers producing quite normal yields by world standards of from zero to nine t/ha and with a very extended right-hand side where some farmers produce over 19 t/ha (Table). The second set of data is long-term fertility studies (Figure). These data show the expected decline in yields with continuous cropping after opening up new land. However, the decline is gradual and in one site yields only declined from around 30 t/ha to 20 t/ha in a sixteen year period. One thorough study found that from an initial yield of 20 to 30 t/ha, yields decrease by half within 9 to 20 years. With such rapid opening of new land as has occurred in the case of cassava, the yield decline in older plots has been offset by the higher yields of new production areas. As yield in older plots fall, cassava supply becomes more sensitive to price changes. Since more than half the farmers operate at below average yields, price declines could result in significant shifts out of cassava.

Mining of soil fertility has a longer-term social cost of enhanced erosion potential and a permanent decline in the productivity of the land resource. This, therefore, puts prime importance on motivating increased application of organic and inorganic fertilizers, as apparently already is happening in the Chonburi and Rayong area. Two factors, however, complicate increased use of fertilizer on cassava. First, in most areas cassava must compete with either rice or sugarcane for capital resources for fertilizer. Second, cassava responsiveness to fertilizer application is not as certain as in these other two crops. There is often no response in the first two to three years after opening up new land (Table). After that, while responses can be shown, they cannot be demonstrated consistently (Table).

What remains extraordinary in Thailand is the high yields that farmers achieve in even depleted soils. Suttibursaya and Kummarohita (1978) report cassava being grown continuously for 25 years without fertilization and yet yields have declined to only 16-17 t/ha. A fertility restoration experiment selected four farmers' fields which had been continously cultivated for 15 years and the average yield of the check plots was 21 t/ha (Interim Committee for Coordination of Investigations in the Lower Mekong Basin, 1979). This suggests that the dominant variety, Rayong 1, is very efficient in the utilization of limited soil nutrients. Moreover, thirty years of experimental work, both on the experiment station and in farmers' fields, suggest that 30 t/ha is an achievable target with an appropriate fertilizer regime.

The results have made fertility management the principal research thrust in cassava in Thailand. What is the advantage of a large investment in breeding, if 30 t/ha is imminently achievable with the current variety? However, defining a recommendation that gives a consistently profitable response has eluded researchers and inhibited adoption of fertilizer use in cassava. Indeed, farmers in Thailand utilize fertilizer; they, however, do not apply it to their cassava. Until the profitability of fertilizer response can be significantly increased, probably by linking application rates to other environmental variables, no effective extension program for fertilization of cassava will be successful, except possibly in the very badly degraded soils such as now exist in Chonburi and Rayong.

Thus, the relatively high prices for cassava products obtained in the European Community was only part of the profit engine that resulted in the rapid expansion in cassava area. The other component was the very high initial yields obtained by new adopters of cassava cultivation. Initial yields in the 25 to 30 t/ha range provided a powerful stimulus to expand cassava area and lack of a viable crop alternative kept farmers in cassava. However, this raises the question of the longer term viability of cassava as the industry stabilizes, as overall yields decline to a low level equilibrium and as output prices come under downward pressure. The task is to transform a dynamic industry, that has been fueled by private costs being lower than social costs, to a sustainable industry where farmers must pay the full cost of soil nutrient extraction.

Costs of Production and Labor Utilization

As yields decline, the farmer's initial means of maintaining profits are by reducing costs. By Asian standards cassava production systems in Thailand are relatively extensive in terms of labor and input use, which in turn reflects the relatively high land-labor ratio existent in the country. Moreover, the existing agricultural frontier and the relatively liberal land policy have further reinforced extensive production practices. The process has thus favored technologies that substitute for labor rather than those that substitute for land.

Labor is the major cost component in cassava production systems. Estimates of labor input per hectare range from 70 to 100 man days. Only maize and broadcast rice have a lower labor input (Table). Additionally, because cassava can be planted almost anytime of the year and can be harvested over a relatively long period, labor activities can be scheduled in relation to other demands for labor. Since upland crops must compete with rice for labor, this flexibility in labor use gives cassava an advantage over other upland crops. Finally, cassava gives the highest average returns per manday of labor input (Boobst *et al.*). Cassava thus is very well adapted to the labor economy of Thailand.

The trend is toward further reductions in labor input. Land preparation through tractors has rapidly spread through the Northeast. With movement to planting in rows, interrow cultivation with animals was employed in those areas that still maintained draft animals. Increases in sales of herbicides have been reported in the major cassava producing area of Chonburi, especially since there were no such sales prior to 1973 (Interim Committee for Coordination of the Lower Mechong Basin, 1979). Thus, farmers have been very responsive to technologies that have substituted for labor; they have not been responsive in the adoption of land substituting technology.

Labor or mechanization costs make up over 85% of total cassava production costs (Table). Input and fixed costs make up the remainder. Moreover, normally about half of production costs are paid in cash; the rest reflects the opportunity costs (evaluated at market prices) of farmer-owned resources. The cost structure reflects some flexibility in absorbing price declines, at least in the short-run, since price declines can be absorbed in terms of lower returns on farmer-owned resources. Major increases in fertilizer would significantly shift this balance, again highlighting the importance for adoption of a consistent yield response.

<u>Supply Response</u>

The reasons behind the rapid expansion in cassava area in Thailand over the last two decades can now be summarized. First and foremost, the crop was very profitable. During the 1971-1981 period average returns to cassava never dropped below 25% and were as high as 145% (Table). Second, the kenaf industry was in decline and even further land was available on which to expand. Given the high yields on uncultivated land, cassava as an income source was unmatched and led to a major increase in incomes in the relatively depressed area of the Northeast. Third, farmers did not face a labor constraint as tractor hire services expanded rapidly in the cassava producing areas.

All of these factors are reflected in cassava supply response. Pongsrihandulchai (1981) has estimated supply equations for cassava by agro-economic zone, and as might be expected, found a very high short-run price elasticity of between 0.58 to 2.78 (the median was 1.77). Price responsiveness in cassava was much higher than in rice (0.27), maize (0.70), kenaf (0.87) or sugarcane (0.62). Moreover, the supply equations suggested that cassava principally competed for land with kenaf, except in the Rayong-Chonburi region, where there were no competing crops with cassava. These equations were estimated while cassava prices were on the whole increasing. The question arises whether farmers would be equally responsive to declining prices and the answer would probably be no. There is limited effective competition between cassava and other crops, reflecting few other cropping alternatives for land in cassava. Farmers would only significantly reduce area if they were operating at a loss.

<u>Technology Development</u>

Research on cassava in Thailand started in 1956 with the creation of the Haai Pong Experiment Station in Rayong. The station comes under the Field Crop Division of the Department of Agriculture and since 1956 has beeen the principal locus of cassava research, although research on other field crops is also done at the station. As research on cassava has increased with the expansion in the crop, other field crop research stations in the northeast have also conducted experimental work on cassava, all of which is coordinated by the Root Crops Branch within the Field Crop Division of the Department of Agriculture.

For the first two decades cassava research focused on soil management and fertilization (see Sittibursaya and Kurmardrita, 1978 for a summary of this research). The principal features of this work are well summarized by the Committee for the Lower Mekong Basin (1979), "high yearly yield fluctuations, probably related to rainfall conditions, rapidly declining yields of unfertilized plots, and variable response to fertilizers". While the research has led to a set of fertilizer recommendations, broken down by soil type, and while a series of farm level demonstration trials were also carried out, only minor adoption of fertilizer has occurred. Some research in this area continues to be done, even though it follows virtually the same approach. The few deviations have been toward evaluation of green and organic manures. These have shown promising results (Table), but have not led to any recommendations.

Lack of progress in the area of fertilization gave impetus to the development of a varietal improvement program. Local clones were collected in 1956. These were evaluated for agronomic characters and yielding ability, but were found not to show significant differences. One was selected and named Rayong 1, which was used as a check variety in all succeeding experimental work. While some selection from collected, open-pollinated seed started in 1971, a controlled hybridization program did not begin till 1974 (Sinthruprama, 1978). Initial crosses were between Rayong 1 and other local cultivars. In 1977 varieties from CIAT were introduced, as well as seed from controlled hybridization. This served to significantly expand the germplasm on which the crossing program was based.

Initial selection is based on high root yield and high starch content. In later evaluations earliness and appropriate plant type for intercropping are introduced as selection characteristics. Promising materials are evaluated for drought tolerance, resistance to the few cassava diseases and pests that occur in Thailand, and in some cases for edible quality characteristics. A testing program of regional and on-farm trials resulted in the release in 1983 of the first promising variety, Rayong 3. Its principal advantages over Rayong 1 are a higher starch content and a higher response to chemical fertilizer. As yet it is too early to evaluate the adoption of this variety.

New production technology has not been necessay to the rapid expansion in cassava cultivation. The high yields obtained with the local variety as new land was cultivated and the high prices set by the European Community were sufficient to maintain high profits in cassava cultivation. These profit levels are now coming under pressure from two sources, the decreasing yields as soil fertility declines and uncertain access to the European Community as the EC attempts to reduce cassava imports. The latter will require lower price levels as Thailand looks to alternative international markets, which in turn will result in a cost-price squeeze at the farm level, effectively increasing the demand for improved technology. The research program is in a position where a new variety, in and of itself, will not have a high probability of markedly improving yields.

This will occur only if the variety is combined with a viable soil fertility management strategy. The first signs of farmer adoption of fertilizer are occurring in the old production areas of Chomburi and Rayong. Motivating this trend will provide the base for yield gains though new varieties.

Markets and Demand

A Synthesis of Production and Utilizacion

Cassava production has grown rapidly in the last two and a half decades, with most of the root production being processed for export. Domestic consumption of cassava is limited to starch and the occasional use of chips in animal feed concentrates. Thailand should be a country, therefore, where cassava utilization and production data are relatively consistent.

A production series is produced both by the Division of Agricultural Economics (DAE) and the Department of Agricultural Extension (AEX), both of which form part of the Ministry of Agriculture and Cooperatives. Both the DAE and AEX maintained the same series through the 1968/69 crop year but diverged then when the DAE changed procedures. In general, the DAE series is most utilized in the literature and is the one reported by FAO. Both series how the same basic upward trend but in any particular year can diverge by as much as 25%.

Converting exports to a fresh weight basis and comparing this export series to the production series (Table) shows that the production data tended to be consistently underestimated in the case of the AEX before 1973/74 and in the case of the DAE before 1982/83. Titapiwatanakun (1979) reviews this discrepancy in some detail and attributes the difference to a failure to accurately monitor the rapid expansion in area, especially where cassava was being planted in more frontier-like conditions in the Northeast. The DAE production series thus provides a relatively consistent underestimate of actual production and the export series probably provides a more accurate minimum estimate of actual production.

The Ministry of Commerce has developed supply and utilization estimates for cassava (Table). These clearly highlight the dominance of the export market, but also identify a not unimportant domestic market for both starch and animal feed. The other dominant component is the very high stock levels being held in this period. The production estimate constructed from utilization data is about 11% larger than the DAE estimate of production. Thus, Thailand provides one of the few cases (Malaysia is the other) where cassava production tends to be underestimated. Moreover, what is of interest for this chapter is the supply and utilization data pinpoint the need for understanding the interaction between the dominant export market, internal consumption, and stock levels.

The Cassava Pellet Export Market

The export market for cassava chips and pellets dominates the Thai cassava economy. High grain prices in Europe, first in West Germany and later within the larger EEC, have provided the genesis for Thai chip and pellet exports. These markets have been able to absorb the rapid expansion in export volumes, to the extent that Thailand has not had to diversify its markets, that is up till 1983. Thai success has given rise to European discontent and in 1982 a agreement for voluntary export restraint was negotiated and signed between the two parties (a lengthy discussion of the structure of the European market, of the history of cassava imports into Europe and of the details of the quota is found in Chapter VIII). The quota, while slowing growth in Thai exports, nevertheless has not stopped it completely (Table).

The pattern of growth in the Thai cassava industry is relatively unique when compared to cases of rapid expansion in other agricultural commodities, especially the grains. The difference comes in the fact that cassava has to be processed very close to the production point, because of its bulkiness and rapid perishability. Sugar cane and palm oil have similar characteristics and in their case relatively large scale processing units have usually been linked to core plantations; though, if properly planned, smallholders can provide a certain percentage of the raw material production. However, in the case of cassava the expansion in root production and processing has been based on linking small-scale producers to relatively small-scale processing capacity. Decentralized, small-scale processing is thus a solution to the problem of minimizing transport costs, where in the case of sugar cane or palm oil the solution is plantations. Moreover, growth in production can be more easily syncronized with needed investment in processing capacity. This is typical of cassava development; other examples are gari in West Africa and farinha de mandioca in Brazil. This development pattern allows cassava both to maintain a small-farm focus, to maximize the employment generation in production and processing, and to distribute more equitably income growth as the industry expands.

The development of investment in processing capacity is portrayed in Table . The data suggest a pattern that first depends on concentration of investment in a few limited areas. About 78% of all chipping plants in 1973 were located in only four changwats; 60% were located in only two, Rayong in the Central Plain and Nakhon Rotchasima in the Northeast. By 1978 these same four changwats accounted for just 41% of all chipping plants. Root production followed much the same, organic, growth process. That is, development of the industry was based initially on the establishment of growth nodes, where increasing density of production made for a more efficient cassava root market. This concentration in turn allowed the orderly evolution of market channels to the export points. By 1978 the next phase in this growth process is apparent, i.e. rapid expansion of processing capacity into other changwats, especially in the Northeast, and expansion in processing scale in those original areas, where production density had reached a certain critical point such that transport costs were not a constraint on scale expansion. A certain production density is necessary to support efficient, large-scale cassava processing.

This organic development of the Thai cassava industry has induced a continual search for cost reductions, especially in processing, storage and transport. In the 1960's this was policy induced, as the EEC varied its tariff rates on meal versus chips (see Chapter VII). The binding of the duty in 1968 provided the market security to justify investments leading to other cost reductions. The first large investments come in the form of pelleting capacity. The objetive here was to reduce transport costs by increasing the density (Table). These were first based on the importation of European pelleters, but this was shortly followed by the manufacture of pelleting machines in Thailand. This gave rise to a quality distinction of brand versus native pellets, with the latter having a lower density, being softer, and not having a pure composition (Mathot, 1974, explores in detail the technical and economic factors determining pellet quality in Thailand).

According to export statistics, Thailand converted from exporting meal and chips in 1968 to exporting virtually all pellets in 1969, that is 750 thousand tons. Reports suggest the first pelleters were established in 1967. Investment in pelleting capacity was thus rapid and was independent of chip processing. Investment in pelleting relied on a significant chip production capacity and a margin defined by transport cost advantages, both internally and in the export trade. Nevertheless, pelleting plants were not large. A 1974/75 survey identified three types of plants: a small-scale plant with an annual capacity of 1260 tons, a medium-scale plant producing 3310 tons and large-scale plants with a capacity of 7280 tons (Titapiwatanakun, 1979). Interestingly enough these were not much larger than the average production capacity of chip plants, and thus suggest no economies of scale in pelleting. That is, since chipping and drying gets over the perishability and transport constraint and since chip production was relatively concentrated, any economies of scale would have suggested investment in larger, centralized pelleting plants.

There were no economies of scale in native pellets; however, for hard pellets produced with steam and/or a vegetable oil binder, scale economies did seem to exist. The cost savings on the utilization side in hard pellets are three. First, density is greater so there is a transport savings. Second, for feed concentrate manufacturers hard pellets do not require as much modification in factory transport systems, i.e. essentially adapted for grains. Third, hard pellets can be stored longer, allowing fewer storage losses. Also, there was a significant declined in dust pollution, which had remained an externality and was dealt with by public funds in ports such as Rotterdam. The price differential resulting from these savings, however, was through the 1970's never sufficient to motivate a larger production or hard of brand pellets. Most major cassava users in Europe, especially in the Netherlands, made the necessary investments to handle cassava in the feed plants and the ports.

Investment in hard pelleting capacity started to increase in 1982 at the start of the quota and by 1985 over 80% of pellet exports were in the form of hard pellets. What is ironical is that investment came at a time when prospects in the EEC market were very uncertain. Two factors prompted this conversion. First, the quota resulted in a large stock build-up, initially due to the quota restriction and beginning in 1983 as a means for the Thai government to allocate the quota (see Chapter VIII). Storage costs (pellet density) and storage time thus become key constraints, leading to an internal demand for hard pellets. Second, the quota allocation procedure forced the big "shippers" [transnational corporations in the international grain trade (see Titapiwatanakun, 1982) who managed the European end of the market] to secure more certain control over supplies in order to guarantee their forward contracting in Europe. They did this by backward integration into large-scale, hard pelleting plants, usually of European manufacture. Thai manufactures did follow with their own, cheaper models to upgrade native pelleting plants. These produce a quasi-hard-pellet, an intermediate product between native and hard pellets.

As the industry developed, lange investments were also made in storage and loading facilities at export points. A reflection of this investment is the change in size of ship that carried cassava. Table charts the progressive change to larger and larger bulk-cassava carriers, which in turn implies investment in loading facilities in Thailand. In 1980 the average cargo size for a ship hauling cassava was 87 thousand tons. This compares to an average size of 41 thousand tons for ships of North American origin. The Thai cassava trade was able to capture significant economies of scale in ocean transport, with Rotterdam being the only port that could take advantage of these scale economies. Prices of cassava pellets in Hamburg, for example, are as much as 50 deutsche marks more expensive per ton than in Rotterdam. Moreover, cassava shipments to the United Kingdom are usually unloaded in Rotterdam and sent on lighter to U.K. ports.

As in biology, so in economics; growth is a far more complex process than surface -- or macro -- appearances would suggest. Thailand in many ways offers an idealized growth pattern for cassava. Early growth based on small-scale production and processing insures syncronization between the two in the growth process. Economies of scale are possible then when critical market size and production densities are reached. It is important to visualize cassava in this more dynamic sense when the comparative advantage of cassava versus grains is discussed later in the chapter. Also, what is important about the Thai cassava case is the rapid growth in investment in relatively small-scale industry and the forward linkages that were made to domestic manufacturing capacity. Investment in small-scale, rural based industries is a particular characteristic of Asian agriculture -- one is tempted to attribute this to the constrained land resource base and the need for alternative employment in the rural sector, the history of investment in the rural sector, particularly irrigation, and generally low incomes which makes even margins in small-scale processing attractive. Cassava is in more ways than one well adapted to Asian conditions (see Chapter IX).

Price Formation: Price is the trottle that has controlled growth in the Thai cassava industry. Understanding how prices for cassava pellets are formed will thus provide a basis for assessing both future prospects and an appropriate response to the EEC quota.

Because the major portion of Thai pellets are exported, of which almost all go to the EEC, the price of pellets in Thailand and the price of pellets in Europe are interdependent. The policy history of cassava in the EEC is discussed in Chapter VIII, but suffice it here to say that, since the binding in GATT of cassava at a 6% ad vaolorem duty in 1968, cassava has had a competitive edge over grain imports, which must enter under the EEC's variable levy system. Since domestic grain prices in the EEC are normally well above world grain prices and through the Common Agricultural Policy insulated from international market conditions, the cassava price is formed within the relative confines of the EEC market. The implications for the cassava price is shown in Figure , where the Rotterdam cassava price and the maize threshold price are compared to the cif price of maize in Rotterdam. Export demand for Thai cassava and therefore the export price is determined by the prices for feed components in the EEC -- import demand for cassava in Europe is analyzed in Chapter VIII.

The structure of the pellet market argues for the formation of cassava prices in the EEC feed component market, with European prices being transmitted back to Thailand. The carriers or shippers are key agents in price formation and transmission. They are the interface between the European and Thai markets. Moreover, cassava is sold on an fob basis in Rotterdam. That is, the shippers assume ownership of the cassava until its unloading in Europe. Grains, on the other hand, are sold on a cif basis, where the feed compounder has assumed ownership in say the Chicago market. Moreover, the major portion of cassava is sold on a forward basis. That is, a compounder contracts a certain quantity of cassava at a specified price for delivery some months forward and the shipper in turn buys in Thailand in order to lock in the margin on his sale. The shipper, obviously, must be in a position to monitor market conditions in both Thailand and Europe, and companies such as Krohn & Co., Peter Cremer and Alfred C. Toepfer are European-base companies with significant investments in Thailand.

To demonstrate the price linkage between the two markets and to evaluate the locus of price formation, European and Thai cassava prices are analyzed in a framework which evaluates "causality" between the two price series. The concept of Granger causality is used in the sense that European prices "cause" Thai prices if the European prices lead the Thai prices in a sense defined by correlation between lags in the two series (see Bessler and Brandt, 1982; Spriggs, Kaylen and Bessler, 1982; and Adamowicz, Booh, and Hawkins, 1984). The methodology rests on prefiltering any autocorrelation in each series using an ARIMA. In this case the series of residuals could be reduced to a white noise series using the same prefilter -- this allows a valid test of Granger causality (Sims, 1972). The residuals were then cross-correlated with varying lags. The correlations then suggest the degree to which European prices lead (cause) Thai cassava prices.

Four European price series are utilized, representing two markets, Rotterdam and Hamburg, and representing spot market prices and the two-month forward contract price. All European prices from the German agricultural market intelligence paper, Ernahrungsdienst. These series are analyzed in relationship to the Bangkok wholesale price for cassava pellets, published by the Thai Tapioca Trade Association in their Tapioca Products Market Review. Prices were available on a bi-weekly and a monthly basis and a series of both time periods are analyzed from 1974 through 1985. The period is divided into two, pre-quota and post-quota, in order to assess the impact of import restrictions on price relationships between the two markets.

The cross-correlations between the Thai and European price series are presented in Table . First, considering only the bi-weekly series, two structural features of the market are confirmed; that is, the forward price generally gives a higher correlation between markets than the spot price and in the case of the forward price the Rotterdam market is more closely linked to the Thai market then is the Hamburg market (for the spot price the correlations are virtually the same comparing Rotterdam and Hamburg).

Considering then only the case of the forward price, Bangkok and Rotterdam prices in the 1974-82 period are significantly instantaneously correlated, i.e. within the two-week time frame. This represents relatively effective flows of information between the two markets and therefore relatively close price integration. Somewhat contrary to expectation there is also some residual tendency for the Bangkok price to lead (cause) the Rotterdam price. In the very short-run this indicates that the short-term supply situation in Thailand, i.e. the ability of the shipper to fill his forward contracts, influences the price negotiated in Europe. This situation is even more marked in the case of Hamburg and again indicates that Hamburg is not as rapidly integrated with the Bangkok market as is Rotterdam.

The quota has radically changed this situation. The strength of integration between the two markets has declined, as reflected in the lower correlation coefficients. As will be shown later, this is reflected in a widening in the margin between the two price series. Moreover, although instantaneous causality between the two series is still apparent, European prices under the quota lead Bangkok prices. Under the quota short term supply needs are adequately met by stocks while in Europe cassava supplies are constrained by the quota. Cassava does not have to sell at much of a discount to grains in order to move available supplies. Therefore, short-term price formation shifted over to demand side factors but with a declined is the strength of the direct price transmission back to Thailand.

Price transmission between Europe and Thailand in the past has run in both directions, but for monthly data at least the above analysis suggests that Europe leads the Thai price. The price transmission process is then analyzed by making Thai cassava prices a function of European prices at varying lags, the transport costs, and a dummy variable for the quota period. The results in Table suggest that only 49% of price changes in Europe is passed back to Thailand in the first month and another 29% in the second month. The transport cost variable was negative as expected, but not significant. This was due to the inability to construct a series that reflected the change in scale of shipping during the period; the variable as specified assumes the same size ship. Finally, the dummy variable for the quota period is negative, implying that the margin between Europe and Thailand has widened under the quota. This is to be expected, with upward pressure on cassava prices in Europe due to a constrained supply and downward pressure on prices in Thailand due to rising stock levels. As is explained in Chapter VIII Thai quota management policy has utilized this larger margin to finance third-country exports, rather than allowing a widefall profit to accrue to cassava export companies.

The previous analysis has argued that the locus of price formation in this cassava market occurs either at the level of negotiations between the shipping company and European feed manufacturer or between the shipping company and Thai suppliers, the type of supplier depending on how for back into the market the shipping company is integrated. This implies that root and chip prices are determined by pellet prices, whether set in Europe or in Thailand. This pattern is distinct from grains, were normally processing is a mark-up on grain prices set in bulk wholesaling markets. In the cassava situation the standard accounting for the chip and pelleting processing are:

$$P_c = c_c P_r + C_c + R_c \quad \text{and}$$

$$P_p = c_p P_c + C_p + R_p$$

where P represents price, c is conversion rate, C is operating cost and R is operating profit and the subscripts refer to roots(r), chips(c), and pellets (p). However, given the assumptions on price formation, price transmission equations are as follows:

$$P_r = \frac{1}{c_c} P_c - (C_c + R_c) \quad \text{and}$$

$$P_c = \frac{1}{c_p} P_p - (C_p + R_p)$$

Making the variable stochastic and assuming an error, the above equations were estimated and the result are presented in Table . The pellet equations follow expectations, with the estimated conversion rates being within a reasonable range of, but somewhat below, the figure of .976 cited by industrial sources. The estimated operating margin (per 100 kg.), however, is significantly below the actual budgeted costs of pelleting (see below). Nevertheless, what the price transmission equations for pellets do suggest is quite restricted margins and therefore a very competitive industry.

The chip equations, on the other hand, only partially confirm expectations. The conversion rates in Chonburi and Rayong are very close to the .372 figure used by industrial sources, while the estimated conversion rate in Korat is unreasonably high, suggesting a far higher level of efficiency than can be expected to be the case. On the other hand, the operating margin estimates cover a wide range, from being reasonable in Korat to being significantly positive in Chonburi, i.e. reflecting operating losses. The equations reflects a delicate balance between operating margins and conversion rates, a binding charactistic in the profitable operation of a chipping plant. The equations again suggest the limited margins within which the chipping plants have to operate to turn a profit. Given the chip price, competition within the industry has generated relatively high root prices and limited operating margins.

Price formation, in summary, in the Thai European pellet market is efficient, reflecting the very competitive nature of the Thai cassava industry. Any excess profits, when they occur, either accrue to cassava farmers or result in inflated margins for the shipping companies. The later has occurred as a result of the imposition of the quota but Thai policy has issured that these windfall profits are directed towards opening up new markets for cassava pellets.

Profitability of the Cassava Pellet Industry: The very marked rate of growth in the Thai cassava industry relative profitability of the industry, especially since prices set in Europe were efficiently transmitted to cassava root prodcuers. The profitability of cassava at the farm level is hown in Figure , which presents a graphic picture of margin development in the cassava industry. Farm-level profits were highly variable but, even in years with low prices, profits were significant. Not surprisingly root production showed continuous growth, even with quite significant variability in prices.

Another major characteristic of the cassava industry is that the farm-level root price makes up only between 40 to 50% of the eventual f.o.b. price. By comparison farm level production costs make up 83% of f.o.b. costs of maize in the U.S.A. (Ortmann, Stulip, and Rask; 1986). The ability of cassava to compete with grains thus lies in its relatively low production costs and an efficient processing industry. As seen in Figure , the processing margin did not vary significantly over the 1975-84 period.

Cassava is very profitable for Thailand. A complete cost accounting for 1981 is summarized in Table (see Appendix for details). The costs are disaggregated by domestic factor costs, foreign import costs, and government taxes, including tariffs. All costs are at 1981 market prices, with interest rates being at the commercial loan rate of 19%. There are no indications of any market imperfections that would cause market prices of factors to deviate from their opportunity cost (see Bertrand, 1980 and Lokaphadhana, 1981). Nor until the quota was there any intervention by the government in the cassava export trade. The Thai cassava industry was one of the few examples of an industry that functioned without government intervention. Deducting taxes and tariffs thus closely approximately social costs of producing cassava.

The cost breakdown suggests that root production costs are two-thrids of total f.o.b. costs of cassava pellets. Chipping, pelleting, and export costs relatively equally divide the other third. Labor is by far the largest cost component, making up 47% of total costs. Import costs are relatively low, making up only 11% of production costs. Comparing costs to 1981 prices implies that almost 30% of the f.o.b. price was garnered by the economy as social profit, with almost two-thirds of that going to the cassava farmer. From a social point of view cassava was very profitable to the Thai economy, and especially for the incomes of the population in the poorest sector of the economy, the rural Northeast.

The quota has made apparent the political underpinnings of the international market for cassava pellets. Uncertainty about long-term access to the European market has raised the question about the ability of the Thai cassava industry to compete in the larger, international feedgrain market. The first point to emphasize is that because Thailand did not sell cassava in the international feedgrain market up till the quota does not necessarily imply that cassava could not compete in that market. The analysis to date and that presented in Chapter VIII clearly shows that Thailand could sell all its production in Europe at prices above what could have been obtained on the world feedgrain market; obviously, it was more profitable for Thailand to sell all its production in the European market. This situation has changed with the quota. Here the issue of cassava's ability to compete in the wider feedgrain market is addressed. In Chapter VIII, the issue is addressed of how Thailand develops that market while continuing to garner the social profits from the quota allottment.

International comparative advantage has commonly been analyzed within a domestic resource cost framework (Pearson, Akrasanee, and Nelson, 1976).

This methodology takes border prices (f.o.b. prices for exporters and c.i.f prices for importers) as the measure against which comparative advantage is assessed. A good summary statistic is the resource cost ratio (Page and Stryker, 1981), where any country with a ratio less than one has a comparative advantage in the production of that commodity. For cassava in 1981 using cassava f.o.b. prices, the RCR was .71, indicating significant comparative advantage in supplying cassava to the European market. To evaluate social profitability of selling on the international grain market, the break-even price (the f.o.b. price at which the RCR is one) is calculated. This price is $77/t. Assuming that under normal circumstances cassava competes with maize at about .7 of the maize price (see Chapter VIII), then the maize equivalent price is $110/t. This compares very favorably to the f.o.b. price of maize in Thailand and in the U.S. in the 1980's.

The issue can be taken one step further and f.o.b. costs compared to f.o.b. costs of major maize exporters (Table). Comparing Thai cassava costs on a maize equivalent basis with those developed by Ortmann, Stulip and Rask (1986), shows that cassava is very competitive with major maize exporters. How much cassava Thailand will produce at currently declining world market maize prices is another issue but the same could be asked of countries such as the United States and France if price and income support policies were eliminated.

In summary, the Thai cassava industry has shown itself to be very responsive to export opportunities and to the vagaries of policy changes in import markets. The EEC became virtually the sole market for Thai pellets essentially because it was the most profitable outlet. Moreover, because of efficient price transmission between the two markets, Thailand could respond very quickly to the changing needs of the European market. The imposition of the quota in 1982 has forced Thailand to begin to restructure its export markets, a subject discussed in Chapter VIII, what that analysis shows is that Thailand has adjusted to the quota by opening new markets in East Asia, thereby allowing domestic production to continue to grow.

The growth of the Thai pellet industry also offers a more general lesson about the development of comparative advantage in the crop. Comparative advantage of cassava versus grain substitutes is based on certain physical characteristics, particularly the availability of land with low opportunity cost and an agricultural sector with a relatively small, farm-size structure. However, there is also a time and scale dimension to comparative advantage because of the critical importance of the processing component, since it makes up from a third to a half of the total costs. In cassava, economies of scale in processing develop over time in relation to the concentration of production, on the one hand, and the size of the output market, on the other. Malaysia and Indonesia have attempted to force the issue through plantation development, but in cassava these have not been notably successful. The social equity benefits from cassava development (marginal agricultural areas, small-scale producers, and rural employment in small-scale agro-industry) provide strong support in certain circumstances for an infant industry argument to support cassava in the initial development of its processing capacity. In Thailand this initial "protection" was provided by the EEC market. The Thai case suggests that cassava can compete with grains, but in the evaluation of the comparative advantage of cassava in the feedgrain market a time perspective should be incorporated for processing costs.

The Cassava Starch Market

The cassava industry in Thailand developed initially on the basis of the market for starch. Starch production and exports have continued to grow throughout the post-war period, but the industry has declined in relative importance, having been eclipsed by the cassava pellet market. Nevertheless, the cassava starch industry in Thailand vies with Indonesia as being the largest in the world. It continues to be dynamic, suppling starch to both an expanding export market and an increasing domestic market.

Constructing a supply and utilization series for cassava starch must rely on data from different sources and this produces some inconsistencies. The series in Table is developed from independent export, production, and utilization estimates and represents the author's efforts at achieving consistency between the estimates. What the data suggests is quite significant growth in starch production, driven through the 1970's by rising domestic consumption and in the 1980's by a sudden spurt in the export market.

Cassava starch has a wide number of end markets in Thailand. The principal uses are as a raw material in the production of monosodium glutamate. In this industry starch competes directly with nolasses, which is interchanyeable. Starch is also important expanding pulp and paper industry, in textile production and in food industries. All of these are growing industries and cassava starch will continue to enjoy an increasing domestic market throughout this century. However, unlike other starch markets in East Asia, one market which cassava starch has not entered is the glucose and sweetner market. This is principally because Thailand is a producer and net exporter of sugar. High fructose sweetners derived from cassava have been advocated as another possible market, since 52% of industrial sugar consumption is for beverage production (Frankel, 1981). Moreover, the Thai government has a policy of subsidizing exports when world prices are low nd taxing exports when prices are high (Lokaphadhana, 1981). Nevertheless, the price variability in cassava starch prices has made the investments needed in large-scale plant and capacity too risky and there has been no development in this market.

Thailand is virtually the sole exporter of cassava starch and the largest exporter in the world of starch in general. The export market was relatively stable through the 1960's and 1970's but increased dramatically in the 1980's as new, non-traditional importers came into the market (see Chapter VIII). Thailand between 1980 and 1985 was able to expand exports by 50% in two years and virtually to double export volumes in four years, without too much affect on domestic consumption levels. This suggests the investment in significant excess production capacity for starch, on the one hand, and the ability of the starch industry to compete effectively for roots -- in 1984 and 1985 root prices were relatively low due to the quota.

The starch industry needs to be very competitive in the sense that its margins are defined by root prices principally set by the pellet export market in the EEC and starch export prices set principally by international maize prices, i.e. the dominant cost in maize starch production (see Chapter VIII). The starch industry very early began a search for scale economies in processing, essentially based on large-scale plants but with equipment manufactured in Thailand -- in Indonesia, on the other hand, these scale economies in starch production do not exist (Nelson, 1984). Based on the development of this market, Thailand is now net exporter of cassava starch equipment, including complete plants. However, with this investment to lower processing costs, excess processing capacity was created, allowing the industry to respond so quickly to new export markets.

Price Formation and Profitability: Like other cassava processing industries, profitability in starch production is primarily dependent on the margin between the root buying price and the starch selling price and the conversion rate. Unlike the pellet industry, where the price of the processed product lead the price of roots, the starch industry must take the root price as a given. The starch industry rarely has been able to under bid the chipping plants. The root price thus sets the price of starch. Competition for limited markets in turn insures both downward pressure on margins and the search for relations in processing costs.

The above scenario for price formation is adequately capatured in the price transmission equations in Table and the processing cost analysis in Table . Note that contrary to the chip industry, starch price is the dependent variable in the regression equation. The estimated conversion rates are only slightly higher than the estimate of 4.34 tons of roots for every ton of starch given by industrial sources. Even the estimated rates suggest very high technical efficiency in starch extraction. The estimated operating margin compares favorably with the budgeting analysis in Table . Again, the evidence suggests a very competitive industry, where there is no indication of excess profits. Moreover, a domestic resource calculation would be redundant in the case of Thai starch, since Thailand sets the world price for cassava starch and apart from import duties of starch processing equipment, there is no government intervention in the starch market.

Continued growth in the starch industry is dependent principally on the supply price of starch, which in turn is dependent on the root price and the changing dynamics of the pellet market. The tendency in the medium term is for cassava starch prices to come in line with maize starch. The other major factor, of course, is growth in export markets. Prospects in the international starch market are analyzed in Chapter VIII.

World and Regional Markets for Cassava Products

World trade in cassava products has increased rapidly over the last three decades, rising from about 200 thousand tons (in product weight) in the early 1950's to a peak of 8.4 million tons in 1982. The latter represents a little less than 20% of total world production of cassava, a very significant figure when compared to a commodity like rice, where only 4% of production moves in world trade. While the volume traded is sizeable by world commodity standards, eg. world rice trade amounts to a little over 8 million tons, the number of countries involved is relatively small. In fact, over 90% of trade is accounted for by exports of Thailand to the European Community. For a commodity trade of such volume, this is a particularly narrow base.

Trade dominates the cassava economy only of Thailand and, in the 1980-82 period, China. Trade achieves a more limited importance -- although rarely exceeding 10% of domestic production -- in Indonesia and Malaysia. In all other cassava producing countries international trade has rarely been an option and is currently of only marginal importance. This relatively unique trade structure raises a number of issues which will be explored in this chapter. Most importantly, the reasons surrounding the relatively narrow participation in world trade in cassava products will be examined. This analysis will then lead to an evaluation of the potential for broadening the import markets for cassava, followed by some prognosis for increasing the number of exporting countries. The discussion will be rooted in an historical evaluation of the changing determinants of comparative advantange, an approach which will allow some speculation on the future role of cassava in world markets for carbohydrate sources.

Protectionism and Substitution: Decline in the World Starch Trade

World trade in cassava started with starch exports from the Malayan peninsula in the mid-1800's. Early trade relied on cassava's advantages as a starch source, the higher value-added of starch compared to other processed cassava products, and the proportionately lower freight costs for starch compared to dry cassava. Starch was the major cassava product in value terms moved in world cassava trade throughout the present century up till the 1960's. The market for starch is relatively small in comparison to trade in wheat or feed grains. Moreover, while this market exhibited moderate growth from the turn of the century to the Second World War, there has been little growth in the post-war period while the grain trade has grown at historically high rates. Underlying these trends in starch is a market structure undergoing signficant change, influenced by shifting comparative advantage, dynamic technical change, rapidly shifting end markets, and trade barriers. It is in these terms that the world market for cassava stárch will be analyzed.

Demand for starch is marked by the product's versatility. Almost every major industry has found a use for starch and as a result, the process of industrialization normally coincides with a significant increase in the demand for starch. This industrialization affect is partially reflected in the historical series on imports of cassava starch over the present century. At the turn of the century the United Kingdom was the largest importer of cassava and other starches. By the 1920's the United States, although a major producer of starch itself, became the largest importer. In the late 1970's, the U.S. was overtaken by Japan, and in the early 1980's Japan was superceded by Taiwan. This pattern closely tracks the industrialization process characterizing the world economy over the present century.

However, a possibly more important phenomenon is the eventual decline of imports of cassava starch into principal markets. This decline in imports is not due to any falling off in overall starch consumption but rather the substitution of imported starch by domestically produced starch. Over time this substitution process has been accelerated, on the one hand, by advantages in starch chemistry and the ability to chemically modify starches, thereby making starches more substitutable, and, on the other hand, by technical change in both maize production and the maize wet milling process, reducing the unit costs for this starch and making it over the post-war period the predominate starch produced in the world. Events in the U.S. played a dominant role in the declining market share of cassava and the rising share of maize in world starch consumption. The analysis thus turns briefly to a consideration of the starch industry in the United States and the effect this industry has on the world starch market.

By the turn of the century, following on the development of a successful processing technique in 1842 (Radley, 1968), maize was the dominant starch produced and consumed in the U.S. Production of maize starch increased from 141 thousand tons in 1904 to 2.27 million tons in 1982, a sustained annual growth rate of 3.6% over the course of almost 80 years (Table). This growth in production speeded up in the post-second-world-war period, rising to an annual rate of 4.8% between 1954 and 1977. In this same post-war period exports of maize starch fell, while imports of cassava starch first increased through to the mid-1960's and then fell dramatically to levels not reached since the turn of the century. A convergence of factors influenced these trends in production and trade in maize starch but the driving force was the declining real price of maize in the U.S. during the post-war period -- except for a small hiccup in the years from 1972 to 1976 (Table). The declining price was due to rapid technical change in maize produciton in the U.S., as per hectare yields increased from 2.4 tons in 1950 to 7.6 tons in 1986. The consequences of this were far reaching in its effect on world starch production and trade.

In the U.S. the declining price to the maize starch industry for its raw material allowed the industry to expand its markets, resist the invasion of traditional markets by synthetic resins, and to substitute for imported cassava starch. The two dominant trends in the U.S. starch market was the expansion of starch use in the paper and cardboard industry (Table) and the technical advances in the modification of starch. The expanding starch use in the paper products industry caused the increasing demand for unmodified starches, while advances in starch modification and the advent of waxy maize allowed import substitution and continued competitiveness in the other end uses. Thus, over the post-war period unmodified starch maintained its market share while the number of different types of modified starch expanded significantly (Table). Finally, the wet-milling industry was able to achieve increasing returns to scale in processing as output per plant has expanded rapidly over the period (Table). Technical dynamism in raw material production, in processing, and in utilization have created exceptional growth in what on the surface should appear to be a relatively traditional, stable industry.

A more recent outgrowth of this technological dynamism in the maize wet milling industry is the rapid growth in high fructose corn sweetners (HFCS). However, the possibly more important dimension to the very rapid growth in the HFCS market is the strong interplay between product substitution and price policy in an already well established market. U.S. sugar policy in the post-war period has been directed to maintaining the incomes of domestic producers, usually against imports from more productive, tropical producers. The rise of the HFCS industry has been due essentially to the protection given the domestic sugar market and the falling relative price of maize. One result has been falling imports of sugar into the U.S. from developing countries, but the salient point in the present context is that tariff policy and product substitution have been the dominant elements influencing both HFCS production in the US and world trade in starch.

Nevertheless, before returning to the world starch market, the analysis of the U.S. market for cassava starch will first be completed. Cassava starch has enjoyed two markets in the U.S.: a speciality market where cassava starch is utilized for its particular characteristics and the broader starch market where starches from different sources are substitutable. The non-speciality market has changed over time. In the early part of the century cassava starch was utilized principally for the manufacture of adhesives or glue, especially for furniture manufacture and for envelopes and stamps. With the advent of resin glue and natural gums, these markets disappeared, to be replaced in the 1950's by the paper industry, where cassava starch was used as a corrugating adhesive. These represented large markets, where other starches could have substituted, and cassava starch was used because of its competitive price. In 1928 the c.i.f. price of Javanese cassava starch in New York was $2.31 per 100 pounds, compared to a maize starch price in Chicago of $3.25 per 100 pounds (Committe on Finance, U.S. Senate, 1929). Thai cassava starch was very competitive with domestically produced maize starch through the 1950's. The cassava starch market share increased from 3.6% in 1952 to 14.1% in 1961 (Arthur D. Little, Inc., 1963). By 1968 cassava starch had ceased to be competitive in the broader industrial market and imports declined dramatically.[1/] Cassava starch has maintained its speciality market in the food industry, but at a relatively insignificant level of around 30 thousand tons. The largest import market for cassava starch over the course of about 50 years was no more.

Responsibility for this dramatic shift in cassava starch imports lies partly with the technological advance taking place in the maize industry and partly with the changing international price for cassava. During the 1960's the linkage between international maize and cassava prices was severed by the creation of the European Economic Community (see the next

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1/ Not coincidentally, 1968 is the year when a tariff hole was opened for cassava feedstuffs in the EEC. This topic will be discussed in the next section.

section for details). The 1960's witnessed the rise of the dried cassava animal feed trade, where cassava chip or pellet prices were linked to the internal grain prices of the EEC and not to the international grain market. Post-war growth in cassava starch trade was halted and throughout the 1960's and 1970's world exports of cassava starch remained stagnant at around 200 thousand tons. However, stagnation did not turn into decline as there was a major restructuring of import markets.

This restructuring had two principal components: the rise of new import markets in Asia and the transfer of maize wet milling technology to major markets, usually through investment by the Corn Products Corporation of the USA. By far the more important element in this restructuring was the development in major markets of a domestic capacity to produce maize starch, usually based on imported maize. This displacement of starch production based on domestic sources, such as rice, potato and wheat, by starch production based on imported maize occurred essentially in the post-war period. Several factors spawned this development, in particular the declining real price of maize in international markets, the cost savings in bulk shipping of grains -- to the extent that starch became more expensive to ship than grains --, the very high tariff barriers in most markets for imported starch, generally much lower tariffs on imported maize in order to support the growing animal feed sector, the technical advances in the maize wet milling process, and the high value of the sub-products, especially the oil and gluten. Thus, maize starch became the principal starch produced in the U.K., all five countries in the original EEC, Spain, and Japan and at the same time maize starch exports from the U.S. declined to insignificant levels. In 1980, out of an estimated world production of starch of 16 million tons, maize starch accounted for 77% (Jones, 1983).

Cassava must move in international trade in a processed form and therefore cassava must buck the post-war trend in international agricultural trade, where bulk movement of raw materials has dominated. Cassava starch has been one casualty of these developments, trends that have been set in motion by technical change and agricultural trade policies. This, however, has not prevented cassava starch from carving out new markets, essentially by minimizing transport costs and by breaching trade barriers. These new markets have come in Asia and the importance of transport costs in the development of these markets can be seen in Table

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Japan developed as a major importer of cassava starch in the 1970's but imported cassava starch was always of secondary importance in domestic markets because of trade restrictions. Japan erected a relatively elaborate set of import restrictions designed, on the one hand, to protect domestic raw material producers, especially sweet potato and potato farmers, and, on the other hand, to meet the needs of a growing domestic starch market. Starch production in Japan increased from 895 thousand tons in 1962 to 1,768 thousand tons in 1980, to become the world's second largest starch producer. Whereas in 1962 sweet potato and potato starch accounted for over 80% of total production (Business and Defense Services Adminsitration, 1967), by 1980 the production share had fallen to 20%. In this period in which the production of sweet potato starch fell, the production share of maize starch increased from 9.3% in 1962 to 75.8% in 1980. Even though maize used in starch production comes under the quota and tariff system, maize starch has come to dominate the domestic market.

Part of the reason is that the major use for starch in Japan is for sweetner production; this accounted for 57% of total consumption in 1978/79 (Jones, 1983).

The cassava starch that is imported services partly a speciality market and partly those industries where cassava starch is subject to quota rather than a 25% ad valorem duty (see Jones, 1983 for a detailed discussion of the Japanese trade protection system for starch). Thus, cassava starch was able to take advantage of the rapid growth in the Japanese starch market but cassava starch only filled in at the margin. Without trade liberlization there is little scope for a large role for cassava starch in the Japanese market, even though imports will fluctuate to a certain extent depending on the import price as happened in 1984 when Thai export prices declined markedly.

However, rapid industrialization in the countries of the Pacific rim have geneated new markets for cassava starch. In 1980 Taiwan became the largest importer of cassava starch. Imports increased from an average of around 10 thousand tons in the 1973-76 period to over 100 thousand tons in 1981-84. This was due to falling domestic production, especially for cassava starch, and rapidly rising demand. Imports went from 4% of domestic consumption in 1975 to 52% in 1980 (Jones, 1983). The only dynamic component in the domestic starch sector was maize starch, where production increased from 17 thousand tons in 1975 to 45 thousand tons in 1980 (Jones, 1983). However, one factor has limited the growth of the maize starch industry and that is a domestic sugar industry. This has forestalled movement to an integrated starch-sweetner technology, while market size has limited scale economies in processing. On the other hand, tariffs on imported maize of 3% are much more favorable than the tariff of Taiwan $1500 per ton on cassava starch -- a rate of about 16% on 1980 cif prices. The future for cassava starch imports into Taiwan hinges on developments in the domestic maize starch sector and here domestic sugar production and scale economies will probably be the driving forces.

The market analysis above provides sufficient reasons for the stagnation at around 200 thousand tons in the world trade in cassava starch over the course of the 1960's and 1970's. What then is surprizing is the very significant expansion in export volumes in the 1981-84 period. In 1984 Thai exports of cassava starch reached an historical high for any country of 465 thousand tons. The U.S.S.R. suddenly entered the market in 1982, importing very large volumes of cassava starch. Singapore, also, became an importer of some substance and Hong Kong has continued to import about 10 thousand tons. However, most interesting of all is that Indonesia imported almost 100 thousand tons in 1982 and over 50 thousand tons in 1983, while Malaysia came into the market for over 10 thousand tons in 1984. All of these are essentially Asian markets and Malaysia and Indonesia are as well major producers of cassava starch. A major devaluation in 1981 and particularly low root price in 1981 and 1984, partly precipitated by the Thailand-EC quota agreement, made cassava starch especially competitive in regional markets. This increased Japanese and Taiwanese imports and made Thai starch competitive with domestically produced starch in Malaysia and Indonesia. Supply side factors, thus, also have an impact on the world market and the analysis thus turns to a brief summary of export trends.

Historically, exports of cassava starch have usually been dominated by a single country, except in relatively brief periods of transition between countries. Comparative advantage in cassava starch production has shifted quickly and dominance is virtually total. Thus, comparative advantage shifted from Malaysia to Indonesia in the period 1907 to 1913 and from Indonesia to Thailand during the Second World War. The first transtition was precipitated by the rubber boom in Malaya, while the second came as a result of the ravages of the war and the demise of the colonial regime in Indonesia. There were thus clear reasons behind the rapidity of the transition period but what is less clear is why single countries should dominate in world cassava starch trade.

A major part of the reason for this dominance is the relatively small size of the world market and the inherent riskiness in scaling up an export-oriented industry in such a thin market. In both transitions, the precipitating cause of decline in the leading country was a loss of profitability in the production of cassava starch. In Malaysia this was due to the rising opportunity cost of land due to the expanding rubber industry and in Indonesia it was due to the destruction of processing capacity and the demise of the plantation systems of Java, where land costs under a colonial administrator did not reflect its true scarcity value. On the other side, in the expanding countries growth in investment in processing and in turn increased cassava production had to be motivated by a significantly large profit margin. This initial establishment phase was usually based on a period of relatively high world prices and some factor which made cassava production particularly competitive, i.e. some basis for comparative advantage. In the case of Indonesia the basis of comparative advantage was a substantial and relatively cheap labor force, a plentiful water supply, international capital availability, relatively liberal terms for plantation development in upland areas, and an existing, smallholder production base. However, the initial base for comparative advantage was reinforced over time by development of excess processing capacity (and therefore quicker supply response), established marketing channels, and a research capacity for developing new technologies. Consolidation of the cassava starch export industry made entry by other countries into this market virtually impossible.

Comparative advantage in thus not just a matter of intrinsic factors which make a country particularly competitive. If export dominance can be established, further evolution in the industry tends to reinforce comparative advantage. That is, comparative advantage in international trade can be created and does not necessarily depend only on initial endowments. To a very significant extent, Thailand created its particular comparative advantage in the production of cassava starch and later cassava pellets. This was based on the development of a major road system, especially into the Northeast, a relatively liberal land policy together with an unexploited frontier, an indigenous engineering capacity so that starch processing factories could be manufactured locally, an existing, well-developed export sector based on rice, and commercial middlemen with the capital to invest. Thailand had exported cassava starch as early as the 1930's but it was not till the demise of the Indonesian exports that the Thai cassava starch industry began to expand, under the impetus of high prices following the Second World War. By the mid-1950's Thailand was unchallenged in the world cassava starch market and by the 1980's both Malaysia and Indonesia were importing cassava starch from Thailand.

The cassava starch industry in Thailand faces two principal constraints on further expansion, both of which are due to trade policies of other countries. The first is the high tariff barriers for starch in practically all major import markets except the U.S. Since cassava starch moves in world trade in a starch form rather than as a raw material, differential trade barriers have resulted in cassava starch not being able to take advantage of the relatively buoyant growth in demand for starch, whereas maize has captured much of the market. Moreover, the only other exports of starch of any signficiance is potato starch from the Netherlands. Potato starch has difficulty competing with maize starch within the EC and substantial subsidies are necessary to export these surpluses. Annual exports from the EC of about 150 thousand tons further decreases the international market for cassava starch. A policy constrained market very much characterizes world trade in cassava starch, even though some price elasticity does exist, as is characteristic of a product with such close substitutes.

This price elasticity is closely linked to the second constraint. In Thailand the starch industry must compete with the pellet export market for cassava roots. Because prices for pellets are defined by internal EC grain prices, the chip and pellet industry makes the price of roots significantly more expensive than if the industry had to compete at world maize prices, which the starch industry must do. The starch industry usually comes into the root market during the rainy period when root prices are low and root demand from the pellet industry is also low. As root prices rise the starch industry is usually caught in a price squeeze and often must cease operation. Significant excess capacity thus normally exists in the industry. Thus, with the low root prices caused by the quota, the starch industry was able to double its exports. Thailand is often constrained in expanding its starch market by the particular policy context of cassava within the EC -- for Thailand this is not a loss since the social profits for selling pellets in the EC market more than compensate for the loss of starch sales.

Future prospects for world trade in starch are, if anything, unpredictable. No studies predicted, nor could have predicted, the rapid expansion in cassava starch trade in the 1980's after two decades of stagnation. The only feature that is clear is that Thailand will continue to dominate exports for the foreseeable future and the prospects for any other country entering the market at any substantive volume are minimal.

The world starch market is really something of an allegory for the history of cassava. The lessons are essentiallty three. First, rarely, if ever, have there been policy interventions by domestic governments in their cassava producing sectors. On the other hand, policy interventions by importing countries either directly on imported cassava or indirectly on domestic substitutes have continually influenced cassava's trade prospects. Second, prior to the Second World War cassava products were very competitive with grain products, even considering the relatively high cost of international shipping. Third, the basic change between the pre-war and post-war position of cassava has been the rapid technical change in grain production in temperate, developed countries, especially the U.S. The relative shift in comparative advantage between tropical cassava and temperate grains has been due to very large differences in research expenditures on grains versus cassava. Every allegory has its moral and the two morals of this tale are that cassava's continued role in international trade is testimony to its inherent productivity and that modern comparative advantage is not fixed in stone but will depend essentially on technical progress, together with economies of scale of post-harvest handling and processing.

Protectionism and Substitution: The Rise in Trade in Cassava Feedstuffs

Apart from Thailand and Malaysia, cassava starch production has normally been a component of a wider cassava sector, where the bulk of the production normally went to food uses. In many cases these were dry products, such as gaplek in Indonesia or farinha de mandioca in Brazil. Prior to the early 1960's surpluses of these products were often exported, principally to be used as an animal feedstuff in European countries. Volumes in this century prior to 1960 were never large, only rarely exceeding 200 thousand tons in a single year. By comparison, the international maize trade was normally around 4 to 6 million tons during this period, having reached a peak of 13 million tons in 1937 (International Institute of Agriculture). Argentina and Eastern Europe were the main suppliers of maize in this period, and international transport costs and the more rudimentary state of balanced feed technology limited the development of a wider trade in cassava feedstuffs.

The current large trade in cassava pellets was essentially policy-induced. The origin of this trade was essentially German price policy in the 1950's. Western Europe in the immediate post-war period was the principal market for feedgrain imports. Germany, nevertheless, developed a policy of high domestic grain prices to support the income of its own farmers (Figure). The rapidly expanding animal feed sector, however, had significant incentive to try develop cheaper supplies of carbohydrate sources, with cassava being a potential grain substitute. German companies in the 1950's began developing supply sources in Indonesia and Thailand. German imports of cassava in 1955 were 131 thousand tons; in 1959 import levels were 240 thousand tons and in 1960, 323 thousand tons. The year 1960 marked the point at which Germany turned from Indonesia to Thailand as a principal source of supply. During this period the other European countries were relatively minor importers of cassava.

The formation of the European Economic Community and its associated Common Agricultural Policy served to expand the market that German policy and German companies had developed. The first stage come in July 1962 when the variable levy and support price system become effective for all feedgrains. The agricultural common market rested on two prices. The intervention price is the guaranteed minimum price for farmers at which marketing agencies throughout the E.E.C. are committed to buy the grain. The threshold price is the minimum price at which grain imports from non-E.E.C. countries enter the community. The variable levy is the difference between the threshold price and the current c.i.f. import price. Internal prices are thus insulated from world market prices and operate within a band between the floor on, intervention price and the ceiling on, threshold price. Bringing all internal prices into line was done gradually and it was not until July 1967 that all national intervention and threshold prices were unified and border taxes were abolished.

During this process cassava was not overlooked but nevertheless was treated differently. Initially in 1962 only cassava meal imports were subject to tariffs. These consisted of a fixed component and a variable component based on the barley variable levy. After various changes by November 1964 the meal levy was fixed at 25 percent of the barley levy plus 2.5 units of account (the European Community accounting unit) per ton (see Nelson, 1982, for further detail). In July 1967 chips and pellets were brought under tariff regulation and these products faced a variable levy of 18% of the barley variable levy and no fixed charge. The meal tariff remained the same. The most important change, however, come in July 1968 when, as part of Kennedy Round of the GATT negotiations, the levy on cassava pellets and chips was bound to a maximum 6% ad valorem basis. Cassava meal was not bound and continued to be subject to the higher duty.

The pattern and trends in cassava imports were remarkably sensitive to these policy changes. First, the form in which cassava was imported changed with the differential duty structure. Meal was the principal form of imports prior to 1962. With the slightly higher duty structure for meal, growth in imports in the 1962-68 period shifted to chips even though chips are bulkier and more costling to transport. Meal was eliminated as an import item in 1968 due to the change in tariff structure, and with the investment security provided by the duty binding, the imports of cassava shifted almost completely to pellets to take advantage of economies in transport.

Germany remained the dominant importer of cassava up to 1967. The unification of prices, however, shifted profitability of cassava imports to the Netherlands and Belgium. Unification resulted in grain prices in Germany coming down and those in the Netherlands and Belgium rising (Table). This reduced cassava's relative profitability in Germany and increased it in the Netherlands and Belgium (Table). As grain prices were the same across countries, transport costs became a determining factor in which areas could most successfully bid for cassava imports. As Rotterdam had by far the most efficient unloading and distribution system, the Netherlands became the locus of cassava imports. Thus, in 1966 Germany imported 702 thousand tons of cassava compared to only 96 thousand tons for the Netherlands. Germany did not reach that level of imports again until 1977. By that time the Netherlands was importing 1.8 million tons (Table).

This process completely changed the dynamics of animal production in Western Europe. Growth in animal populations occurred in those areas with the cheapest feed sources and these are precisely the areas which have transport advantages in the import of those feedgrain substitutes that do not come under the variable levy. The process was extraordinarily rapid and was especially pronounced in the swine industry. Between 1965 and 1970, swine populations increased 59% in the Netherlands and 103% in Belgium, compared to only 16% in Germany and 21% in France (Table). In the period 1970 to 1985 the swine population increased 103% in the Netherlands and only 19% in Germany and actually declined in France. These trends are correlated with the use of grains in compound feeds. Overall the proportional use of cereals in balanced feeds has declined in the EEC, but especially in the Netherlands (Table). Cereal use in compound feeds in that country has dropped below 20%, whereas worldwide the figure is closer to 60%.

Cereal substitutes are essentially imported and the principal one is cassava. Cassava imports into the EEC over the past two decades and a half have shown dramatic growth, increasing from 400 thousand tons in 1960 to a high of 7.8 million tons in 1982 (Table). Every country in the EEC imports cassava but the Netherlands is by far the largest importer. Cassava imports by West Germany remained relatively stagnant until 1976, at which point imports more than doubled in two years. In 1975 national grain prices in West Germany finally recovered to their pre-1967 level. From that point national prices continued to rise. The mark in 1976 also started to appreciate rapidly against the dollar, and the international price of cassava declined slightly. This again made cassava very attractive in Germany and imports increased markedly.

The basic rationale behind the Common Agricultural Policy was that the European consumer would bear the principal costs of the higher prices paid to farmers. Moroever, consumers as well paid the cost of the higher prices of cereal substitutes, which because they were not subject to the variable levy, resulted in the higher prices being transferred to exporting countries as social profits above what could have been earned on the world market. Cereal substitutes did not add to the EEC's tax revenue account. Budgetary outlays by the EEC government for the costs of grain policy started to increase significantly in the early 1980's. In that period the EEC became a net exporter of grains, the dollar started to appreciate against European curriencies, making the domestic costs of export subsidies high, and cassava imports reached record high levels in 1981 and 1982. The budgetary costs of grain policy started to reach levels that were putting strains on the capacity of the EEC to generate tax revenue.

Cassava started to play a significant role in the ability of the CAP to sustain its objectives. In an econometric model of the EEC feedgrain market, Rastegari (1982) found that cassava imports and consumption had a positive impact on livestock production -- thereby confirming the previous analysis -- and had a negative impact on feedgrain imports. The latter effect is expected and results in the loss of tariff revenues to the EEC treasury. The more significant finding was that cassava imports had a negative effect on the setting of threshold prices. Cassava imports were reducing the flexibility of the EC to set domestic farm prices, especially when the EC moved into a net export position in grains, where export subsidies were large and dumping developed political repercussions with traditional grain exporters, especially the U.S.

The EEC was under significant pressure to reduce the growth in budgetary costs of the CAP, without the possibility of major structural reform in agricultural policy. The EEC sought to resolve the situation by reducing the growth in imports of cassava. Because the 6% *ad valorem* import duty on cassava was bound in the GATT, the EEC sought to negotiate voluntary export restraints with principal supplying countries, especially Thailand. The EEC found this to be the politically most tractable solution, since unbinding of the tariff would have required agreement of compensation with exporting countries with which the binding had been negotiated and with the country (if different) which is the major supplier. Moreover, all the EEC countries would as well have had to agree to the unbinding. In November 1980 Thailand agreed in principle to the "voluntary" limitation of cassava exports to the EEC.

Thailand felt that she had little bargaming power at this stage. She had already negotiated quota agreement for textile exports to the EEC, an industry in which investments had been large and which was a principal component of her industrialization strategy. Moreover, Thailand did not want to put a politically sensitive industry, such as cassava (because of its importance as a source of farm income in the Northeast), at risk by relying only the difficulty of EEC members reaching agreement among themselves on an unbinding of the duty. In addition Thailand was promised a significant increase in agricultural development aid to be spent on cassava diversification in the Northeast. Finally, as Blyth (1984) has shown in another context, "from the exporters' viewpoint, voluntary export restraints are the least harmful form of providing protection against imports into the EEC". Weighing the options, Thailand chose the less risky course. However, as Britain's Overseas Development Institute observed, "The story combines all those elements which so often bring the CAP into disrepute misdirected public expenditure (in this case of aid money), insensitive protectionism, and uncritical acceptance of the views of European farming interests, at the expense of consumers (in this case other farmers) and overseas suppliers." (House of Lords, 1981).

As a concession to Thailand, the EEC also committed itself to maintaining Thailand's position in the European cassava market. The EEC thus sought voluntary export restraints from other principal exporting countries. In 1982 an agreement was signed setting EEC import limits over a five-year period to those set out in Table . Thailand was further disadvantaged in the agreement by being the only country whose export quota would decline over time. Also in the initial understanding the EEC would also "bear in mind the importance of imports of carbohydrate products which would compete directly with manioc" (House of Lords, 1982). Significantly the other cereal substitutes of importance were maize-gluten feed and citrus pulp pellets, the principal supplier of which was the United States. The EEC has not found it possible politically to restrain the imports of these products and during the quota period imports of maize gluten feed rose dramatically. This situation underscores a basic point about the political economy of cassava, which is that cassava's vested interests have always lain with the economically powerless.

Before the end of 1986, the EEC and the principal cassava exporters, i.e. Thailand, had to come to terms on a new agreement or return to the situation prevailing before 1982. By late 1986 Thailand and the EEC had both ratified a new agreement on export controls of cassava. The agreement covers four years from 1986 through 1989 and specifies a maximum export volume of 21 million tons over the period. This amounts to 5.25 million tons a year, some improvement on the 4.5 million ton quota of 1985-86. However, exports to Portugal and Spain as well would now come under the agreement. Some minor flexibility was allowed in distributing the quota from year to year, as Thailand could export up to 5.5 million tons in any single year. This pattern of periodic deliberation and renewal of a new agreement on export restraint will most likely continue to be the pattern of EEC-Thailand trade in cassava.

Demand for Cassava in the EEC:

With the "voluntary" export restraints in place since 1982, estimation of import demand is something of a mute point, at least as far as total quantity imported by the EEC is concerned. However, price and the distribution of those imports within the EEC does have an effect on the profits to be earned by the Thai cassava industry and the comparative cost of animal feed across EEC countries. How prices for cassava are determined thus is of key importance to Thailand, especially in its management of the restraints on exports to the EEC.

The feed industry in Europe is highly competitive and factories base their purchasing decisions on least-cost feed formulation models. In general cassava will enter into swine rations first, that is at higher cassava prices than its entry into poultry rations. A large feed manufacturer in the Netherlands maintains a 40% maximum incorporation level for swine rations and a 25% inclusion maximum for poultry rations, which are probably normal limits for most manufacturers. Within any individual country, cassava demand is a step function operating between the price when it first enters the swine ration to that price at which cassava reaches maximum incorporation levels. Because internal grain prices vary between countries, cassava will be utilized first in those countries with relatively high grain prices. As Nelson (1983) points out, cassava demand will be relatively elastic in these countries between the price at which it first enters the ration and the maximum incorporation rate. "For additional imports, demand becomes less elastic as the cost of transporting cassava from the port increases, and it must compete in regions where feed-grain prices have been lowered by green rates."

The import demand function for cassava is fraught with difficulties in specification. Given a short enough time period so that supply cannot respond, demand theory would suggest a price dependent function. Moreover, since grain prices vary between countries, a market clearing price for cassava will be defined in each of the major importing countries, with some potential for arbitrage between neighboring countries. Using monthly data, price dependest import demand functions were estimated for the Netherlands and Western Germany, with the internal cassava price being a function of the market price for the dominant feedgrain, net imports of cassava, the soybean meal price, and the swine population.

The results of this estimation shows that cassava prices respond to changes in feedgrain prices. As would be expected cassava prices are more responsive to maize prices in the Netherlands, the main importer, than to barley prices in Germany. Although cassava imports have a significant and negative effect on cassava prices in both countries, the size of the coefficient is remarkably close to zero, suggesting very little elasticity in the market. This result is counterintuitive, given the rapid rate of growth in cassava imports and the ease of substitution in feed components. It is therefore worthwhile to analyze more closely the mechanisms surrounding price formation of cassava.

Cassava prices are quoted in Europe in Deutsch marks on an fob Rotterdam basis, which is distinct from the cif Rotterdam quotes for other commodities such as soybean meal. The difference is the point at which the buyer takes ownership of the commodity. In the case of soybean meal it is purchased on the Chicago Board of Trade and the feed manufacturer pays the freight and insurance at the unloading point in Rotterdam. In the case of cassava he buys on a customs cleared basis from the shipper in Rotterdam. The shipper pays the freight and insurance, discharge costs, and customs duties. The shipper has ownership of the cassava till discharge in Rotterdam, while in the case of soybean meal he does not, providing only freight services.

The reason feed manufacturers have gone to this system was essentially the uncertainty of quality and customs clearance. At one stage Thai pelleters were introducing rice hulls, which under EC tariff rules would be classified as a compound feed, dutiable at a very high tariff. Under the current system the shipper guarantees the quality and the price, and the buyer assumes no risks. However, this system potentially reduces the efficiency of price transmission between the two markets.

This last point is reflected in the determination of a market price for cassava in Europe. Most buyers purchase cassava on forward contracts, so that supplies are guaranteed and storage costs are kept to a minimum. In general cassava is contracted between 2 to 6 months forward. Thus, approximately 90% of each shipment has already been contracted. Only a small percentage is sold on a spot market or at the so-called afloat price, the price normally quoted from trade sources. Moreover, the afloat price generally reflects speculators in the market who have not yet covered their contracts and is therefore more variable than the forward price.

The market price is therefore a negotiated forward price between shipper and feed concentrate manufacturer and this price is often not quoted. The shippers can negotiate on the basis of known production costs for pellets in Thailand, known handling and freight cost -- in 1985 $4/t for loading, $9/t for freight and insurance and $5/t for discharge -- and the tariff, while the buyers will negotiate on the basis of the shadow price of cassava in their feed cost models and their sense of the cassava price in Thailand and Europe.

The analysis of price transmission between Thailand and Europe (see Chapter), suggested that forward prices in Europe were much better correlated with Thai prices than afloat prices and that prices were transmitted instantaneously, with some residual tendency for prices in Thailand to lead those in Europe before the quota and those in Europe to lead Thailand after the quota. The forward contracting and the nature of price transmission suggests that the cassava price is given exogenously and thus the endogenous variable in the demand function should be cassava imports.

An import demand equation was thus estimated using net cassava imports as the dependent variable. Since this is an amount which is forward contracted, traders have suggested that an average period is about three months and so imports were lagged three months. Lagged imports were then made a function of the forward price for delivery in three months, current swine stocks, current soybean meal prices, and the threshold price three months ahead. Since grain prices are fixed on a monthly basis before the crop year, the threshold price is the best estimate of the future grain price. Because a fixed amount of cassava must be allocated among the various countries, the equations were estimated using Zellner's seemingly unrelated regression technique.

The results (Table) are significantly better than the previous specification. The direct import elasticity is relatively elastic, although lower for the Netherlands than for Germany. This is expected in a country where cassava imports already are 30% of the combined production of pig and poultry feeds and moving additional amounts involves more radical prices changes. This conclusion does not extend to grain prices, where cassava imports in the Netherlands responds much more strongly to changes in grain prices. Interestingly the coefficient on the soybean meal price is positive, and in the case of Germany, significant. In Germany oilseed meals make up between 30 to 40% of feed concentrates. Because oilseed meals are often similarly priced to grains, they enter as a calorie source as well as a protein source and these results suggest that cassava and soybean meal are substitutes rather than complements. Finally, the quota is principally affecting cassava use in the Netherlands, where cassava imports have declined, other things being equal, to what they were prior to the quota.

The effects of the quota thus have been (1) to reduce the efficiency of price transmission between Europe and Thailand, shifting cassava price formation in Europe essentially to demand-side factors, (2) to widen the margins between Europe and Thailand, a factor which Thailand is using to open third-country markets, and (3) to reallocate cassava imports between countries. On the latter point, Spain and Portugal's entry into the EEC, the suggested elimination of green rates and MCA's, and the environmental constraints being placed on expansion of livestock enterprises in northern Europe, all suggest potential for shifting the locus of growth in animal production to these two countries, if based on the ability to import efficiently feed components which do not come under the variable levy. Given grain shortfalls in both these countries, some experience with importing cassava in 1984 and 1985, and the projected improvement in port facilities, conditions seem appropriate for such a restructuring.

The world market for cassava feedstuffs is something of the reverse of that for cassava starch. In the case of feedstuffs tariff and price policies in Europe have created a large market insulated form world trade conditions in feedgrains. Since the market is politically defined (even though almost every agricultural market has its political dimension) cassava's impingement on other EEC objectives has resulted in restraints on future growth of EEC imports. The European market is, nevertheless, providing the base for the restructuring of trade in cassava pellets and to understand this process requires some analysis of the feed and livestock sector in East Asia.

<u>The Asian Regional Market for Cassava Feedstuffs:</u>

Do cassava feedstuffs have a wider international market than just the European Community ? Trade and price policies, as in all trade matters dealing with cassava, hold the key to the answer. To a certain extent this issue is being forced by the EC itself through its imposition of import quotas, which in turn has caused Thailand to devise mechanisms to open third country markets. The solution amounts to unintentional dumping, in which the European consumer is in effect subsidizing Thai exports to non-EC countries. What better irony then that the EEC should be subsidizing Thai-cassava exports to third countries. This outcome is to international trade what epicycles were to Ptolemaic astronomy, a further complication to produce a workeable system where the central thesis is faulty. What it achieves is time to develop a more rational system and the bulwark of such a system will inevitably be the Asian market for feedstuffs, which is currently dominated by imports of U.S. coarse grains.

Food consumption patterns in East and Southeast Asia are changing rapidly. The causes for these changes arise as much from the supply side -- technical change in food production and processing, improved foreign exchange availabilities allowing an increase in and diversification of food imports, and improvements in marketing -- as from the demand side -- increasing per capita incomes, urbanization, declining influence of religious prohibitions on certain foods, and changing relative prices. Changing food consumption patterns are thus set within an evolving economic system, which reflects fundamental structural change and basic shifts in food processing, marketing, home preparation methods, and purchasing patterns as the population shifts from rural to urban residence.

The most fundamental shift in food consumption patterns in Asia has been the rapid increase in the consumption of livestock products, especially meat (Table). For example, in Japan in the two decades spanning the period 1960 to 1980 per capita consumption of beef grew at an annual rate of 5.6%; pork at a rate of 11.1%; and chicken at a sustained rate of 16.7%. Even after such high rates of growth, per capita meat consumption in Japan is still only about a quarter of levels in the United States. This highlights the first salient feature of meat consumption patterns in Asia; that growth in consumption has started from a very small base, since for most countries no more than 5.0 kg. of meat per person was consumed in the early 1960's. Only the Philippines and Taiwan would appear to have had a higher consumption base, due essentially to the larger role of swine in farming systems and rural consumption patterns. Pigs also were important in large parts of China. Swine have played a differential role across Asian countries in defining meat consumption patterns, partly because of religious restrictions, such as Moslem taboos in Malaysia and Indonesia and Buddhist prejudices in Thailand and Japan, and partly because of feed availability on farms in swine producing countries, usually the root crops, sweet potatoes or cassava.

In the two decades encompassing 1960 to 1980, annual growth in per capita GNP was over 4% in all countries under study here except for the Philippines, which grew at 2.8% per year. Meat demand is very income elastic in Asia (Table) and yet income elasticities and income growth do not explain all the growth in per capita meat consumption. In Asia income growth has also precipitated diversification of the diet, as reflected in the very low per capita consumption figures for meat in the early 1960's. Also income growth is closely related to other basic changes in the economy that affect food consumption patterns, particularly urbanization and the growth of food retailing networks. Implicit in migration from a rural to urban setting is a shift in food sources from one based primarily on production to one based on purchases. Also, convenience becomes an important factor in food choice, in preparation methods and in food storage in the home. Finally, food preferences become more susceptible to advertising and to the diversity found in eating out of the home. Therefore, implicit in income growth are the basic changes in lifestyle that impinge on food consumption patterns; these have had a large impact on the rising demand for meat in Asian countries.

Income elasticities do not vary significantly across the different meats, except for the lower estimates for pork in the high consuming countries. Income growth thus does not account for the very significant differences in growth rates between the different meats. Thus, while income explains much of the growth in total meat consumption, price is the more relevant variable in analyzing growth rates in individual meats. In all meats the own-price elasticity is very high, and while cross-price elasticities are normally significant (Table), substitution has not yet played a dominant role in meat consumption patterns in Asia, as it has, for example, in Latin America. Differences in growth rates in consumption of the various meats is due to the differential trends in real prices of the meats, especially the decline in chicken, and to a certain extent pork, prices vis-a-vis stability or increases in the price level of beef. It is the fundamental effect of prices on meat consumption that makes basic cost changes on the supply side so important.

Japan has the longest history in the modernization of its feed and livestock industry and thus in many respects will presage the future developments in the livestock industry of many Asian countries. The dominant factor in the expansion of the livestock sector in Japan was technical change. This is shown in Table which shows rapid expansion in meat production of chicken and pork even though product prices were declining relative to feed prices. This relationship is the more impressive considering that feed makes up 35% of pork production costs and about two thirds of chicken production costs (Coyle, 1983). Three important changes account for these rapid increases in production efficiency, changes that are now occurring in other Asian countries.

First, structural change in livestock production has been rapid. Production has moved from small units on farms to specialized, large-scale enterprises. In Japan this process has been particularly impressive in both swine and broiler production (Table). Structural change in livestock production has not implied a gradual increase in animal populations on farms but a rapid shift away from farm units to specialized production units. In the process the number of producers declines rapidly. In Japan the number of swine producers declined from 800 thousand in 1960 to 156 thousand in 1979 (Coyle, 1983). Statistics on total animal populations thus usually masks quite marked shifts in sources of production. Thus, in disaggregating the statistics for Thailand for poultry (Table), while growth in the total population has been moderate, the increase in large-scale commercial operations has been very rapid and on-farm populations have declined.

This search for scale economics through structural change has characterized the pork and poultry sectors of all the countries under study here except Indonesia and China. In China the very rapid rise in pork production and consumption since the political changes of the late 1970's has been due to shifts of production from collectives to individual households and intensification of production through the improved availability of grains (Sicular, 1985). In Indonesia, on the other hand, income distributional objectives have been translated into a 1983 policy which limits the size of poultry operations to thousand layers and 750 broilers (see World Bank, 1984, for a more extensive discussion of the policy). Since pork is not consumed among the Moslem population, this policy may limit the price declines that have come in other countries and therefore the expansion in consumption. On the other hand, since the population is still overwhelmingly rural, the policy may in fact lead to decentralization of production away from urban areas and increased rural consumption, as is occurring with pork in China. The feed companies appear willing to respond by developing rural, feed distribution channels. Indonesia and China may offer an alternative livestock development strategy oriented towards rural consumption. However, eventually when the policy turns toward urban consumption, the development of large-scale poultry and swine units will be essential to cost and price reductions for urban consumers.

The second important change in livestock systems in Asia is the shift to balanced feeds as the principal source of animal nutrition. The impact of this on production efficiency has come through improved animal nutrition, which has allowed quicker weight gains, usually higher slaughter wlight, and improved reproductive capacity. Whether balanced feed is cheaper than on-farm feed sources is questionable, especially for swine, where feedstuffs with relatively low opportunity costs are used. Concentrate feeds, however, allow balanced nutrition, especially for protein requirements, and expand the availability of feed sources, which are usually constrained at the farm-level. Development of a mixed feed industry has been especially critical in the growth of the poultry industry.

Development of a mixed feed industry usually leads the structural change in livestock production, with the initial linkages generally being made with the poultry sector. Growth in compound feed manufacture has been very rapid in East and Southeast Asia in the last one to two decades. Most countries have managed annual growth rates of well over 10%, with Japan maintaining a 9.9% annual rate of growth over a period of 22 years from 1960 to 1982 (Table). Growth can be remarkably rapid in the early stages in the establishment of the industry. Thus, in the 1960's Japan's compound feed industry grew at annual rate of 17%, comparble to the growth of South Korea's industry in the 1970's of 18% but well below the remarkable growth in Thailand of 30% per annum through the course of the 1970's.

There is a chicken or egg question in the gestation of a compound feed industry. In most cases the establishment of the industry is based on the development of commercial poultry enterprises, with the two often vertically linked in the initial phases. The feed industry often assumes the initiative in the development of its market. If developments in the industry follow the example of Japan, then eventually divestment of the poultry enterprises takes place and diversification occurs, with a signfificant rise in swine feed and dairy feed production. However, signficant differences will be expected to occur across countries in the development of the latter two industries, because of Moslem prohibitions of pork consumption in Malaysia and Indonesia and lactose indigestability in many Asian populations. In Asia, more so than any other continent, the development of the livestock industry is and will be based on either the purchase of mixed feeds by livestock producers or the purchase of the feed ingredients by the livestock producers to mix their own feeds. However, expansion of the livestock industry will not be based on an integrated farm system in which own production of feed components is linked to livestock production.

The third element responsible for rapid technical change in the livetock sector is the improved feed conversion rates in the animal population. This is due to both more efficient animal breeds and improvements in management, especially in animal health. A particular trend in swine production is the movement away from breeds with a high fat carcass to those with a much higher percentage of lean meat. However, aggregate feed conversion rates only partially reflect this improvement, since they as well incorporate the movement away from on-farm feed resources to compound feeds (Table). Aggregate feed conversion rates, thus, first increase and then decline when the conversion by livestock producers to compound feed has stabilized. Comparison of these aggregate rates across countries will not differentiate between improvements in the efficiency of feed conversion and the degree of penetration of compound feeds in the livestock sector. What the limited data in Table indicate is that aggregate feed conversion rates are still rising in all countries but Japan.

Rising demand for livestock products and the structural change in livestock production have created a very rapid increase in the derived demand for feedstuffs, especially carbohydrate sources. The response to this situation in all cases but Thailand has been to increase imports of feed grains. In the non-cassava and non-maize producing countries the growth in feed grain imports has been very rapid indeed. In 1960 Japan, Taiwan and South Korea together imported less than 2 million tons of coarse grains. By 1984 the import level for these three countries stood at 27.6 million tons. Domestic production of feedstuffs in these countries declined during the period, especially barley in Japan, sweet potatoes and barley in South Korea and cassava and sweet potatoes in Taiwan, which thereby reinforced the linkage between domestic livestock production and feed grain imports. Decline in domestic production of feedstuffs in these countries was due to the demise of integrated, livestock-crop farms and the rising costs of farm labor as a result of industrialization and rural-urban migration.

In maize-producing countries, however, development of the livestock sector has been one of the factors stimulating increases in grain production. Thus, in the Philippines, Indonesia, Thailand, and China feedgrain production has increased signficantly (Table) but this has not been sufficient to keep up with rising demand, except in the case of Thailand. The Philippines moved from the position of net exporter or minor net importer of maize to a major net importer in 1971; Indonesia did the some in 1976; and China has signficantly increased its imports in the last five years. Finally, Thailand has not been able to increase significantly its maize exports, even through domestic production has increased from 2.3 million tons in 1973 to well over 4 million tons in 1984. In all countries feed demand has increased at a much more rapid pace than domestic production of feedstuffs. Significant scope therefore exists in the tropical countries in Southeast Asia to link increasing internal demand to production growth in feedstuffs, thereby improving farmer income in principally upland areas.

The rapidly rising demand for carbohydrate sources for the growing animal feedstuff industry in East and Southeast Asia thus raises a dual potential for cassava, that is exports from Thailand to the large import markets in Japan, South Korea and Taiwan and increased domestic utilization in the cassava producing countries. As regards the former, the quota placed by the EEC on cassava imports has had the secondary affect of shifting Thai surpluses into principally East Asian markets. The mechanism by which this has been accomplished has to do with Thailand's internal management of the quota, on the one hand, and liberalization of tariff barriers on cassava for animal feed by the principal importing countries in East Asia.

Since the agreement between Thailand and the EEC restricting cassava flows to Europe is a voluntary export restraint, Thailand had to accept the responsibility for managing the quota (as Blyth 1984, has shown voluntary export restraints are the least harmful form of protection from the exporter's view point). Since the agreement which covers the period 1982 to 1986 was not signed till September of 1982, only in 1983 did Thailand begin to effectively limit cassava exports to the EEC. During 1983 the Ministry of Commerce in Thailand adopted an export licensing system and attempted several forms of allocating the licenses. First, the quota was allocated on a quarterly basis to exporters based on historical shares in the export business. Then the quota allocation was shifted to a first-come-first-serve system, where licenses were granted for the quarter upto the point that the quota for the period was exhausted.

Finally, by the end of 1983 Thailand had arrived at a workeable system for allocation of the export quota. Starting in 1984 the year was divided into seven periods. Export allocations in a period were based on the stocks held by exporters, such that those holding higher stocks would be given a higher percentage share of the export quota. In addition a bonus system was instituted in which any exports to third countries in the previous period would allow first priority to export allocation in the next period, depending on the size of the third country exports. The bonus system was established on a 1:1 basis and the ratio was changed to 1.25:1 at the end of 1985, that is a one ton quota allocation for every 1.25 tons exported to third countries. However, due to the declining stock levels in mid-1986, the bonus ratio was changed back to 1:1 in June of that year. The reversal indicates that the Ministry of Commerce recognizes the policy role of the bonus ratio, whereby market surpluses can be managed by adjustment in this ratio.

The result of this quota allocation system has been the development of a two-tiered price structure at the export point. The system has allowed Thailand to appropriate the rents to be accrued in the European market while maintaining a unified domestic price structure. The divergence in prices at the export point is due to the situation where cassava prices in Europe are determined by the grain price set under the Common Agricultural Policy and those in third countries are set by the world price for feedgrains. As one of the results of the quota has been an increased price spread between Thailand and Europe, the Ministry of Commerce has developed its export allocation policy to divert these exporter rents in order to finance exports to third countries. As export allocations have been as low as 11% of total stock holdings (Table), there is significant incentive for exporters to guarantee their access to the European market by utilizing some of these profits to sell in third countries. Thailand has, thus, taken the logical step of stratifying its market.

On the import market side there has been a progressive liberalization of tariff and quota restrictions on cassava in most markets. With the recognized shift to dependence on imports to meet their animal feed requirements, East Asian countries have progressively liberalized import restrictions on feed components. In general liberalization of feed grains, especially maize and sorghum, precedes that of cassava. In Japan and South Korea this has been due to a vestigial desire to protect domestic sweet potato producers and in Taiwan to protect both sweet potato and cassava producers. Nevertheless, in 1968 Japan reduced its tariffs on cassava imports for feed use to zero. In South Korea the liberalization has been much more recent. Upto 1984 the general tariff for cassava was 40% compared to 5% for maize -- cassava chips for alcohol manufacture were imported at a lower duty under a quota system. In 1984 cassava tariff rates were reduced to 20% and in 1985 to 7%, which was then equal to the rate on feedgrain imports. Taiwan, on the other hand, has continued to maintain a low tariff rate on maize of 3%, with a significantly higher rate for cassava. Taiwan has been reluctant to liberalize the duty because of its own cassava producers, even though domestic cassava does not go into animal feed concentrates.

East Asian markets have easily absorbed the surpluses from Thailand. Thai exports to East and Southeast Asian markets increased from 48 thousand tons in 1982 (this was all chip exports to South Korea for alcohol production) to 129 thousand tons in 1983, 225 thousand tons in 1984, and finally to 954 thousand tons in 1985. In 1985 Japan took over 400 thousand tons and South Korea and Taiwan over 200 thousand tons each. The potential market for cassava in East Asia is more than even current cassava export levels, as long as it is competitively priced with maize. East Asia will develop as the secondary or residual market for Thai cassava, with Europe having first call on Thai cassava exports upto the quota limit.

On the other hand, for the cassava producing countries in Southeast Asia, increased cassava production is one of the means for meeting the rapidly rising domestic demand for carboydrate sources in feed rations (Table). Feed concentrate production has been increasing rapidly in most countries in Southeast Asia, as demand for animal products have increased and technical change has taken place in animal production systems. In Malaysia and the Philippines feed component demand has been met to a significant extent by increased maize imports. In Thailand increasingly maize production has been diverted to meeting domestic demand, while exports have largely stagnated. Finally, in Indonesia structural change in animal and feed production is just beginning and if Indonesia follows trends in the other countries, Indonesia will also become a net feedgrain importer. Therefore, the potential exists to link increasing domestic demand for feed energy sources to increased cassava production.

Realization of this potential depends on cassava being price competitive with other carbohydrate sources in animal feed diets. In Asia this is maize, supplemented by broken rice when available. Cassava is competitive if it enters into the solution of a least cost feed formulation model. For the period 1982 to 1984 cassava enters into the least cost diet in Indonesia and the Philippines. Cassava comes in and out of the diet in Thailand and does not enter at all in Malaysia. To enter the diet cassava, in general, has to be priced at about 65 to 70% of the price of maize, depending on the price of soybean meal. Viewed in the longer term, this maize-cassava-price ratio has been very variable in Indonesia and Thailand, reflecting the disarticulation between the two international markets. In Malaysia the trends in this price ratio have been consistently rising. In Malaysia cassava has progressively gotten more expensive in relation to maize. Starting in 1980 cassava began to be periodically uncompetitive and in mid-1982 this trend became relatively permanent. In Indonesia, on the other hand, cassava has become relatively cheaper compared to maize, although with signficant variability.

This analysis reinforces conclusions from the previous chapters. In Malaysia in the 1980's cassava has failed to remain competitive with maize imports. In Thailand cassava will come in and out of the ration depending on price relationships for maize and cassava, defined in two independent, but nevertheless international, markets. In Indonesia cassava could form a more important component of the as yet nascent feed industry. Cassava in some years is extremely competitive with maize and yet cassava has not been utilized in this industry. Use in this industry could put a more effective price floor under cassava on Java. However, since the feed industry has so far relied on imported maize through BULOG, the marketing channels there have yet to develop. In the Philippines cassava is competitive but an even further step is required of developing cassava processing capacity. In general, there is sufficient demand in existing domestic markets to absorb cassava production in these countries. Cassava's entry into the growing animal feed market will, apart from Thailand, depend on increased domestic production.

A COMPARATIVE ANALYSIS OF CASSAVA PRODUCTION AND UTILIZATION IN TROPICAL ASIA

Cassava was probably first introduced into Asia during the Spanish occupation of the Philippines. According to Rumphius cassava was being grown on Ambon, one of the outer islands of Indonesia by 1653 (Nelson, 1982). Cassava was introduced from Java to Mauritius in 1740 and from Mauritius to Sri Lanka in 1796 (Greenstreet and Lambourne, 1933). Certainly by the beginning of the 19th century cassava had been effectively distributed throughout tropical Asia. Expansion of cassava production in the 19th century was hastened by colonial administrations, first by the initiation of a cassava processing and export industry in Malaya in the 1850's, followed by the Dutch in Java, and second, by the promotion of cassava as a famine reserve, particularly by the Dutch in Java and the British in Southern India.

Of the new world, food crops introduced into tropical Asia, cassava has become the most important on a production basis. Characteristic of the crop, the development of cassava has responded to different forces in each country, as is particularly reflected in the utilization patterns for the different countries in Table 1. Cassava is an important food source only in India and Indonesia, an important export crop in Thailand, and an important source of starch in all countries. Just as cassava has filled a particular market niche in each country, the crop also occupies a different production niche in each country, that is in terms of the type of land resource which has been exploited and the type of cropping system which has evolved.

The crop's peculiar adaptability to upland conditions, particularly where there are either soil or moisture constraints, and its multiple, end-market uses give cassava a certain malleability in adapting to quite different demand and production conditions. By utilizing a comparative approach this paper proposes to bring out the diversity and similarities in systems of cassava production and utilization in tropical Asian countries. From this conclusions will be drawn about potential for and constraints on further development of the crop in the region.

An issue dominating this discussion will be whether principal constraints have their origin on the production or the demand side or vice versa whether growth has been production or demand led. This view departs substantially from the more orthodox perspective in Asia - which is dominated by the case of rice - which suggests that the restriction on increased food supplies is lack of sufficient factors of production, especially land, and the solution is therefore improved production technology and land productivity. The question for cassava, on the other hand, is whether improved technology is a sufficient stimulus for the expansion of production or whether this as well needs to be integrated with market development.

A Comparative Analysis of Production

Cassava is essentially an upland crop in tropical Asia. Only in rare cases when water is limiting, such as occurs with well-fed systems in Tamil Nadu in India or during the secondary season on sawah soils of Java, is cassava planted in irrigated areas. The agro-climatic conditions under which cassava is grown in the upland areas of Asia vary enormously, but the defining factor in major cassava producing zones is the existence of a constraint on plant growth. In areas such as Kerala, India, the off-islands of Indonesia, or the eroded slopes of eastern and central Java the limiting factor is soils. In the northeast of Thailand, Tamil Nadu in India, or Madura island in Indonesia the problem is moisture stress. Cassava produces high carbohydrate yields under such conditions compared to other crop alternatives. Cassava has thus tended to be concentrated in those areas where competition with other crops is relatively insignificant.

This, however, is too broad a generalization, for cassava competes quite effectively at both the extensive and intensive margin (Table 2). Cassava is grown in upland areas where farm size is a major constraint on farmers' crop production, such as Kerala and Java. Cassava is selected because of its high yields and yield responsiveness, even where there are agro-climatic constraints. Exploitation of the yield potential of cassava is clearest in the irrigated area of Tamil Nadu. Here farm-level yields commonly exceed 50 t/ha.

On the other hand, cassava is well adapted to more land extensive, production systems, such as occur in frontier areas. Cassava has been a major crop component in the transmigration schemes in Indonesia, and where infrastructure has developed, cassava has expanded rapidly, such as the Lampung area an Sumatra. The same applies in the Mindinao area of the Philippines, where cassava has become a major crop. In such areas infrastructure development is a principal stimulus in moving cassava from essentially subsistence status to a major cash crop.

In Malaysia, as compared to other Asian countries, cassava's role in the agricultural economy is defined more by access to land than by land quality. Malaysia is by Asian standards a land surplus country and much of the unexploited land remains under control of the federal government. Cassava is the crop of first choice for squatters on federal land and apparently much of the cassava grown in Malaysia is grown by squatters. In the major producing state of Perak a 1976 estimate indicates that 3,892 ha of cassava were planted legally while 10,240 ha were planted illegally (Hohnholz, 1980).

Given cassava's demonstrated ability to exploit the heterogenity of the land resource in Asia, a major factor determining the production potential of cassava is its ability to compete with other crops for land in the upland areas. An important point emerges: on the production side cassava rarely competes for land with the same crops with which it competes on the demand side. That is, cassava rarely competes with food or feed grains. There is some competition with maize in the central plain of Thailand and to a more limited extent in Mindinao in the Philippines, but the one area where maize and upland rice overlap with cassava is on Java and Lampung and here the three are often found in an intercropping system. In areas where rainfall is limiting such as the northeast of Thailand, or the unirrigated areas of Tamil Nadu, cassava has no effective competing crop.

In most of the other cassava producing areas cassava competes principally with tree crops: coconuts in the Philippines, coconuts and rubber in Kerala, oil palm and rubber in Malaysia and the off-islands of

Indonesia, and rubber in the southern part of Thailand. Southeast Asia has an international comparative advantage in these crops; over 80%, 85%, and 90% of world exports of rubber, coconut oil and palm oil respectively originate from the region. Expansion possibilities in these crops are limited by the growth potential of world markets and, moreover, these are markets in which close substitutes exist. Cassava's ability to compete with tree crops for land, labor and capital in these areas is an open question but it will essentially depend on the relative importance given to expanding export markets versus meeting domestic demand for carbohydrate sources.

While it is the land issue that largely determines where cassava is grown, it is relative endowments of land to labor that determines how cassava is grown, that is in what type of cropping system. Cassava-based cropping systems vary substantially across Asia (Table 3), and the labour intensity of these systems is fairly consistent with the land/labor ratio in each country (Table 4). In the countries with the highest land/labor ratios, Malaysia and Thailand, tractor services for land preparation are widely used in cassava production systems. In the Philippines animal traction is common, while in Indonesia and Kerala land is principally prepared by hand. A similar trend is found in weeding intensity and the propensity to achieve a higher land productivity through intercropping and fertilizer application.

One common theme that does run across cassava cropping systems in Asia is the low use of chemical fertilizers (Table 3). Even in Kerala and Java chemical fertilizer application to cassava is low, despite the fact that application levels on other crops, particularly rice, is very high. To a significant extent in Indonesia and India farmers compensate for this by applying organic manures and wood ash. In India what green manure that remains in the field is incorporated into the soil below the planted stake. Although many published fertilizer experiments have shown a yield response of cassava to fertilizer application, the fact remains that few farmers utilize chemical fertilizer in significant quantities. A better understanding of the fertilizer response issue at the farm-level is needed, but it does appear to offer one potential avenue for significant yield gains.

These differences in cropping systems lead to significant differences in labor input, per hectare production costs, and yields across Asian cassava production zones (Table 5). The largest cost component in cassava production is consistently labor. Differences between countries in total per hectare labor costs are substantial. However, once differences in yields are taken into account, there is a significantly reduced range of variable production costs per ton. Expressed on a dried equivalent basis [1/], these production costs must be seem as low, compared to per ton production costs of grains.

However, it is probably yield rather than per hectare production costs that is the principal variable in the determination of costs per ton. Cassava, as compared to the grain crops, has a potentially high

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[1/] As a gross approximation 2.5 t of fresh roots produce 1 t of dried cassava, expressed on a 14% moisture basis. This will obviously vary depending on the dry matter content of the roots.

yield variance. Yields as low a 2 t/ha are not uncommon in many parts of the Philippines while farm yields reaching as high as 80 t/ha have been recorded in Tamil Nadu, India. This very large yield potential has always been the hallmark of the crop, and it is in Asia that this yield potential has been most exploited. Compared to Africa or Latin America yields in Asia are high. Part of this is due to the significantly lower disease and insect pressure, since Asia is outside cassava's center of origin. The other factor is the more intensive cassava cropping systems found in Asia.

The other basic characteristics of the crop, however, is it adaptation to marginal growing conditions. Yield potential must, therefore, be defined in terms of agro-climatic conditions. Because of the differences in agro-climatic conditions of the major production regions and in cropping systems between these regions, there is a large variation in yield levels within tropical Asia (Table 6). While general causes for the differences in yield between regions can be postulated, there has been no systematic work which has specifically related differences in agro-climatic conditions, input levels, varieties and management practices to variation in yield levels [2/]. Without this information, it is very difficult to assess the principal constraints on cassava yields and in turn the potential for increasing cassava productivity. The potential yield gains from new technology and in large measure the definition of that technology still remain rather amorphous. Nevertheless, the range of yields suggested

2/ The research by Roche (1982) on cassava cropping systems on Java is the one exception. Apart from age at harvest, fertilizer, and labor input, the other explanatory variables were regional or land system dummies.

in Table 6 are at least suggestive of substantial scope for yield improvement in many countries.

A Comparative Analysis of Consumption

The food economies of tropical Asia are dominated by rice; any other starchy staple is only of secondary importance in the regional diet. Within this context cassava has achieved a significant role in the food economies of Indonesia and Kerala and only maize is as significant a calorie source in tropical Asia. The impetus for the early expansion of the cassava crop in Kerala, the Philippines, and Indonesia was to supplement inadequate supplies of rice and it was in land-scarce Kerala and Java that cassava production expanded most significantly. In Thailand and Malaysia, on the other hand, the incentive for production expansion came from non-food markets.

The locus of cassava consumption in Indonesia and Kerala is in the rural sector and among the lower income strata. Moreover, because cassava is very much a secondary staple in the food economy of these countries, it is significantly less preferred than rice in the diet. These characteristics to a large extent define cassava's role in these food economies: as a cheap calorie source which supplements shortfalls in the availability of rice, whether due to insufficient supplies or restricted purchasing power. Cassava has thus come to play a significant role in the calorie nutrition of that population most at risk in the region (Figure 1). While food policy in these countries will still have rice as its central component, cassava can add a certain flexibility to these rice-based policies. Unfortunately, it is rare that policies on secondary staples are integrated with those on rice in developing an overall food and nutrition policy.

The role of cassava in nutrition planning has been analyzed most rigorously in Indonesia (Dixon, 1982; Timmer and Alderman, 1979; Timmer, 1980). Cassava's low cost relative to rice, the very skewed distribution of consumption toward the low income strata, the existence among the poor of calorie intake well below recommended standards, and, among the lowest income strata, the significantly positive income elasticity for cassava (Dixon, 1982) create a situation where increased cassava production and lower prices will impact exclusively on the poor consumer.

Overall inelasticity in food markets, while providing substantial benefits to consumers when improved technology is introduced, does not provide much scope for increasing farm incomes. Cassava is a cash crop in Asia. Even in Indonesia and India, where there is some subsistence food consumption, the major portion of the cassava moves into market channels. Where cassava production has expanded rapidly in the region, this expansion has been associated with dynamic markets. Thus, if cassava is to play a role in food policy, there must be a means of maintaining incentives to producers. Cassava's role in generating increases in farmer incomes is, therefore, associated with markets other than traditional food markets. Where traditional food markets are important, development of these alternative markets provides something of a price floor to sustain farmer incomes.

The economies of Southeast Asia have been changing rapidly in the last two decades (Table 7). Industrialization, rapidly rising income, and significant rates of urbanization have created significant changes in domestic demand for food. Food demand within the region is being driven principally by changes occurring outsides the agricultural sector; yet it is this sector which must continue to generate both the bulk of employment in the economy and continued increases in marketable surpluses. Increasing demand in the quantity and variety of food products can be a stimulus to the agricultural sector or can put unwanted pressure on internal food prices-- and thus affect the nutrition levels of the poor-- and/or food imports. This situation is potentially aggravated by the winding down of the production gains achieved by the dwarf rice varieties and by the significant portion of resources devoted to export, tree crops.

One of the dominant trends in Asian food economies is the rising demand for livestock products and the derived demand for carbohydrate and protein sources for concentrate feeds (Table 8). This growth in demand for livestock products has been most striking in the poultry sector, that is for meat and eggs. The poultry and feed concentrate sector has developed rapidly over the last decade in the cassava producing countries of Thailand, Philippines, and Malaysia and in the non-producing countries of Taiwan, Japan and the Republic of Korea. The sector is only in a very formative stage in Indonesia. However, per capita consumption levels remain low and FAO (1983) anticipates annual growth rates to the year 2000 on the order of 8.8 and 6.3% for poultry meat and eggs in the Far East.

Maize is universally the principal feedgrain used in the feed concentrate industry in the region and only Thailand, Philippines and

Indonesia are significant producers, of which only Thailand is in a net export position. Without a doubt Southeast Asia will have a continuing deficit in production versus consumption of feedgrains. However, at present only very insignificant amounts of cassava enter into animal feed rations in the region. At around 15 thousand tons, Malaysia is apparently the largest utilizer of cassava for feed concentrates. A large and growing domestic market thus remains unexploited in most countries.

After direct food use starch is by far the largest form of domestic utilization of cassava in the region. As in the case of livestock products, consumption levels of starch have increased rapidly in most countries in the last decade (Table 9). In countries such as Indonesia and Malaysia and regions such as Tamil Nadu, India and Mindinao, Philippines starch processing dominates the market for roots. These similarities contrast with significant heterogenity across countries in the end market for cassava starch, competition with other starch sources, principally maize, and the scale of processing technology within the starch industry. These latter factors determine to a large extent the future growth potential for cassava starch in each of the countries.

The other major cassava market is the export market; exports are dominated by chips/pellets, although there is a significant volume of cassava starch that is exported as well. While all of the major cassava producing countries in the region have exported cassava products in the recent past, only in Thailand is production principally directed to export markets. In all other countries the export market is minor when compared to the domestic market. India and China have been intermittent exporters, while Indonesia has been a consistent exporter but with large fluctuations in quantities. Malaysia has been a consistent, but declining exporter. For these latter countries the export market serves as something of a surplus vent, which usually is operational only at relatively high world market prices. This was particularly the case in 1979-80 and demonstrates the role that the export market can play in setting a price floor under domestic markets, even though at historically low to moderate world price levels, domestic prices in most countries make cassava exports uncompetitive.

A multiple market structure has developed for cassava in most countries in the region, with each country having developed its own particular utilization patterns. Yet, as has been noted, significant untapped potential exists for cassava in undeveloped markets, such as the domestic feed concentrate markets. Other markets which have been unmentioned are the composite flour market, especially where the wheat flour is used principally in noodles, and in sugar-importing countries, such as Indonesia, high fructose syrups. A natural question is what has been constraining the development of these alternatives markets and in turn whether improved production technology could be a motivating factor in their development. At the heart of this issue is the original question of whether it is production or demand that is constraining or generating further development of the crop and to answer this question the issue of price formation must first be analyzed.

Marketing and Price Formation

In a multi-market situation it is essentially price which allocates the cassava roots between the different end uses. It is axiomatic that the price must be able, on the one hand, to cover the farmer's costs of production and, on the other hand, to compete with substitutes in the various markets. Forces on the supply side, such as increasing input or factor costs or the advent of more profitable crops, may drive the production cost of cassava out of line with the market price of substitutes. Vice versa, forces on the demand side, such as inelastic output markets or falling price of substitutes, may drive the market price out of line with production costs, at least for more high cost producers. At issue in this section then is delineation of the principal factors determining cassava price in the different countries and of the mechanism influencing the allocation of cassava between different end uses.

The cassava products in the different cassava markets tend to compete with different substitutes. This sets up something of a hierarchy of markets in which cassava in some markets can be competitive at higher prices than in others. Thus, in Kerala, India the fresh food market is the principal demand-side factor in price formation. Since there are severe supply-side constraints on expanding cassava production, cassava prices set in the food market tend to be higher than are profitable for the operation of the starch industry, which absorbs seasonal surpluses and roots of inferior quality. In the Philippines, on the other hand, the fresh food market usually sets a higher root price than the starch market, but because the size of the food market is so limited, the starch factories tend to be the major market force in their supply area. However, expansion in this starch market has been apparently constrained by competition with maize starch. There is potential for expanding cassava area and production for the animal feed market, but yields need to be higher than their current average of around 5 t/ha and therefore costs of production lower.

Factors determining cassava prices are very different between countries (Table 10) and the constraints on further development of the crop also vary markedly. In Thailand and the Philippines the constraint is on the demand side, while in India, Malaysia and Java the constraint is very much a production constraint. Where cassava production has expanded rapidly in Asia, such as Thailand and the Lampung area of Indonesia there has been the convergence of access to a very expansive market and underutilized land to support area expansion. In the other areas, apart from the possible case of Malaysia, growth in production will depend on increasing yields, whether to make cassava competitive in alternative markets or as a means of substituting for land where land availability is very limited.

For a crop where, in most countries, prices are so dependent on forces within domestic markets and where there is such a diversity in market structure, the expectation would be that cassava prices would very markedly across countries. Evaluated at current exchange rates, farm-level prices are consistently the lowest in Thailand and are the highest either in India or Indonesia (Table 11) -- although the latter are probably inflated because the series is based on village-level prices. Clearly, however, the competitive position of Thailand in the world market is firmly established, while the other countries remain either minor or intermittent exporters. Moreover, it is only in Thailand that there has been any clear trend in real, farm-level prices over the last decade and this has been a downward trend, which is consistent with the very rapid expansion in production. In the other countries farm prices have been relatively stable, which would appear to imply a relatively stable supply-demand situation. The case in Indonesia is more complex than that but certainly for the other countries there has been little incentive to develop lower-priced markets.

Different end markets and different forms of marketing cassava raise the second issue of how price allocates the cassava roots and dried products between the different markets. As it has been noted, only a relatively small part of cassava production remains on the farm for subsistence consumption and this occurs only in Indonesia and Kerala; the greater portion moves into marketing channels. Farmers market the major part of their production as fresh roots and it is generally the assembly agent who decides on the end market to which the cassava will go. However, farmers also have the option of producing gaplek-- by peeling, quartering, and drying the root. This practice predominates in Indonesia and is utilized to a much more limited extent in Kerala and the southern region of the Philippines. Gaplek plays a fundamental role in Indonesia in integrating cassava markets across different forms, space, and time.

Various demands are made on a cassava marketing system due to the bulkiness and extreme perishability of the roots, the different end uses and forms, and in most countries the seasonality of production. Seasonality is a problem in only the major cassava producing countries of Thailand, Indonesia and India. In Thailand about 50% of cassava area is planted in the April-June period; in Kerala 60-65% is planted in the same three month period, and in Java 75% of area is planted in the

November-January period. In Thailand the seasonality problem is overcome by processing all the cassava roots and by the availability of a large storage capacity. In India and Indonesia where consumption of fresh roots as food is important, there is a definite seasonality in consumption, as can be seen for the case of Indonesia in Table 12. In Indonesia, and to a much lesser in India, gaplek, although a less preferred food, serves to extend the consumption period, thus resolving the seasonality problem not by adjustments in the production system but through adjustments in marketing, processing and consumption form.

Gaplek provides the storage capability in cassava markets and thus tends to integrate them through time. Gaplek also permits economical transport of cassava and thus tends to integrate cassava markets across space as well. That is, consumption points for fresh roots normally draw on only a very small supply area, due to the high transport costs and the perishability constraint. This situation would tend to create relatively independent markets in which prices vary significantly between areas. These would tend to occur in countries in which food markets for fresh cassava dominate, that is the Philippines and Kerala (Table 13). Widely traded commodities, such as starch and gaplek, where arbitraging is possible, have more of a national market where prices are determined more by aggregate rather than local supply and demand situations. Because farmers and/or assembly agents have the option of supplying roots to these markets, gaplek and starch prices will tend to integrate fresh root markets within the economy, as occurs in Thailand and Indonesia (Unnevehr, 1982).

Price integration across markets, space and time is critical in fostering growth in cassava production and utilization. Integration provides incentives for cassava to be grown in areas where production is most efficient, it maintains competitive price formation, and it provides the necessary information, implicit in nationally determined market prices, to motivate investment in processing capacity for which there is greatest market potential. Fragmented markets, in a crop such as cassava, can significantly inhibit wide-spread investment in processing plants by making cassava appear too costly in price terms in relation to its actual production cost. This is certainly one factor in explaining the lack of growth in Philippine cassava production compared to that in Thailand and Indonesia.

Finally, an observation arises on the role that gaplek can play in price integration between different and markets. Gaplek is in many ways a cassava "grain". If properly dried, it can be stored, which provides food supplies out of the harvest season. Because it is peeled, it can be ground for composite flour production or go into domestic or export animal feed markets. Starch plants in India and the Philippines occasionally use gaplek for starch processing, especially for glucose production, when fresh root supplies are limited. Apart from kokonte in Ghana and farinha de raspa in Brazil, dried cassava chips of this quality are only produced in Asia, almost solely in Indonesia. Interestingly, Indonesia has the most diverse end markets for cassava and is probably the most fully integrated cassava market, where the bulk of production is for domestic use. Motivating a gaplek market of a certain minimum, critical size would appear to give the cassava economy a large degree of flexibility in responding to changing economic and market conditions.

Cassava's Future Role in Asia

Beyond the central role that rice plays in the food economies of tropical Asian countries, the agricultural sectors of these countries are very diverse. Cassava production and utilization has adapted itself to this diversity. As is apparent in the previous analysis, it is the differences rather than the similarities that are most striking in comparing cassava sectors across countries. Cassava has developed within different types of land constraints, and multiple markets have evolved around the crop, with the particular market structure reflecting the overall development of the economy. The rate of development of most of these economies has accelerated over the past two decades, creating a potential demand for further broadening of cassava production and utilization.

Rapid development of the crop in most cases will depend on increases in yields, either to relieve land constraints or to be competitive in these emerging markets. It is natural in an Asian context, where expansion of crop area is frequently constrained, that there should be a bias toward crops with very high yield potential, more so when this is high yielding ability under upland conditions. Very high productivity is already being achieved in certain areas but in general average yields remain below the known potential of the crop. What still remains largely undefined is the means to achieving this high yield capability across tropical Asia. Obviously the type of technology necessary will vary, requiring a continued commitment of research resources to maintain the cassava research capacity in Asia that has emerged over the last two decades since the founding of the Indian program in 1963. Governments, however, require some justification for research investment, which follows from the role cassava could play in the policy arena.

Cassava's adaptation to a wide range of upland conditions and its multiple-use characteristics give cassava a substantial flexibility in agricultural policy. As has been stressed, cassava's role in each country's agricultural economy will be different (Table 14), but in each case cassava can be a basis for meeting multiple policy objectives. In India and Indonesia cassava can play a clear role in nutrition policy. In all countries, even in India and Indonesia, cassava, because of its multiple-market potential, can play a major role as a source of income generation for small-scale farmers in upland areas. A further advantage in satisfying growing domestic markets by increased domestic production is the positive impact on balance of payments. Further market diversification of cassava, however, will require both improved production technology and appropriate processing technology, together with, in some countries, better integrated markets.

The Green Revolution that swept the continent in the late-sixties and the seventies was limited to the irrigated areas. The next major challenge is to raise crop productivity and farmer incomes in the upland areas. With probably limited prospects for further major growth in world demand for rubber, palm oil and coconut oil, with growing domestic markets that could absorb cassava products, and with a growing regional market for carbohydrate sources for livestock, cassava is a major, if not the major, crop in a position to foster income growth in the upland areas of tropical Asia.

Table 1. Production and Utilization of Cassava in Principal Producing Countries

Country	Production (000t)	Export (000t)	Domestic Utilization: Human Consumption: Fresh (000t)	Domestic Utilization: Human Consumption: Dried (000t)	Domestic Utilization: Starch (000t)	Domestic Utilization: Animal Feed (000t)	Domestic Utilization: Waste (000t)
India (1977)	5688	22	2610	619	1784	-	653
Kerala	4189	22	2437	619	499	-	503
Tamil Nadu	1310	-	126	-	1162	-	131
Indonesia (1976)	9686	801	3444	2212	2747	-	482
Java	6317	253	1815	1760	2134	-	355
Off-Java	3369	548	1629	452	613	-	127
Malaysia (1977)	432	66	-	-	302	43	21
Philippines (1975)	450	-	223	37	92	32	65
Thailand (1977)	13,554	9,996	-	-	745	16	2797

Source: Unnevehr , 1982; Titapiwatanakun, 1979; CIAT data files.

Table 2. Type of Land Constraint in the Principal Cassava Production Zones

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

Table 3. Characteristics of Cassva Cropping Systems in Major Production Zones

racteristic	Thailand Northeast	Malaysia Perak	Indonesia Java	Philippines Mindinao	India Kerala	India Tamil Nadu
ncipal Power Source	Tractor	Tractor	Manual	Bullock	Manual	Bullock
ercropping	Monoculture	Monoculture	Maize and upland rice principal intercrops	Monoculture	Peanut recent intercrop	Monoculture
or Input for ling n days/ha)	37.6	13.3	high	12.8	high	96.7
tilizer Use						
rganic (t/ha)	-	-	0 to 8.6	none	high	18.5
norganic (kg/ha)	9.6	198	21.7	none	19	200
sonality in Planting	50% planted April-June	slight	75% planted Nov-Jan	Moderate	60-65% planted April-June	Major porti planted Jan-Mar
verage Yields (t/ha)	13.8	27.2	9.7	4.7	13.6	24.5
Subsistence Consumption	none	none	27%	17%	60%	neg

rce: Thailand Ministry of Agriculture and Cooperatives, 1982; Tunku Yahya, 1979; Roche, 1982; Mejia, et.al., 1979; Uthamalingam, 1980.

Table 4. Land-labor Ratios and Average Farm Size for Various Asian Countries

Country	Land-Labor Ratio 1/ (ha/person)	Average Farm Size (ha/farm)
India (Kerala)	0.12	0.49 (1971)
Indonesia	0.22	1.05 (1963)
Java	N.A.	0.4 (1973)
Malaysia	0.65	2.19 2/ (1970)
Philippines	0.44	3.59 (1960)
Thailand	0.51	3.72 (1978)

1/ Arable land and land in permanent crops divided by rural population, 1980.

2/ Does not include estates which make up 31% of cultivated area.

Source: FAO, 1981; agricultural censuses of different countries.

Table 5. Labor Use and Cost Structure in Cassava Production Systems 1/

Country Location Period	Indonesia Gunung Kidul 1979/80	Indonesia Kediri 1979/80	Thailand Cholburi 1977/78	Thailand Nakornrajsima 1977/78	India Salem 1978/79	Philippines Central Visayas 1976/77	Malaysia Perak 1977/78
abor Input (m.d./ha)	345.8	237.2	74.8	67.2	138.5	65.0	62.2
and Costs (US$/ha)	0	233.7	28.9	74.8	121.3	46.4 2/	17.3
ariable Costs (US$/ha)							
Labor	97.8	227.0	76.2	64.0	90.9	50.1	116.4
Land Preparation	0	106.7	59.2	33.5	13.4	5.1	38.9
Fertilizer	0	114.9	16.6	0	59.8	0	25.9
Pesticides	0	0	2.7	0	0	0	12.1 3/
Seed	2.6	4.8	16.6	1.9	0	0	3.5
Total	100.4	453.4	171.3	99.4	164.1	55.2	196.8
ield	2.6	17.5	10.9	13.7	10.7	5.5	27.2
ariable Costs (US$/ton)	38.6	25.9	15.7	7.3	15.3	10.0	7.2

/ Domestic currency converted to US dollars at existing exchange rate.

/ Share tenancy - 33% of gross value.

/ Herbicides

OURCE: Roche, 1982; Tinprapha, 1979; Uthamalingam, 1981; Mejia, et.al., 1979; Tunku Yahaya, 1979

Table 6. Comparative Yields Derived from National Statistics and Production Surveys

Country/Region	National Statistics Year	National Statistics Yield (t/ha)	Production Survey Year	Production Survey Yield (t/ha)
India	1978-79	16.7		
Kerala	1978-79	14.6		N.A.
Tamil Nadu	1978-79	31.2	1978-79	13.6 and 23.0[1]
Malaysia	1978	17.4		
Perak		N.A.	1978	27.2
Indonesia	1977-79	12.9		
West Java	1977-79	10-12	1979-80	6-20
Central Java	1977-79	9-11	1979-80	5-12
South-Central Java	1977-79	7-9	1979-80	2-10
East Java	1977-79	10-11	1979-80	10-40
Philippines	1977-79	10.3		
Central Luzon	1977-79	2.4	1977-79	5.8
Bicol	1977-79	9.6	1977-79	2.5
Central Visayas	1977-79	3.5	1977-79	5.5
Eastern Visayas	1977-79	4.2	1977-79	2.2
Western Mindinao	1977-79	14.7	1977-79	5.4
Northern Mindinao	1977-79	4.6	1977-79	4.0
Thailand	1980-81	13.1		
North	1980-81	17.0	1980-81	14.2
Central	1980-81	15.5	1980-81	15.1
Northeast	1980-81	13.3	1980-81	13.8

Source: Uthamalingam, 1980; Tunku Yahaya, 1979; Roche, 1982; Mejia, et. al., 1979; Ministry of Agriculture and Cooperatives, 1982; and national statistical sources.

[1] Non-irrigated and irrigated conditions

Table 7. Selected Economic Indicators of Principal Cassava Producing Countries

untry	GNP Per Capita		Percent of GNP of Industrial Origin		1980 % of Population in Urban Sector	Growth in Urban Population	
	1980 Level ($US)	Growth 1960-80 (%)	1960 (%)	1980 (%)	(%)	1960-70 (%)	1970-80 (%)
dia	240	1.4	20	26	22	3.3	3.3
donesia	430	4.0	14	42	20	3.6	4.0
laysia	1620	4.3	18	37	29	3.5	3.3
ilippines	690	2.8	28	37	36	3.8	3.6
ailand	670	4.7	19	29	14	3.5	3.4

ource: World Bank, 1981

Table 8. Production of Feed Concentrates in Relation to Coarse Grain Imports

Country	Feed Concentrate Production-1980 (000t)	Growth in Concentrate Production 1970-80 (%)	Coarse Grain Imports 1980 (000t)	Growth in Coarse Grain Imports 1970-80 (%)
Cassava Producers				
Thailand	1350	28.6	- 2,175	-
Philippines	936[1]	12.9[2]	351	27.5
Malaysia	549	12.2[3]	431	7.4
Indonesia	410	N.A.	34	3.5
Non-Cassava Producers				
Republic of Korea	4775[4]	5.2[5]	2,364	27.2
Taiwan	N.A.	N.A.	3,618	N.A.
Hong Kong	N.A.	N.A.	270	4.4
Japan	19,876[6]	N.A.	17,165	5.7
Singapore	N.A.	N.A.	552	14.0

[1] 1979 [2] 1970-79 [3] 1972-80 [4] 1981 [5] 1972-81 [6] 1977

Source: FAO, 1975 and 1982; CIAT data files

Table 9. Characteristics of the Cassava Starch Industry in the Principal Producing Countries

ntry	Cassava Starch Production 1980 (000 t)	Growth in Cassava Starch Disappearance: 1970-80 (%)	Growth in Total Starch Disappearance:1970-80 (%)	Two Largest Final End-Uses	Modal Scale of Processing
a	415	N.A.	N.A.	Tapioca Pearl Cloth Sizing	Medium
nesia	662	8.9 [1]	8.9 [1]	Krupuk Other food Indus-tries	Medium to Large Large
ysia	50	9.9 [2]	9.9 [2]	N.A.	Large
ippines	17 [3]	- 2.9 [4]	7.9 [4]	Glucose Monosodium Glutamate	Large
land	416	7.7	7.7	Food Industry Monosodium Glutamate	Large

974-79   [2] 1972-80   [3] 1979   [4] 1970-79

rce: Nelson, 1982; CIAT data files

Table 10. Principal Factors Determining Cassava Price Formation and Constraining Expansion of Cassava Production and Utilization

Country	Major Market	Principal Secondary Market	Principal Constraint in Development of Alternative Markets: Supply-side	Principal Constraint in Development of Alternative Markets: Demand-side	Dominant constraint in Expansion of Production and Utilization
Indonesia	Starch and Food-Fresh Root	Food gaplek	Java-Farm Size Constraint Off-Java-Competition with Tree Crops	Java-Existing Growth Market Off-Java-Infrastructure	Java-Supply-Side Off-Java-Demand-Side
India					
Kerala	Food-Fresh Root	Starch	Farm Size Constraint	High Prices in Food Market	Supply-side
Tamil Nadu	Starch	Food-Fresh Root	Farm Size Constraint	Existing Growth Market	Supply-side
Thailand	Export-Pellets	Export-Starch	Price Distortions Relative to Grains Created by EC Export Market		Demand-side
Malaysia	Starch	Animal Feed	Land Use Policy	Competition with Imported Maize	Supply-side
Philippines					
Mindinao	Starch	Food-Fresh Root	Lack of Integration of Appropriate Production and Processing Technology		Demand-side
Rest of Country	Food-Fresh Root	Starch	Lack of Integration of Appropriate Production and Processing Technology		Demand-side

Table 11. Farm-level Prices of Cassava Roots: Real (1975 = 100) Domestic Currency Prices and US Dollar Prices, 1970-81

Year	India 1		Indonesia 2		Malaysia 3		Philippines 4		Thailand 5	
	Real Price (Rupee/t)	Dollar Price (US$/t)	Real Price (Rupee/kg)	Dollar Price (US$/t)	Real Price (M$/t)	Dollar Price (US$/t)	Real Price (Pesos/kg)	Dollar Price (US$/t)	Real Price (Baht/kg)	Dollar Price (US$/t)
1970	N.A.	N.A.	19.7	22	N.A.	N.A.	.25	20	.79	24
1971	391	29	17.7	19	83	20	.27	23	.82	25
1972	406	31	21.5	23	56	15	.25	22	.72	23
1973	446	40	28.3	40	65	22	.30	31	.38	14
1974	423	47	16.1	32	79	32	.31	42	.30	14
1975	400	48	17.6	42	78	30	.29	40	.40	19
1976	449	44	23.4	67	73	29	.26	37	.44	22
1977	376	37	21.9	70	76	33	.26	40	.43	23
1978	353	39	19.9	64	58	28	.26	43	.29	18
1979	411	49	19.4	53	67	36	.25	50	.56	36
1980	N.A.	N.A.	20.3	67	89	51	.25	58	.47	37
1981	N.A.	N.A.	19.7	73	72	43	N.A.	N.A.	.30	25

1 Kerala, Farm-level 2 Java and Madura, Rural Village-level 3 Perak Factory Buying Price 4 Average Philippines, Farm-level

1 Non-irrigated and irrigated conditions

Source: CIAT Data Files

Table 12. Indonesia: Seasonality in Consumption and Prices of Fresh Cassava and Gaplek, 1976

	January-April	May-August	September-December	Annual Average
Consumption (kg/capita)				
Java-Rural				
Fresh Cassava	33.7	25.1	15.8	24.9
Gaplek	24.7	31.6	33.9	30.1
Indonesia				
Fresh Cassava	33.3	27.0	17.0	25.7
Gaplek	19.7	25.3	23.0	22.6
Prices (Rupiah/1000 calories)				
Indonesia				
Fresh Cassava	21	24	26	23
Gaplek	14	13	20	16

Source: Dixon, 1979

Table 13. Retail Prices of Cassava Fresh Roots in Different Market Areas, Kerala and the Philippines, 1979

Kerala (District)	Retail Price (Rupee/kg)	Philippines (Region)	Retail Price (Pesos/kg)
Trivandrum	0.50	Ilocos	1.29
Quilon	0.48	Cagayan Valley	1.34
Alleppey	0.59	Central Luzon	1.11
Kottayam	0.63	Southern Tagalog	1.01
Idukki	0.70	Bicol	1.07
Ernakulum	0.60	Western Visayas	1.53
Trichur	0.51	Central Visayas	1.15
Palghat	0.47	Eastern Visayas	0.95
Malappuram	0.56	Western Mindinao	1.18
Kozhikode	0.62	Northern Mindinao	1.05
Cannanore	0.87	Southern Mindinao	1.30
		Central Mindinao	1.00

Source: CIAT data files

Table 14. Potential Role of Cassava in Agricultural Policies of Selected Asian Countries.

Agricultural policy objectives	Contribution according to country				
	Indonesia	India	Thailand	Philippines	Malaysia
Food and nutrition policies					
a. Flexibility in rice policies[1]	X	X			
b. Nutrition of the poor	X (gaplek)	X (fresh)			
Farm income and land use					
a. Higher small-farm income in upland areas	X	X	X	X	X
b. Exploitation of frontier areas	X (except Java)		X (in the NE)	X (in Mindinao)	X (peat soils)
Balance of payments					
a. Increased export earning			X		
b. Import substitution	X (sugar)			X (feed grains)	X (feed grains)

[1] In Indonesia there exists a price policy on rice and in India rice comes under a food rationing system