Food and Agriculture Organization of the United Nations

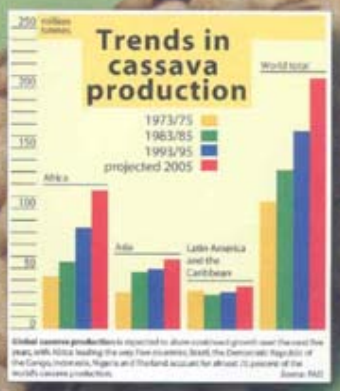
PROCEEDINGS OF THE VALIDATION FORUM
ON THE GLOBAL CASSAVA DEVELOPMENT STRATEGY

Rome, 26-28 April 2000

IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT

A review of cassava in Asia with country case studies on Thailand and Viet Nam

Volume 3



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INTERNATIONAL CENTER FOR TROPICAL AGRICULTURE

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INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

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Rome, 2001

FOREWORD

In Asia's largely rice-based food systems, cassava is emerging as a fully commercial crop and entering a diversified market. The capacity of cassava to adapt to soils of marginal fertility and uncertain rainfall, as well as its capacity to provide income and thereby alleviate poverty, are the principal attributes that allow this crop to play a catalytic role for rural development in Asia. The factors that tend to further reinforce this key role are the domestic industry demand for starch and animal feed, the market opportunities for processed food products, the export potential for pellets and starch, and the competitive costs of production.

Today, Asia produces about 28% of the world's cassava. On the basis of current projections, it is expected that by 2020, the production of cassava in the region will remain important in terms of quantity and will become increasingly significant from a global perspective. Increased demand is expected for cassava for processed food, specialized starch products and for fodder. The competitiveness of these products, and the resulting benefits to low-income households should be assured by the continued reduction of production costs through the adoption of soil fertility and erosion management practices and the uptake of higher-yielding varieties with higher quality traits. However, increased population, the poor soils on which cassava is grown, the limited options for other crops due to environmental constraints, and pollution are still major concerns. In particular, technologies that respect the environment will be increasingly important in Asia, and a major challenge will be to overcome the environmental constraints associated with waste and waste-water management from cassava processing plants.

Generous financial assistance from IFAD, the World Bank, Swiss Development Cooperation and IDRC supported the preparation of the Asia Regional Review on Cassava, the Country Case Studies for Thailand and Vietnam, and the Report of the Asia Regional Consultation on the Global Cassava Development Strategy. These documents form the basis of the Global Cassava Development Strategy presented to the International Validation Forum that was jointly organized by FAO and IFAD at FAO Headquarters in Rome, from 26 to 28 April 2001. The Forum officially endorsed the Strategy and adopted an implementation plan, which outlines a sequence of follow-up actions for its realization.

The Plant Production and Protection Division of FAO has compiled the documents prepared during the process of building the strategy on the cassava sub-sector in Asia and which were presented at the Forum in Rome. The Division is now pleased to publish the Proceedings in order to disseminate the information to stakeholders, cassava producers and their organizations, governments and policy makers, donors, technical and research institutions and their networks, NGOs and their networks, the private sector - as well as to scholars, experts and interested individuals.

We trust this information will help to sustain cassava production in Asia and to guide research and development efforts towards a particular regard for the environmental considerations relative to the sector.

Mahmud Duwayri

Director

Plant Production and Protection Division

Food and Agriculture Organization of the United Nations

CONTENTS

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
APEC	Asia Pacific Economic Cooperation
AUSAID	Australian Aid
CAP	Common Agricultural Policy
CBN	Cassava Biotechnology Network
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CRTCRI	Central Root and Tuber Crop Research Institute, India
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension
EU	European Union
FAOSTAT	FAO Statistical database
HARC	Hung Loc Agricultural Research Center, Viet Nam
IAS	Institute for Agricultural Science for South Viet Nam
IDRC	Canadian International Development Research Centre
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Commodities and Trade
IRRI	International Rice Research Institute
MARDI	Malaysian Agricultural Research and Development Institute
MGRN	Manihot Genetic Resources Network
NGOs	Non-governmental organizations
NRI	Natural Resources Institute
OAE	Office of Agricultural Economics, Thailand
PHTI	Post-Harvest Technology Institute, Viet Nam
SCCI	State Committee for Cooperation and Investment in Viet Nam
TTDI	Thai Tapioca Development Institute
TTFITA	Thai Tapioca Flour Industries Trade Association
TTTA	Thai Tapi Trade Association

CASSAVA IN ASIA[1]

Expanding the Competitive Edge in Diversified Markets

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[1] Background document prepared as part of the process of defining a global cassava development strategy, an initiative of the International Fund for Agricultural Development, and with participation of a broad representation of stakeholders in the cassava sector. A draft was reviewed in an Asian stakeholders' meeting in Bangkok in November 1998. The authors gratefully acknowledge comments and corrections of reviewers. Any remaining errors or omissions are the sole responsibility of the authors. March 2000.

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EXECUTIVE SUMMARY

Successful agriculture not only directly sustains its practitioners, but can also establish the foundations for broad-based development. This paper reviews the constraints and opportunities for improving the well-being of Asia's rural poor, by way of focusing on cassava, one of the region's most important food and industrial crops. Cassava production, processing and marketing has already contributed to considerable social and economic development in Asia, but the full potential is yet to be realized. The appeal of a substantial investment in the cassava sector lies in the efficiency and effectiveness with which some key economic and social goals can be met.

CASSAVA AS A CATALYST FOR DEVELOPMENT

In Asia cassava is emerging as a fully commercial crop entering diversified markets. This status defines an evolving and dynamic role in development for the region. Roots are converted into an array of products - human food as fresh or processed roots, starch and flour for food and industry, and animal feed. Rice continues a long tradition as the principal and preferred energy source in much of Asia, but where soils are marginal in fertility, and rainfall uncertain, cassava has a strong adaptive advantage. In this context, cassava serves as an ideal focus to achieve several key development goals. Improving this crop is a way to direct various benefits toward the poorest of rural populations, as well as contribute to broader economic development.

Cassava is a crop of the poor, and occupies mainly agriculturally marginal environments. These and other features endow it with a special capacity to contribute to food security, equity, poverty alleviation, and environmental protection.

Cassava's role in food security has declined in post-Green Revolution Asia, but continues as a factor in times of political unrest, wars, food shortages, or other disruptions of normal food supply. On a country-wide basis, only Indonesia has moderately high consumption - about 50 kg per capita per year, in the form of a wide array of different food products. The rapidly growing on-farm use of cassava as animal feed in China and Viet Nam meets basic needs both of food security and income generation.

The capacity of the crop to provide income, and thereby alleviate poverty, is the principal attribute allowing cassava to function as a catalyst for development. The forces that enable and augment this central role are: a tradition of diet diversity, which expedites the success of new food products on the market; internal industry demand for starch and animal feed; and opportunities for export of pellets and starch.

The benefits of improving the cassava sector are generally skewed toward the lower income strata, thereby nudging the economic system toward a greater measure of income equity.

However, mechanized production, while occurring slowly, is disproportionately displacing the labour of women. The trend toward larger centralized processing facilities is having similar effects where starch is the main commercial product. The cassava sector is not immune to the gender equity issues arising out of the modernization of agriculture and industry.

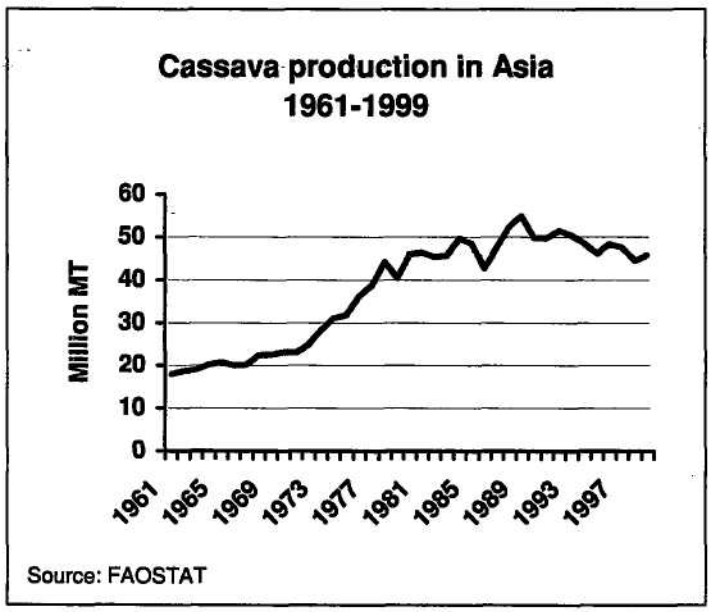
The links between cassava and environmental protection revolve mainly around implications of the large proportion of this crop grown in fragile or otherwise marginal ecosystems. Cassava's undeserved reputation as a crop that causes exaggerated soil degradation grew mainly out of the plant's ability to produce on poor soils, when most other crops would fail. Nonetheless, managing erosion is a critical need where cassava is grown on slopes and in light soils, especially during the first months before the canopy closes.

Disposal of waste products from processing is a growing environmental concern. The solutions lie in research on environmentally and economically sound waste management, by-product development, and reasonable but effective regulation. As processing plants become larger and more centralized, they are able to apply more resources to pollution control, especially through improved efficiencies of extraction and by-product utilization.

Cassava is a new crop in Asia, introduced from the Americas by Spanish explorers. Colonial rulers promoted it first as a famine reserve crop, and then as a source of starch for export.

TRENDS IN PRODUCTION, TRADE, AND UTILIZATION

Spanish explorers probably first introduced cassava to Asia, through the Philippines, from its Latin American homeland. By the beginning of the 19th century it was widely distributed throughout tropical Asia. Cassava gained status as a famine reserve crop and as a raw product for starch production, especially in Indonesia and Malaysia. World War II disrupted starch trade, and in the post-war era, maize became the principal source of starch.



The region produces about 46 million tonnes of cassava on 3.4 million hectares (1999). In Southeast Asia it is fourth in production (dry matter basis) after rice, sugarcane and maize. Two-thirds of the total comes from Thailand and Indonesia alone. Seven countries account for 99% of the region's production: Thailand, Indonesia, India, China, the Philippines, Viet Nam and Malaysia. About 40% of cassava is used for

direct human consumption, especially in processed form. Most of the remainder is destined for animal feed or processed for starch.

Trade policy has been instrumental in shaping cassava's role in the region. The most successful market evolved from policies that opened a niche for dried cassava in Europe's animal feed industry. Thailand's public and private sectors responded by supporting a vertically integrated system of production, processing and marketing, based on tens of thousands of small producers. From near zero in 1960, Thailand's exports of chips and pellets grew to over eight million tonnes annually in 1992-94. Gradual withdrawal of cassava's special treatment in Europe's feed market in the past decade is now forcing diversification of the export industry. Whereas in 1982 chips and pellets represented 88% of the total utilization of Thailand's production, this share declined to 70% by 1992. In the same period, starch increased from 12% to 28%.

Indonesia has maintained a relatively stable production for over 30 years, with most used internally as human food. In India, cassava is concentrated in the southern states of Kerala and Tamil Nadu, which accomplish the world's highest national average yield levels through intensive cultivation. China and Viet Nam are expanding production to meet rapidly growing internal demands for industrial starch and animal feed.

Technology and markets are allowing higher-value crops to displace cassava in some of the traditional growing areas. Cassava is then pushed to continually more marginal lands. The downward pressure on yields from this push to lower-productivity lands has been offset by adoption of new technology such as high-yielding varieties.

There are also some examples where cassava is cultivated under more favorable conditions - on larger plantations in southern Sumatra and the Philippines, and in Kerala, India, where early-maturing varieties are planted after a first paddy crop.

Assuming application of improved production and post-harvest technology, substantial levels of institutional investment in research, and supportive agricultural and trade policies, there are good prospects for sustained growth in cassava demand and production for the next two decades (Rosegrant and Gerpacio, 1997). Most of this growth will come from yield increases averaging about 0.4% per year. Total area in Asia will climb from 4.0 million (1993) to 4.2 million hectares.

CONSTRAINTS AND OPPORTUNITIES FOR SYSTEM IMPROVEMENT

Successful interventions to exploit cassava's potential rely on alleviating constraints in the system, as well as pursuing new opportunities. These are impacted by both the larger socio-economic and political milieu, and the characteristics of the cassava sector itself.

An evolution toward more open **trade policy** brings cassava and its products into direct competition with alternative energy sources for food and industry. A competitive position depends on improving efficiencies of production and processing, and on developing new markets.

External influences strongly impact cassava demand and supply

- Urbanization
- Broad income growth
- Limitations of the resource base
- Alternative food/feed energy Agricultural and trade policy
- sources
- Infrastructure for accessing production inputs and markets

Urbanization and income growth are changing food consumption habits, with greater diet diversity, less demand for starchy staples, and more demand for convenience foods. Cassava's versatility is a decided advantage for adapting to these changes.

Comparative advantages for production in marginal and fragile agricultural areas mean that **management of the resource base** is an acute concern. Thailand has invested in crop diversification programs in the Northeast, mainly in response to pressure from Europe to reduce exports, but also in part out of concern about inappropriate practices leading to soil degradation. Concentrated research attention to this issue in the past decade is bringing new options to protect the environment in cassava-based systems, especially with soil erosion control and fertility maintenance technologies.

General **trends in commodities** are closely linked with cassava's competitive edge in different markets. These linkages are related to two principal factors. First, much of Asia's cassava enters markets where raw product substitution can readily occur. These are primarily rice and wheat for food and maize for feed and starch industries. Secondly, protein supplementation, e.g. soybeans, is necessary to compensate for cassava's low protein content in animal feeds. In inflation-corrected terms, prices of agricultural commodities have been on a downward trend for the past fifty years, driven by improved efficiencies in production and transportation, and, recently, lowered trade barriers. Cassava will have to meet and surpass the rates of improvement in efficiency achieved by the major grain crops in order to sustain a competitive edge.

Inadequate **infrastructure,** especially in rural areas, limits the ability of growers to obtain inputs at reasonable prices, and to market their products. Cassava's bulkiness, especially as fresh roots, makes it especially vulnerable to infrastructure constraints. The need for local value-added processes becomes especially critical-as a way of sustaining income growth.

Improving cassava's capacity as a catalyst for development requires both a long-term and a multi-faceted agenda. This will only be possible with a network of **institutional resources** that provide the capacity and motivation to see a viable cassava-based development in Asia. The region has some of the world's strongest cassava research programs. But without greater investment it will be increasingly difficult to compete with the well-funded, advanced

research systems in competing commodities from more developed countries. Networking to achieve complementarities has already been highly effective in agronomy, genetic improvement, and post-harvest research. The continuation and strengthening of this work needs to be assured.

Cassava's productivity in Asia could be doubled with practical genetic and management inputs.

Constraints	Potential increase (%)
Soil erosion	10
Soil fertility	22
Planting material	8
Weeds	7
Intrinsic yield potential	24
Pests and diseases	5
Climate	11
Other	9

Source: Henry and Gottret, 1996.

An extensive survey to quantify constraints to production and post-harvest factors (Henry and Gottret, 1996) showed that cassava yields in Asia could be almost doubled by applying technology within reach of typical cassava farmers.

Soil erosion control and **fertility maintenance** are now widely recognized as critical to sustainable income generation from cassava. Soil fertility is most commonly maintained by iertinzer inputs, although still at quite low levels in comparison to many crops. The technology for reducing erosion includes land preparation practices, fertilization, plant density and varietal canopy characteristics, vegetative erosion barriers, and intercropping or understory crops. Alleviating the constraints from these two components of soil management would increase yields by 33%.

As a whole, Asian countries employ relatively intensive cassava crop management practices, probably the major contributing factor to the higher yields as compared to Africa or Latin America. Still, there are significant improvements to be made. Vegetative reproduction introduces several potential constraints. Appropriate management of planting material can alleviate the effects of biological and physical stresses, for yield gains of about 8%. Weed control is mainly manual, and applying additional labour inputs is impractical for most growers. Farmers are increasingly looking to mechanical or chemical weed control. Improvements should contribute 7% to current yields.

Asia appears to have a narrower range of genetic diversity, relative to Africa or the Americas, a constraint that impacts mainly cassava's intrinsic yield potential. The constraint of a narrow genetic base among the local landrace varieties is being met by massive introductions from Latin America since the mid-1970s. New varieties already occupy nearly a third of Thailand's cassava area. Growers in Indonesia, Viet Nam, the Philippines, China and India are increasingly experimenting with and adopting new hybrids from national and international centers.

Pests and diseases are a minor constraint in most of Asia. Highest potential gains can come from controlling mosaic virus in India and bacterial blight in the subtropics.

The crop's remarkable adaptation to drought is one of the main factors that define its distribution: two-thirds of Asia's cassava is grown in the sub-humid or semi-arid tropics. Northeast Thailand, eastern Java, and southern India (mainly Tamil Nadu) are all dry areas where cassava is widely cultivated. Low winter temperature is a second climatic constraint in the sub-tropics, mainly affecting southern China and North Viet Nam. Cassava's relatively poor adaptation to cool temperatures is compensated by its tolerance to poor soils in these areas.

Even with diverse and highly developed cassava markets in Asia, post-harvest factors pose significant constraints on economic output of the system.

Constraint	Potential increase (%)	Attributed to:
Quality	13	Price premiums
Processing	4	Cost reductions
Product marketing	4	Reduced consumer prices

While Asia has a highly diversified cassava market sector, the CIAT survey results estimate that a 21% increase in economic yield is possible through improvements in quality, processing, and product marketing. The largest share of this (13%) is attributed to potential market premiums for quality improvement, mainly improved root starch content to increase the efficiency of extraction for industrial uses. Longer term, there are possibilities to substantially reduce losses from rapid post-harvest deterioration. Although cassava competes with alternative carbohydrate sources in several major markets, there is potential for developing more markets where unique starch characteristics are required, to bring a market premium to growers and processors. Technology for improving efficiency of starch extraction, and for value-added by-products of processing, will contribute both to the financial position of processors, and to a cleaner environment.

PRIORITIES AND STRATEGIES FOR MEETING DEVELOPMENT GOALS

Cassava needs to compete with steadily lower grain prices in its main markets. Its long-term viability hinges on a combination of increased on-farm efficiency and productivity, and expanded market opportunities. Most cassava farmers have limited options for other crops, because of soil and water constraints. For them; cassava must be a link to-new economic opportunities.

Cassava can fulfil Its potential as a catalyst for development only in an appropriate socio-economic and policy context.

- Agricultural and trade policy that does not discriminate against cassava, or against the rural sector in general
- Infrastructure improvements in rural areas
- Broad support of research and development

The broader economic and policy context is crucial to cassava's potential contributions to development: policies that support infrastructure development in rural areas, promote trade policy that brings long-term growth with broad benefits, seek equitable investment between urban and rural sectors, build

capacity in research and development. While recognizing the importance of this broader environment, this review focuses on cassava itself, and the specific goals and activities of cassava research and development. These interventions are broadly divided into demand side and supply side.

On the demand side, the challenge is to target growth sectors with product and market development. In the animal feed and native starch markets, cassava products will compete largely on price, consistency of supply, and quality. Product and process development is already well-advanced in parts of Asia, and there are considerable opportunities for technology transfer within the region. As industry attempts to achieve greater economies of scale, processing is moving away from household and village-level to larger centralized plants, especially for starch. Large plants can better control the variables of production, but at the same time diminish opportunity for growers themselves to add value to the cassava they produce. This, combined with a long-term trend of downward pressure on prices for raw agricultural commodities, challenges the ability of the small Asian farmer to derive reasonable income from cassava. Growers'/processors' cooperatives are an effective way to distribute benefits among a broader base of society. Another opportunity for raising incomes is the development of specialty markets. Cassava starch has several unique properties that create demand for particular industrial processes: resistance to shear stress and freezing, high viscosity, and production of transparent gels. Starch content and quality will increasingly become criteria for adding value for producers. Specialty starches, by definition, need to be of the highest quality, a challenge for growers unable to control the variables of production, or for smaller processors. The private sector is well-positioned to engage in this type of research, but needs support and collaboration from development-oriented public institutions.

An increase in demand is, in turn, an opportunity to deploy technologies, policies or methodologies that increase supply. The urgent needs on the production side are to substantially increase returns to land and labour, while conserving and improving the resource base.

Cassava can exploit specialty markets that require its specific starch characteristics.

- Resistance to shear stress and freezing
- High viscosity
- Transparent gels

Some elements of better production technology now exist for many regions, including high-yielding varieties and an effective package of cultural practices. Fertilizer is often the input with best economic returns, but access is a problem. New varieties are spreading rapidly in Thailand, and beginning to make inroads elsewhere.

Genetic improvement is a continuing long-term process, and optimizing progress in Asia will depend on targeted germplasm introductions from the Americas, continued investment in both classical breeding and biotechnology, and expanded networking. Involvement of the private sector in genetic improvement should be encouraged. Risks of introducing new pests

or diseases must be minimized with continued vigilance through standard quarantine procedures and training in plant protection.

Meeting development goals for the cassava sector.

Goal	Strategy
Stimulating higher demand	<=> Market development
Adding post-harvest value	Process and product development
Increasing long-term profitability for producers	Production efficiency; resource conservation; adding pre-harvest value
Support to production, processing and marketing	Institutional strengthening and policy support

With modest levels of inputs and management, and new varieties, on-farm trials can easily achieve over twice the national average yields, except in India where farm management is already high. Achieving these increases requires little additional labour input. Greater efficiencies in labour productivity will come with further mechanization in land preparation, harvest, and weed control with herbicides or mechanization. However, given the sloping and irregular topography of many production areas, combined with small farm size, full mechanization will be difficult.

For both demand-side and supply-side interventions to succeed, broad institutional strengthening is needed. Most countries have some research activity, linked by regional and global networks. Research investment for cassava, on a production value basis, is well below that for the major grain or specialty export crops.

There are effective approaches to achieving a balance in supply and demand that will optimize long-term benefits to the cassava sector. For cassava systems, synchrony between the interventions that target demand and those that target supply is often a special challenge.

Production technology may be slow to reach farmers because development time is longer than for most crops (long growing cycle; limited research capacity), extension services are under-staffed and under-funded, and the private sector is only beginning to get involved in cassava technology development or diffusion.

A system in balance:

- Demand and supply developed in parallel through integrated production, processing, and marketing projects
- Interests of stake-holders validated in participatory research
- Complementarily of private and public sector investments

Market demand may develop more quickly, especially where private industry has a strong vested interest. Integrated projects are a development model that specifically keeps supply

and demand in balance during the early phases of technology introduction. Expansion of both market demand and production can then usually continue with less institutional intervention. Finally, a full commercial phase is reached when demand and production spontaneously find the appropriate level where producers, processors and marketers make a fair profit, and consumers obtain a product at a competitive price.

Technologies and methodologies to alleviate poverty, address equity issues, improve food security, and protect the environment	
Marginal and fragile production environments; production efficiencies	• Adapted germ psalm • Erosion control practices • Cropping systems management • Fertilizer and lime
Intrinsic varietals traits	• High yielding hybrids • Rapid propagation techniques • Adaptation to mechanization
Biological constraints	• Integrated pest management • Mechanized and chemical weed control • Quarantine protocols
Processing constraints	• Mechanization • High-starch varieties • Genetic, chemical or physical starch modification for specialty markets • Improved shelf life • Pollution control • Economic use of by-products
Marketing constraints	• Value-added products • Market channel development

A complex array of forces acts on the cassava sector, some of which favor its competitiveness, and others that are a detriment. The outcome will be crucial to the segment of rural Asia that depends on cassava. Because of environmental constraints in most of the areas where it is cultivated, growers have few options for alternative crops. Cassava is a key, sometimes the only key, to economic and social opportunity for these farmers. Cassava markets are highly diversified in Asia, stimulating a demand-led growth of the cassava sector in the past. A significant part of this demand grew out of special international trade agreements with Europe, which are now being withdrawn. In global markets, cassava competes mainly with coarse grains, whose prices have tended gradually downward for the past fifty years in response to increasing production efficiencies. The degree to which its production and utilization bring adequate benefits to the poor is very much dependent on future research and development investment. The key elements of that investment will focus on- production efficiency and profitability, conservation of the resource base, processing efficiency, and market development of specialized products. Private and public sectors have a mutual interest in supporting a vital cassava industry. A significant institutional and technological base is already in place, on which to build new initiatives. The investments required to achieve these goals are substantial, but assuring a dynamic cassava sector in Asia will bring urgently needed benefits of poverty alleviation, equity, enhanced food security, and protection of the environment.

CASSAVA AS A CATALYST FOR DEVELOPMENT

OVERVIEW

Targeting development in the rural sector is highly appropriate for most of tropical Asia. Despite rising urbanization, the majority of households still derive a significant part of their income from agriculture. Further, urban dwellers, especially the poor, rely on the success of agriculture to consistently fulfill their nutritional needs at an affordable cost. Historically, few countries have realized sustained economic growth without the precursor of success in agriculture.

Agricultural systems are universally complex - the interaction of multiple physical, biological, social and economic elements. Overall improvement is rarely accomplished by changing a single factor. On the other hand, individual components within these complex systems may sometimes serve as a catalyst to stimulate and drive the changes needed to benefit specifically targeted populations. Cassava in Asia is a good example. Because the crop and its products have specific linkages to common development goals, the cassava system is an appropriate focus for a concerted investment in research and development.

In Asia's largely rice-based food systems, cassava has fundamental roles in supporting fanners where soils are marginal and rainfall uncertain. The urban poor benefit from availability of a low-cost calorie source. Industry and consumers alike gain from the multiple products for which cassava is a raw material. National economies balance trade with cassava products through exports, or through import substitution. Cassava in Asia is almost wholly a commercial crop, and its success is strongly affected by the broader economic environment. Diversified markets are the driving forces of Asia's cassava sector, providing a demand-led incentive for growth.

Continuing to realize, and expand, cassava's opportunities is neither automatic nor simple. The global economic environment continues to evolve rapidly, and agricultural research is changing farmers' options. Liberalized trade, regionally and globally, is breaking down the artificial cost barriers between internally and externally-produced goods. Strong research investment in grains, especially in export-oriented developed countries, is driving prices downward and making them more attractive in food, animal feed and starch markets. Continued acute under funding for cassava could leave it in a less competitive position for new markets, and even in its traditional markets.

Does this matter? There are compelling reasons to assure cassava's competitive position in the mature, diversified Asian markets. This review explores cassava's role in Asian agriculture, commerce, and industry, with emphasis on future potential for contributing to sustainable and equitable rural development. The objective is to set a framework for planning and prioritizing continued investment in research and development of cassava-based

production, processing and utilization systems, toward meeting broad development goals. Recommendations follow from evidence that strategic investments in cassava have critical benefits for the rural poor, who could be left behind if development policies exclude consideration of this crop's special roles.

DEVELOPMENT GOALS

In discussions leading to development of a global cassava strategy, a broad representation of stakeholders in the cassava sector endorsed the goals of food security, poverty alleviation, equity, and protection of the environment. Appropriately-focused research and development strategies can contribute substantially to meeting these goals.

Food security

Use of cassava for food in Asia is defined by its complementary position relative to rice, the highly preferred staple. From its introduction to Asia, through the middle part of this century, cassava was widely planted as a famine reserve crop. The *Green Revolution* in rice in the 1960s and 1970s considerably improved the food situation throughout Asia, and cassava's importance as a food security crop declined in response. Nonetheless, malnutrition remains a deep concern. In the Asia-Pacific region as whole, about 762 million people were chronically malnourished in 1970. This declined to about 540 million in 1990 - from 40 to 20% of the population. Most of the improvement took place in Southeast Asia, while South Asia was about constant (Cohen and Reeves, 1995). During the past two decades, much of the media and aid attention turned to Africa, where the numbers of chronically malnourished people doubled in this same period. However, in absolute terms, in spite of remarkable improvements, malnutrition is far more prevalent in Asia, affecting about three times more people than in Africa.

Like in Africa, cassava gains importance as a food security crop, relative to other staples, in times of political unrest, wars and famines. In modern times, this has been especially relevant for China and Viet Nam. Across developing Asia, average annual per capita cassava consumption is just under 7 kg fresh root equivalent. A generally positive income elasticity for cassava at the lower income levels creates a situation where increased production and lower prices will bring benefit almost exclusively to poor consumers.

Indonesia has the highest per capita consumption levels, with an intake of about 135 kcal/day in 1997 (FAOSTAT). Cassava nearly parallels maize in its consumption patterns across different income levels. Rice consumption falls off rapidly at the lower end of the income scale, and cassava and maize rise. The region's largest producer, Thailand, has almost no consumption. Cassava is consumed at low levels throughout the Philippines and Viet Nam. In India and China consumption is localized in the southern regions. For much of tropical Asia, cassava still has a modest role as a backup crop to rice - should the rice crop be in short supply, cassava will likely still have some yield.

Poverty alleviation and equity

Poverty is a root cause both of food insecurity and environmental degradation in developing countries. Asia as a whole has realized astonishing economic growth in the past two decades, but poverty is still widespread, and especially among those who are dependent on agriculture. The *rural* poor account for up to 75% of the poor in many Asian countries. Rural development stems the tide of migration to the cities, which brings even greater burdens to public institutions.

Throughout the region, cassava's main role is income generation potential in more marginal environments. Its versatility in products and markets enhances its role in poverty alleviation through income security and stability for the poorest farmers. These farmers usually occupy land where other crops simply cannot be grown, or their production is risky and results in wide year-to-year yield variations. A focus on these poorest farmers is a move toward some measure of equity of income distribution.

Protecting the environment

Before scientific research showed otherwise, cassava was often criticized as a crop with a propensity for depleting soil nutrients and causing erosion. The reputation stems from the crop's ability to thrive on soils *already depleted* by other crops, or which are inherently marginal. Cassava is thus relegated to the erosion-prone hillsides, to soils of low nutrient status, and to regions of uncertain rainfall. The ensuing environmental concerns are *associated with,* but not necessarily *caused by,* cassava cultivation practices. Farmers may be unaware of the extent of soil loss or nutrient depletion, but more often simply do not have the resources to apply remedial inputs. The desperation of poverty generally does not engender environmental sensitivity. Without some management interventions, these cassava-based systems on erodable hillsides are not sustainable.

Environmental concerns are starting to attract government attention throughout Asia, as more scientific evidence becomes available. Average soil losses are considerably higher than in Africa or Latin America. Because of population pressure, even *steep* slopes are cultivated. Even on lesser slopes, many cassava soils are light-textured and prone to erosion, particularly in Thailand, parts of Viet Nam and Bohol Island in the Philippines. Highest losses have been measured on Hainan Island, China, of 154 t/ha/year dry soil loss (Howeler, 1995). There is still some opportunity for expanding agricultural area in Thailand, Indonesia (outer islands), Malaysia and the Philippines. These are almost exclusively areas of poor soils and/or erratic rainfall. Cassava will continue to have a fundamental role on the frontier, and technology for protecting the environment will be ever more important.

Asian farmers, especially in high population density regions, have some experience in intensive crop and soil management to protect fragile soils. Technologies for erosion control are tested and available, and farmers have already begun to adopt some of these. The

challenge is to present effective methods that provide short-term profit as well as long-term benefit. Farmer participation in the search for better methods is a key to success.

A lesser, but increasingly important, environmental concern is waste and waste-water management from processing plants. Starch processing factories use large volumes of water, first to wash roots, and then for the starch extraction itself. The total process consumes 15-40 tonnes of water for every ton of starch extracted. The two main concerns are the potential cyanide poisoning of water life, and the oxygen depletion from organic matter in the effluent. Generally, small factories cannot afford the investment for proper water treatment. Throughout the region there is a tendency toward consolidation into larger processing facilities. With the greater capitalization and economies of scale of these larger plants, there is better possibility to invest in pollution control systems, and in systems that commercialize the by-products of processing.

TRENDS IN PRODUCTION, TRADE AND UTILIZATION[8]

Cassava in Asia has been a highly versatile crop, able to succeed in diverse physical, socio-economic, and political environments. The species is a relatively recent introduction to the agriculture of Asia, in comparison to the several-thousand-year-old rice culture. Best evidence indicates it was first introduced to the Philippines during the Spanish occupation. By the beginning of the 19th century, explorers and traders had effectively distributed the crop throughout tropical Asia. Colonial administrators promoted cassava culture by developing a starch processing and export industry in Malaya in the 1850's, and later in Java. The Dutch in Java and the British in southern India also promoted cassava as a famine reserve crop. In this heavily rice-dependent region, cassava found a niche in environments where rice was risky or difficult to grow. Production was concentrated on Java and Malaysia for much of the period up to World War II. The disruptions of the war and the rising prominence of maize as a source of starch brought a decline to the cassava starch export industry. Markets for internal consumption remained strong in Indonesia, and this country led production in Asia up to the late 1970s.

[8] This section draws heavily on Lynam, 1987, for the period up to the mid-1980s.

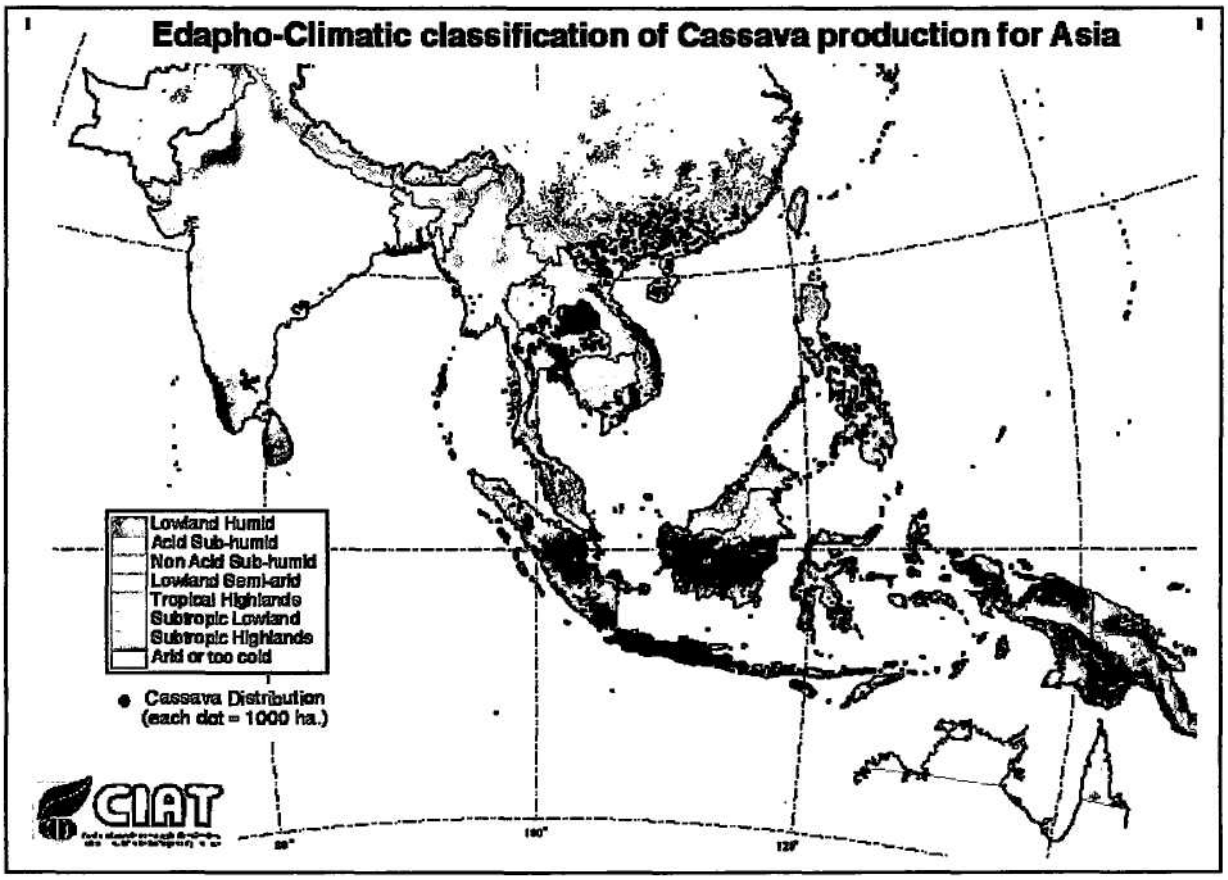


Figure 1.

Two powerful influences dominated the cassava sector in the post-World War II era, through the 1970s. First, the *green revolution* in rice brought a measure of food security in the region, diminishing the importance of cassava as a famine reserve crop. Secondly, rapid growth in the animal feed industry in developed countries, and a twist on Europe's import policies, brought opportunities for dried cassava exports. From the beginning, Thailand dominated the export market for animal feeds.

From the 1980s to the present, the main influences on cassava production and commerce were:

(1) rapid growth in many Asian economies, with accompanying changes in food consumption patterns;

(2) increased demand from industry for starch; and

(3) increasing implementation of trade policies that reduced cassava's preferential treatment in European markets. Except for a few products such as *krupuk* in Indonesia, cassava generally enters markets where other calorie or industrial starch sources may readily be substituted. Future growth, therefore, is largely linked to cost competitiveness. Alternatively there is growth potential in markets that require specific characteristics that only cassava provides.

This review concentrates on seven countries which together account for 99% of current production: Thailand, Indonesia, India, China, the Philippines, Viet Nam, and Malaysia (Figure 1). Thailand and Indonesia alone produced 70% of the region's cassava in 1999. Sri Lanka was a significant producer in the 1970s, with over 150 000 ha, but this has declined to about 30 000 ha. Cambodia, Laos and Myanmar each produce cassava on about five to seven thousand hectares.

Country briefs

Thailand has, in a sense, *put cassava on the map,* in Asia and in the industrial world. The pellet export industry to Europe that developed out of a series of fortuitous circumstances (see details in later section on *Products and Markets)* has virtually defined the cassava sector in Thailand. How these circumstances were exploited by agriculture and industry, and supported by national policy is a major lesson from Asia.

Evolving from an early concentration of production in the Southeast, almost two-thirds of the cassava is now planted in the seasonally dry Northeast. Nearly all is grown on small farms of one to five hectares. Chipping and drying is done on simple drying patios nearby, while processing for starch is generally done in large factories. The pellet export industry depends heavily on the middle-men who either own trucks or drying patios, and who consolidate production from these small farms into processing and marketing channels.

For many years, a single variety, Rayong 1, occupied almost 100% of the country's area. This began changing in the mid-1980s as new hybrids gained popularity for the market premium assigned to higher starch content. By 1999, new hybrids from the national program and Kasetsart University extended over more almost half of the total area. The research program established by the Department of Agriculture, based at Rayong Station, is among the most productive in the world. Breeding and agronomy are the main focus. Private industry (mainly starch factories) plays an important role in promotion and distribution of new technology. Mechanized land preparation, fertilizer application, and mechanical or chemical weed control are becoming more common,

Thailand has been keenly aware of the need to develop domestic markets and diversify export markets. In 1982 chips and pellets represented 88% of the total utilization of production; this share declined to 70% by 1992, as starch increased from 12 to 18% in the same period. By 1996, root utilization was about equally divided between starch and pellet production, and use of roots for starch now surpasses pellets.

Indonesia is historically by far Asia's largest producer, outpaced by Thailand in terms of area planted only in the mid-1980s. The relatively stable area of planting across years is a function of market diversity and comparative advantage in upland environments not suited to rice. The multi-use characteristics are fully exploited and provide a range of market options

to stabilize prices. The traditional products in the internal markets are *gaplek* (dried cassava chunks used in a variety of local dishes), and *krupuk*, a crispy snack wafer made from cassava starch.

Production systems in Indonesia are in general more complex than elsewhere in Asia. Intercropping is common on Java, especially where there are not severe soil and water constraints. Common intercrops are upland rice, maize and various legumes. Farms are small and intensively managed, with few purchased inputs except fertilizer. On the outer islands rainfall is usually less limiting, but poor soils are a constraint on ability to intercrop cereals and legumes. The starch industry in Sumatra is partially based on large, vertically integrated plantations where moderate input levels are applied, and new high-yielding varieties planted. However, many of these starch factories supplement their own production with that of nearby. Some of these industries have joined with the national program in supporting production research, which has benefited surrounding small independent farmers as well as the plantations. Small scale processors have found it increasingly difficult to compete with large processors, and some are switching to other raw materials.

Cultivation in *India* is concentrated in the southern states of Kerala and Tamil Nadu. The country is distinguished by the world's highest average yields - about 24 t/ha. These high yields are accomplished by intensive cultivation, and, in Tamil Nadu, by irrigation. In Kerala, much of the production is consumed as boiled roots, one of the few regions in Asia where this is common. Cooking quality is one of the principal criteria farmers use in selecting varieties for cultivation. In Tamil Nadu nearly all of the production is for starch.

A geminivirus similar to the African mosaic virus affects much of the cassava area in India. While it does not appear to cause widespread yield losses, its presence poses severe restrictions on germplasm exchange with other countries. The Central Tuber Crops Research Institute in Trivandrum, Kerala, has a well-staffed interdisciplinary research team which has contributed significantly to the global knowledge base on cassava, especially in cytogenetics, genetics, physiology, and post-harvest issues.

China produces cassava in the southern provinces of Guangxi, Guangdong, Hainan, and more recently Yunnan. Most is planted on hillsides surrounding rice paddies, with few production inputs. Historically cassava was a famine reserve crop, grown in marginal areas with high risk of crop failure. Production data from China are not very reliable, but according to FAO, area peaked at 420 000 ha in 1980. This came when China had begun to enter the European market with dried chips, along with Thailand and Indonesia. Although a minor crop in China as a whole, it is increasingly looked upon in the South as an efficient producer of raw material for starch and on-farm pig feeding. China imported 300 000 tonnes of dried cassava, and 320 000 tonnes of cassava starch in 1998 (FAO). The possibility of replacing these imports with local production is an incentive for supporting research. There are modest

research programs at the provincial level, concentrating efforts on varietal testing, soil erosion control and fertility maintenance, and utilization.

Like Indonesia, the Philippines is a multi-island economy, but differs in that population is spread more uniformly across different islands. Cassava fits well within an agricultural policy that emphasizes self-sufficiency in basic foods (except wheat), import substitution, and development of the small farm sector. Cassava is produced throughout the Philippines, but is more concentrated on the southern islands, especially the Visayas region and Mindanao. Most production is on small farms, although there are some large plantations supplying starch factories. Rainfall is generally not a limitation, but, as in other countries, cassava usually occupies the poor upland soils unsuited to grain crops. Input use is low in comparison to other countries and is reflected in some of the lowest yields in Asia (about 8.5 t/ha in 1999). Nonetheless, increasing adoption of improved varieties and cultural practices should begin to improve yield performance.

Cassava is distributed more uniformly across *Viet Nam* than perhaps any other Asian country. Area planted peaked in the late 1970s at nearly half a million hectares, but then declined to nearly half that level because of lack of markets and competition from other crops. It occupies the poor soils of mountainous and hilly areas, mainly in monoculture systems. Since many of these soils are highly erodable, their recuperation and conservation is currently a major research thrust. In early years, most of the plantings served as a food security crop, but human consumption now occupies only 10-20% of production. About 30% is used as animal feed, much of it on-farm for chickens and pigs, after chipping, drying and milling the roots. Industrial uses are on the increase as Viet Nam undergoes rapid economic development. Industry absorbs about 30-40%. Since the mid-1980s, a small but dedicated cadre of scientists has given the first significant research attention to cassava since its introduction. New varieties, mainly introduced from Thailand's breeding programs, are gaining popularity, especially in the South, for their high yield potential and high starch content.

Early production in *Malaysia* was based on the starch and tapioca export market. Area peaked near the turn of the century at about 45 000 ha, but declined rapidly due to competition from Java, and internally from the expanding rubber and oil palm industries. Malaysia is unlike most of Asia in having relatively ample per capita land resources. As a result, policy has focused on plantation agriculture. Labour costs are comparatively high, a strong incentive for use of labour-saving inputs such as mechanized land preparation and herbicides. The Malaysian Agricultural Research and Development Institute (MARDI) had a modest but effective research program on cassava for many years. The program concentrated on genetic improvement and agronomy, and most recently on adapting production to the acid peat soils. However, MARDI no longer carries out cassava research.