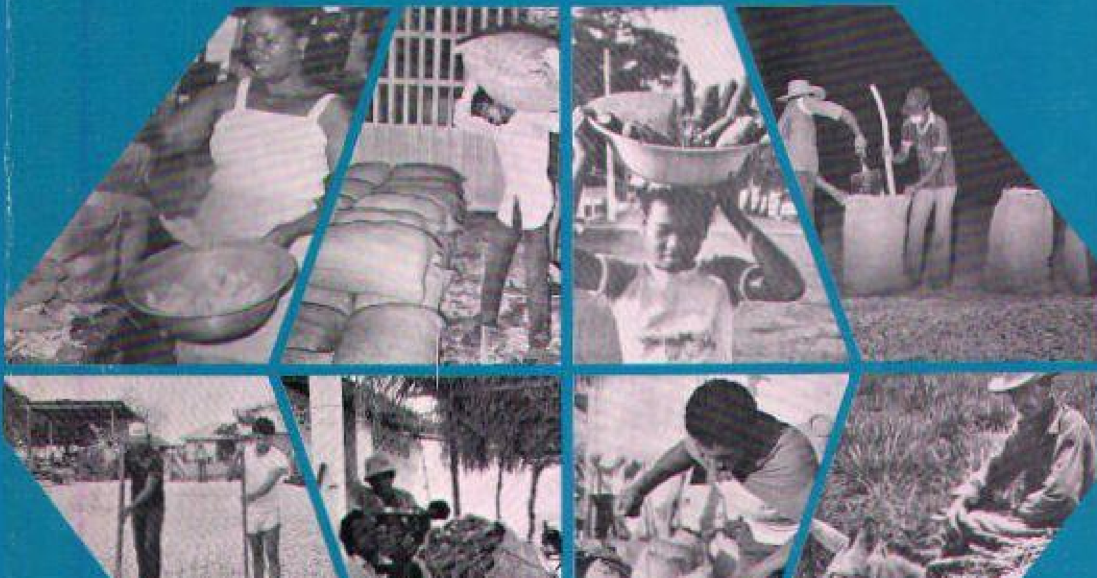
Market impact on cassava's development potential in the Atlantic Coast region of Colombia

W.G. Janssen



CIAT
Centro Internacional de Agricultura Tropical

STELLINGEN

I

De vraag die op grond van voedselstatistieken beantwoord dient te worden, is niet slechts hoeveel mensen er honger hebben, doch ook waarom ze honger hebben.

(R.W. Hay (1978). The statistics of hunger. Food Policy, Vol.3, pp.243-255)

II

De onvruchtbaarheid van de gronden waarop cassave veelvuldig verbouwd wordt, is vaak geweten aan het inefficiënte nutriëntengebruik van dat gewas. Cassave's aanwezigheid op onvruchtbare gronden vormt integendeel het bewijs van haar efficiënte nutriëntengebruik.

III

De veel gehoorde stelling dat onderzoekers van kleine boeren moeten leren is niet meer relevant dan de stelling dat kleine boeren van onderzoekers moeten leren.

IV

Kleine boeren in ontwikkelingslanden worden geacht zich risicomijdend te gedragen. Vaak zijn zij wel risicomijdend van aard, doch staan de geringe middelen, die hen ter beschikking staan, risicomijdend gedrag niet toe.

V

Het belang van prijsstabilisatie voor de individuele boer wordt onderschat, indien de discussie hierover aan de hand van geaggregeerde cijfers gevoerd wordt.

(K.L. Robinson (1975). Unstable farm prices: Economic consequences and policy options. American Journal of Agricultural Economics, Vol.57, pp.769-777)

VI

Marktverbetering vormt een goedkope, effectieve en emancipatoire vorm van kleine boeren-ontwikkeling.

VII

De verandering in de samenstelling van de vraag naar landbouwprodukten in het ontwikkelingsproces bevoordeelt grote boven kleine boerenbedrijven.

VIII

Convenience is een verwaarloosd aspect voor de acceptatie van voedingsmiddelen in de urbane delen van de derde wereld.

IX

Marktverbetering en introduktie van nieuwe verwerkingsmethodes veroorzaken vaak een verhoging van cassaveproduktie en van het inkomen van cassaveproducenten, terwijl verbeterde produktiemethodes alleen dat vaak niet doen.

X

De bijdrage van agrarische marktkunde aan ontwikkelingsprocessen heeft tot nu toe voornamelijk gelegen in de analyse van structuur en gedrag van marktkanalen. Een belangrijke potentiële bijdrage ligt in de analyse van de invloed van marktkanalen op het gedrag van consumenten en producenten.

XI

Het aan Gabriël Garcia Marquez toegeschreven magisch realisme vormt een betrouwbare beschrijving van het leven van alledag in de Atlantische kuststreek van Colombia.

XII

Het spreekwoord "mens sana in corpore sano" geeft in gelijke mate aanleiding tot geestelijke ontwikkeling en tot lichamelijke vorming.

W.G. Janssen
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Wageningen, 3 september 1986

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ABSTRACT

Janssen, W.G. (1986) Market impact on cassava's development potential in the Atlantic Coast region of Colombia. Doctoral thesis submitted to the Agricultural University of Wageningen, the Netherlands. 357 p., 26 figs., 59 tables, 174 refs., 10 appendices, summary in Dutch.

Free descriptors: Markets and development, market improvement strategies, marketing channel analysis, cassava production, supply analysis, cassava marketing, cassava consumption, purchasing convenience, market system simulation.

The impact of markets on agricultural development was analyzed by means of a case study on cassava in the Atlantic Coast region of Colombia. In the development process, the demand for agricultural products changes considerably. Traditional food products, such as roots and tubers, face a decreasing demand in the course of urbanization and income growth. Feed grains and animal products face a growing demand. The agricultural sector is often not able to adapt to these demand changes and imports result. In case the structure of agriculture is dualistic, small farmers might be harmed and large farmers benefitted by these changes. This leads to unbalanced agricultural development. Market improvement strategies directed to small farm products might correct part of the unbalanced development.

Cassava in the Atlantic Coast region is a small farm crop which faces severe market(ing) problems in the development process. Fresh cassava consumption, the traditional utilization, decreases because it has a high marketing margin, because it has to be bought on the day of consumption and because other products become more widely available.

Two market improvement strategies for cassava are evaluated: improvement of the traditional fresh cassava market by means of improved storage; opening the market for dried cassava as an animal feed in order to replace sorghum. To study the impact of

these strategies the role of cassava in the Atlantic Coast region is analyzed within a systems framework. The interactions that are found between production, marketing and consumption are strong. Cassava production will be stimulated by the price stabilization that the establishment of a cassava drying industry will cause. The improvement of cassava's storage characteristics will decrease marketing costs, increase consumer convenience and, therefore, stimulate cassava consumption.

Because of the interactions encountered, the impact of cassava market improvements cannot be measured in the market alone. An analysis of the cassava system that integrates production, marketing and consumption is needed. The integrated analysis is made by means of a multi-market, multi-farm type simulation model. The model forecasts the impact of market improvement strategies given different assumptions on the development of the Atlantic Coast economy and on the cassava systems behavior. Cassava drying for animal feed is a strategy, which explicitly benefits cassava producers. Additionally Colombia could save on sorghum imports. Improvement of the fresh market would most benefit urban consumers. Considering the rural-urban migration problems of Latin America, cassava drying appears the most attractive strategy.

Both market improvement strategies have very favorable rates of return. Market improvement projects might serve additionally as a diving board for further rural development efforts. Increased attention to the role of markets could contribute to fulfilling the goals of agricultural development and to balancing overall economic growth.

CONTENTS :

Appendices :

Chapter 1: MARKETING IN AGRICULTURAL DEVELOPMENT; ITS IMPACT ON CASSAVA PRODUCTION

1.1 Introduction

This study is concerned with the importance of product markets in the development of the agricultural sector. Although the relative importance of the agricultural sector declines with rising incomes, its development is critical for balanced development. Most theories identify increased agricultural productivity and improved infrastructure as the motors of agricultural development, but the relationship of agriculture with the rest of the economy is not clearly defined. Indeed, development is characterized and furthered by the application of improved technologies and by increasing degrees of specialization. However, the ability to specialize successfully is dependent on the development of efficient markets to facilitate the exchange of production, thus elucidating another characteristic of most development processes: the rising importance of markets.

The central thesis of this study is that efficient and promising markets for agricultural products facilitate and expand the contribution of agriculture to overall economic development. However, efficient and promising markets to procure optimum development are not always available. This lack can cause deviations from an optimum development path, especially with regard to income distribution. This leads to the conclusion that market improvement could make a significant contribution to better development strategies. To assess the validity of this reasoning, this study takes a specific case--cassava in the Atlantic Coast region of Colombia--and analyzes the impact of its marketing on its role in development. Conclusions on cassava in Colombia are subsequently extrapolated to other crops and other circumstances.

This first chapter will briefly discuss the relationship between agricultural and overall economic growth and the role of agricultural product markets in this process. After a short overview of theories on general development, the question of sources of agricultural production growth will be addressed and correlated to overall economic development. Two important aspects of the association of agricultural growth with overall economic growth will be distinguished. The first aspect is the structural development of the different sectors: the agricultural and non-agricultural sector, in order to foster their growth, compete for the same scarce resources, with the exception of land; at the same time, the different sectors have to absorb the rapidly expanding labor force, characteristic of many developing countries. The second aspect is how the effective demand within a developing economy determines growth incentives, specifically in regard to the demand for agricultural products. Since the study is concerned with the impact of markets in a Latin American country, special reference will be given to the situation in that continent.

The affiliation of demand with structural development leads to the conclusion that market improvement for specific farmers and specific crops could bring more balanced economic development. Different types of market improvement programs are outlined and their relevance for cassava is investigated. Finally, the specific objectives of the study are outlined: validation of the thesis that efficient and promising markets are vital for balanced agricultural development.

1.2 Economic development and the agricultural sector

Early scholars observed that the importance of the agricultural sector within the economy tends to decrease during the development process (Fisher, 1939, Clark, 1957, or Chenery, 1960). Conclusions based on this observation suggested that agricultural development was of limited importance for overall development, and models were developed which put great emphasis on industrial development (Prebisch, 1959 and Hirschmann, 1958). These models neglected the agricultural sector, as industrial development was considered to be the driving force for economic growth; it was assumed that the beneficial effects of industrial development would filter easily to the other sectors of the economy. In contrast to traditional agriculture, productivity in the industrial sector was considered to be high; the process of capital accumulation efficient; and the demand for industrial products large and elastic. Agricultural labor was considered to have low marginal productivity and could be removed at almost no social costs. Demand for agricultural products, and therefore the expansion potential of agriculture was considered to be limited. It was supposed that agriculture would provide the initial pool of cheap labor to support industrial growth, and that continued growth of the industrial sector would gradually absorb more labor, thus pulling up agricultural wages and productivity. These models were conceptualized mainly in the 1950's and their application resulted in high urban growth and increasing inequality (Nugent and Yotopoulos, 1979). Afterwards, the high growth of the industrial sector became more difficult to maintain. Domestic demand for industrial products was more limited than foreseen, while export markets were difficult to enter. Industrial labor remained scarce due to the higher educational requirements of this segment of the population.

At the same time, the effects of improved medical care began to result in quick increases of the population and, thus, the labor force. The modernization strategy (based on capital-intensive industrial development) was not able to absorb the growing labor force.

The resultant problems caused by this strategy (inability to maintain high growth on the basis of industrial development; increasing inequality; and failure to absorb the growing labor force) caused the focus to turn towards more broadly based development models in which the interactive nature of sectors within society was recognized.

Agricultural development became a major goal in these "growth-with-equity" strategies. In most developing countries agriculture provides from 15 to 55% of the Gross National Product , and agriculture often supplies more than 50% of total employment (Table 1.1). Agricultural development can contribute in various ways to increased economic growth by providing labor, capital, foreign exchange, food, and the necessary domestic markets to the growing industrial sector

Table 1.1. Selected indicators for a number of developing countries.

	GDP per capita (US-dollar) (1980)	Population (millions) (1980)	Agricultural Production as a % of GDP (1980)	% Agricultural employment (1980)	Average non-agricultural income / Average agric. income (1980)	Industrial Production as % of GDP (1980)	% Industrial employment (1980)	% Urbanized population (1980)	Urbanized population / Non-urbanized population (1980)
Bangla Desh	130	88.5	54	74	2.42	13	11	11	0.12
Zaire	220	28.3	32	75	6.38	23	13	34	0.51
India	240	673.2	37	71	4.17	26	13	22	0.28
China	290	976.7	37	69	3.79	47	19	13	0.15
Kenya	420	15.9	34	78	6.88	21	10	14	0.16
Indonesia	430	146.6	26	58	3.93	42	12	20	0.25
Bolivia	570	5.6	18	50	4.56	29	24	33	0.49
Thailand	670	47.0	25	76	9.50	29	9	14	0.16
Nigeria	1010	84.7	20	54	4.70	42	19	20	0.25
Colombia	1180	26.7	28	26	0.90	30	21	70	2.33
Malaysia	1620	13.9	24	50	3.17	37	16	29	0.41
Brazil	2050	118.7	10	30	3.86	37	24	68	2.13
Mexico	2090	69.8	10	36	5.06	38	26	67	2.03

Source: World Development Report, 1984 and 1982.

(Johnston and Mellor, 1961). Moreover, an important part of industrial development depends on agriculture for its raw materials. Agroindustry contributes up to 20% of the national product in even highly developed countries and forms a successful basis for beginning industrialization efforts (Austin, 1979). The labor-intensive nature of agriculture permits the absorption of the growing labor force (Krishna, 1973). In developing countries a large portion of any extra income will be spent on agricultural products (Mellor, 1978). Well-directed agricultural development can be an important instrument for handling equity issues, since agricultural production, nutrition, and income are strongly interwoven in developing countries (Timmer, 1981, Pinstrup- Andersen, 1981).

The role of agriculture in economic development theory has changed completely in the last twenty years. Previously, agriculture was seen as the "appendix" to industry-led development, whereas now agricultural development is considered the basis and source for successful, balanced, and continuous economic growth. The recognition of the need for simultaneous development of the agricultural and the industrial sector stimulated theory development on the roots and mechanisms of agricultural growth. At the same time, the relationship between agriculture and structural change has received considerable attention (e.g. Mellor, 1966, Thorbecke, 1969, Ghatak and Ingersent, 1984).

Sources of agricultural growth

Ruttan (1977) describes six models which explain the roots and mechanisms of agricultural growth:

1) The FRONTIER MODEL considers the incorporation of additional land resources to be the major factor behind agricultural production growth. The value of this model is limited to regions where surplus land can be included in agricultural production (Sanders and Bein, 1976). Since frontier land is often of less-than-average quality, it does not contribute greatly to increasing agricultural production.

2) The CONSERVATION MODEL considers intensification of land use through improved farm management to be the main mechanism of agricultural growth. Exponents of this model include improved rotational practices or livestock cropping interactions. Farm management research as proposed in various FAO programs fits reasonably well in this category (e.g. Dillon and Hardaker, 1980 or FAO, 1984). Ruttan writes that the agricultural growth rate that can be maintained with this type of development is not much above one percent per year.

3) The URBAN-INDUSTRIAL IMPACT MODEL is the third. In this model, agricultural intensity depends on the connections of rural and urban areas. Labor productivity in agriculture is considered a function of labor productivity in industry. Land productivity depends on the urban demand for agricultural products. According to this model, agricultural productivity can be improved through better functioning product and labor markets. Studies on the efficiency of agricultural product marketing originated from this model. These studies assume that efficient marketing would guarantee optimal prices, optimal allocation, and therefore an equitable sectoral income distribution (see Unnevher, 1984 or Southworth et.al., 1979).

4) The DIFFUSION MODEL assumes that low productivity is primarily caused by traditionalism and inefficient resource allocation within farms. Through diffusion of agricultural techniques from more developed areas, productivity can increase. Ruttan states that this model stresses extension coupled to capital investment as a means of overcoming inefficient farming. Evidence gathered in the 1960's, however, showed that most farmers in developing countries were neither traditional nor inefficient in resource allocation (e.g. Hopper, 1965 and Behrman, 1968). Most farmers were constrained by factors very different from those in the developed world. Where the agricultural sector shows great resemblance to agriculture in the developed world, diffusion of new techniques has been and can be applied with considerable success.

5) The HIGH-PAYOFF INPUT MODEL is the fifth model described by Ruttan. It distinguishes three groups of critical inputs to

accelerate agricultural development: knowledge, created by increased research efforts; chemical inputs and appropriate machinery; and, the capability of farmers to absorb this new knowledge and to use these inputs and machinery. The model stresses the need to develop specific solutions for productivity needs of the developing world. The enthusiasm for this model was increased by ex-post studies that showed remarkably high rates of return to research and development expenditures (e.g. Arndt, Dalrymple and Ruttan, 1977; Scobie and Posada, 1977).

6) The INDUCED INNOVATION model was developed by Ruttan and Hayami (1972) from an expansion of the former model. This model supports the high-payoff input model but stresses that research strategies and institutional developments depend on the factor endowment of the agricultural sector. Ruttan and Hayami illustrate their model with the development of machinery in the United States, where land was ample and labor scarce, versus the development of high yielding rice varieties in Japan, where land was limited and labor abundant. This model assumes efficient factor markets and a thorough understanding of producers' needs on the part of the research and development institutes. These requirements are not always fulfilled and the validity of the model has been questioned (Beckford, 1972). Farming systems research (detailed studies to determine the governing production constraints in order to develop appropriate technology) forms a strong exponent of the induced innovation model of agricultural development (e.g. Shaner, Philipp and Schmehl, 1982). The potential of this model to guide or explain other development efforts has not been used sufficiently. An issue that could be appropriately investigated with this model is the role of marketing in development. The appropriate type of marketing for fostering agricultural development can only be identified on the basis of a sound understanding of the specific factor endowments.

These six models of agricultural growth put strong emphasis on the mechanisms which determine the increase in agricultural output. Each model is valid for partially explaining agricultural growth, but the models do not exclude each other. Available resources, management practices, input and factor markets, research and institutional development are highlighted in separate models. The question of what the incentives are for increasing agricultural production is not addressed in detail. The urban-industrial impact model and the induced innovation model each include a linkage with the surrounding markets, but more for production factors and inputs than for agricultural output. The connection between agricultural growth and output markets has not been strongly recognized in development literature.

Agriculture and structural change

Theory development on the relationship between agriculture and structural change has focused on the competition for scarce resources by different sectors. Two issues have received special attention: the distribution of employment between the agricultural and the other sectors, and the capital investment patterns to optimize agricultural growth (Johnston, 1970). At first the effect of differential distribution of labor and capital on the output of the economy was emphasized. In a second phase, urban versus rural development and income distribution received considerable attention.

Initially the opinion was that capital could be drained from agriculture to facilitate accelerated development of the modern sector. In opposition to this view, Jorgenson (1961) stated that development of the non-agricultural sector depends on the amount of surplus food production. He wrote that, at the start, capital might flow from industry to agriculture. Afterwards the growing dependence of developing agriculture on purchased inputs implied a more balanced approach to capital allocation (Harrar and Wortman, 1969). Lack of investment in the farm input industry might constrain agricultural development.

A pervasive question in developing countries has been how to employ a growing labor force in a fast-growing, capital-intensive, non-agricultural sector, and a slow-growing, labor-intensive, agricultural sector. The yield-increasing technologies of the early 1970's improved the potential for maintaining the population in the countryside

(Mellor, 1966). The disparity between agricultural and non-agricultural incomes, however, forced people to migrate from the rural areas to the urban areas. The industrial sector was not able to absorb these people, pockets of urban poverty sprang up around many urban centers, and the informal sector experienced considerable expansion. These problems were severe in Latin America and Africa and stimulated research on the issue of rural urban migration (Todaro,1981) and on the role of agriculture in mitigating these problems (Sanders and Lynam, 1981). The recognition of the severity of these problems increased support for the development of small- scale, labor-intensive farming (Mellor and Johnston, 1984).

Agricultural development that promotes acceptable overall growth with minimal migration is especially relevant in countries where agriculture itself has a dualistic structure. This is the case in most parts of Latin America, where the historical development of property rights has caused the largest number of farmers to possess limited areas of land while a limited group of farmers possess large areas (Lynam, 1985). The development of the different farm types tends to follow distinct routes. Large farms will maximize their benefits according to the most scarce resource within the farm system--i.e., management--with extensive cattle holding and mechanized cropping, often directed to industrial or export markets, characterizing their production. Small farms will try to maximize their profits with regards to land by planting labor intensive crops, often for food consumption, possibly in rotation with intensive cattle holding. The contribution of small farms to agricultural output is grossly disproportionate to their access to land (Crouch and de Janvry, 1980). However the large farm sector has more political influence and is able to direct considerable research and credit resources to their production (de Janvry, 1975). The small farm sector is often left alone; productivity does not increase quickly, and many small farmers try their chances in the urban areas. In this situation the social benefits of small farm development are considerable and justify private rates of return on investment in the small farm sector that are lower than in the large farm sector (Mellor and Johnston, 1984).

1.3 Demand for agricultural products in a developing economy

Appropriate demand for incremental production is critical for successful growth and improvement of the income potential of agriculture. However, the impact of effective demand on agricultural development has not received much attention (e.g. Ghatak and Ingersent, 1984). Most theories seem to assume that domestic or international markets will provide ample sales perspectives. Two observations on the market mechanism in many developing countries indicate a need to pay more careful attention to demand. First it has been noticed that agricultural markets in developing countries do not tend to behave according to the neo-classical theorems of perfect competition and profit maximization (Lele and Candler, 1981 or Harriss, 1979). Prices for agricultural products will not correctly represent consumption needs or production potential, and will not initiate optimum allocation of productive resources. Second, even when markets are competitive, but more so when they are not, the resulting income distribution is not necessarily equitable. This problem is relevant for countries with a dualistic production structure, where better-endowed farmers have more market control and dominate the attractive sales opportunities (de Janvry, 1975). For small farmers attractive sales opportunities are often not available.

In the first half of this century, when large parts of the world were still under colonial rule, cultivation of cash crops for export was a major economic activity in many regions of the developing world. Well-organized marketing channels guaranteed an efficient flow of the product from production areas to consumption centers. Today, many developing countries still depend on the export of agricultural products to acquire most of their foreign exchange (Table 1.2). The international demand for cash crops does not rise quickly and expansion of cash crop production is not a popular alternative for agricultural planners in developing countries. Interest in the expansion of cash crops is limited for three reasons. First, cash crops have often been planted in the best agricultural conditions and extension would not be possible at similar profit rates. Second, the supply of cash crops in international markets is often constrained by

Table 1.2 Agricultural exports as a percentage of total exports.

	%	Year
Latin America:		
Argentina	40.1	(1982)
Colombia	62.7	(1982)
Costa Rica	49.1	(1981)
Paraguay	62.1	(1981)
Africa:		
Ethiopia	75.7	(1982)
Ghana	76.4	(1979)
Kenya	55.0	(1979)
Tanzania	70.1	(1980)
Asia:		
Sri Lanka	62.9	(1981)

Source: UN: Yearbook of International Trade Statistics, 1982.

international agreements to avoid price competition and to stabilize prices. Third, price increases of traditional tropical cash crops have lagged behind price increases of export crops from the temperate areas (Hillman, 1981).

Some developing countries have been able to enter the world market with non-traditional export crops (food and feed). Because of the enormous rate of agricultural development in the temperate areas, as caused by technological improvements (e.g. Griliches, 1958) and favorable domestic agricultural policies (Koester, 1981), competition in the world market has proved to be too strong for most developing countries. Also, internal demand in the developing economies has risen quickly. Often international markets are penetrated at the cost of considerable income disparity between the agricultural and the non-agricultural sector (see Table 1.1 for the case of Thailand).

Gearing agricultural development towards international markets has been more complicated than early theorists imagined, while on the other hand, national markets for agricultural products have been growing quickly. Urban migration has increased the number of people that depend on the market to satisfy their nutritional needs. Productivity per head in agriculture has to rise rapidly to keep up with this change (Table 1.1). At the same time, marketing channels have to develop to transfer production from the rural to the urban areas.

Mellor and Johnston (1984) write that the income growth of many developing countries has resulted in strong extra demand for agricultural products. They distinguish three phases in the relationship between development and agricultural product demand:

<u>In the first phase</u>, when development has just begun, food availability balances at a low level per capita. Countries will be mostly self-sufficient in food production, except for sharp year- to-year fluctuations due to weather variability. Limited demand constrains the development of agricultural production, while the low productivity does not allow a surplus to transfer resources to the non-agricultural sectors. The analysis of Mellor and Johnston appears slightly optimistic in the light of the recent African droughts. When population increases precede development, the food balance might deteriorate.

<u>In the second phase</u> development begins to have an effect. The importance of the modern sector increases and incomes grow quickly. The desire to improve nutritional status leads to increased demand for food products. The demand for animal proteins tends to increase very quickly. The inefficient conversion of vegetable protein into animal protein creates a large demand for animal feed, and the specific production of grains destined for animal feed begins. The share of grain consumption by humans in total use (food plus feed) might

decrease from close to one to below 0.4. In this phase agricultural production grows quickly, often at a higher rate than the population, but might not be able to keep up with the demand increase. This is mainly due to the lack of physical and institutional infrastructure to support higher agricultural production growth. Prices of agricultural products tend to increase, but agricultural incomes will lag behind non-agricultural income because of the rapid productivity growth outside agriculture. To satisfy the growing demand for animal feed, many countries have to import feed grains. Mellor and Johnston consider the following countries to be currently in this phase: Brazil, Colombia, Ivory Coast, Malaysia, Mexico, Morocco, Pakistan, Paraguay, the Philippines, Sri Lanka, Thailand and Tunisia .

In the third phase, when incomes become comparable with those of the developed world, the marginal propensity to spend on food approaches levels around zero. The institutions that stimulate increases of agricultural production are still in place and basic food supply will continue to rise while demand is rather stable. Prices of agricultural products tend to decline. The rural-urban income disparity may be considerable and will lead to government-induced income transfers. Often this is in the form of price support, which in turn stimulates production. Resulting surpluses will be exported.

These descriptions of development phases indicate that in many countries the food sector will be not only a source of foreign exchange through export of cash crops, but also a user of foreign exchange by the importation of necessary food and feed. It was once believed that developing countries would supply agricultural produce to the developed world, but the present evidence suggests that the reverse may be true.

The structure of agricultural product demand in developing countries

In the process of development, demand for agricultural products rises quickly, albeit unevenly for different product categories. Evidence from developed countries shows that demand for animal proteins, such as beef, chicken and eggs, tends to increase strongly; that demand for fruit and vegetables rises slowly but constantly; and that demand for food grains and starchy products, such as potatoes and cassava, levels out at higher income levels. The average demand development per product group does not always indicate the specific demand development of one product. While overall growth of food grain demand, for example, might be low, demand for specific products within the group (e.g. rice and wheat) might grow rapidly. FAO income elasticities for major products in a number of countries, given in Table 1.3, illustrate the changes in food consumption that occur with rising incomes.

The change in food demand appears rather similar for rural and urban areas. For some products, demand changes differ. In the rural areas of Colombia, for instance, beans and fats consumption increases with rising incomes, while the opposite happens in the urban areas (Table 1.4).

Locally produced crops adapted to the specific circumstances of the region have dominated the rural diet for centuries as in the case of maize in Mexico, potato in Peru or cassava in the Brazilian and Colombian Amazon. The wide availability of these low-cost local crops fostered a multitude of recipes to keep the diet variable.

Urbanization has a strong impact on food consumption patterns. Considerations different from those guiding rural diets determine the urban diet. In addition to production costs, marketing and processing costs influence the attractiveness of a certain food. Voluminous and costly starchy staples such as potato and fresh cassava tend to lose importance in the diets in urban areas (Janssen and Wheatley, 1985), whereas poultry and pork (produced cheaply in intensive systems close to the urban areas) become more important. Time pressure becomes a big factor in food acquisition and preparation, and products that are convenient to buy and prepare become more desireable. Products like maize, which are laborious to prepare, lose importance. Urban diets appear to be more uniform than rural diets and often tend to approach diets of the temperate areas. Food consumption in the urban

Table 1.3 Income elasticities for major crops in selected countries.

	Grains	Rice	Wheat	Starchy Roots	Sugar	Meat	Beef	Poultry	Eggs	Vegetables	Fruits
Zaire	0.82	1.20	1.30	0.67	1.60	0.88	1.20	1.00	1.00	0.60	0.39
India	0.25	0.40	0.50	0.00	1.03	1.17	1.20	1.50	1.00	0.70	0.80
China	0.36	0.40	0.50	0.20	1.18	1.22	1.30	1.30	1.20	0.55	0.88
Kenya	0.40	0.70	0.80	0.30	1.00	1.01	1.20	1.20	1.00	0.50	0.50
Indonesia	0.64	0.70	1.00	0.20	1.37	1.32	1.50	1.50	1.20	0.60	0.80
Bolivia	0.48	0.50	0.60	0.15	0.50	0.86	1.00	1.20	1.00	0.40	0.59
Thailand	0.20	0.20	0.50	-0.15	0.91	1.13	1.00	2.00	1.00	0.60	0.75
Nigeria	0.41	0.90	1.50	-0.13	1.50	1.13	1.30	1.00	1.20	0.60	0.60
Colombia	0.40	0.50	0.60	0.17	0.03	0.69	0.70	1.00	0.70	0.50	0.52
Malaysia	0.22	0.19	0.39	-0.15	0.48	1.07	1.17	1.46	0.97	0.80	0.89
Brazil	0.14	0.20	0.40	-0.02	0.09	0.48	0.60	0.70	0.60	0.50	0.49
Mexico	-0.18	0.30	0.40	0.27	0.32	0.61	0.60	1.00	0.70	0.50	0.54

Source: FAO: Projections for agricultural products, 1970-1980, Volume II, Rome, 1971.

Table 1.4. Expenditure shares (percentage) of main food types by income quintile and area, Colombia, 1981.

Type of food	Urban Lowest quintile	Urban Highest quintile	Average	Rural Lowest quintile	Rural Highest quintile	Average
Beef	14.2	16.6	17.7	11.6	15.1	14.3
Dairy products	8.7	11.3	10.5	7.7	10.4	9.1
Rice	9.7	4.2	5.7	9.4	5.6	7.2
Beans	2.7	1.6	2.0	1.8	2.7	2.2
Cassava	2.0	1.0	1.4	4.8	2.7	3.7
Sugar	12.0	1.0	1.4	4.8	2.7	3.7
Vegetables	6.7	7.5	7.6	5.1	7.2	6.0
Fruits	3.4	10.5	7.5	3.3	6.3	4.8
Fats	6.9	5.5	6.1	5.3	6.0	5.6
Potatoes	6.5	3.2	4.3	8.8	4.7	6.7
TOTAL	72.8	68.2	70.8	70.0	70.2	70.0

Source: Sanint, L.R., L. Rivas, M.C. Duque and C. Sere, 1984.

and rural areas of Colombia is presented in Table 1.5.

The differences in urban and rural consumption patterns and the effects of rising income have been well-documented (e.g. Timmer and Alderman (1979) for Indonesia, Gray (1982) for Brazil, and Sanint et.al.(1985) for Colombia). Most of these studies focused on malnutrition, and their conclusions were directed towards nutritional policies of those countries (Kennedy and Pinstrup- Andersen, 1983). Other food consumption studies were undertaken to guide agricultural research strategies (summarized in Pinstrup-Andersen, 1982).

Table 1.5. Colombia: Rural/urban food consumption by region, 1981 (kg/adult equivalent/year).

	Atlantic 1/		Eastern 2/		Central 3/		
	Rural	Urban	Rural	Urban	Rural	Urban	Average
Rice	65.07	58.50	26.00	30.13	31.15	32.00	39.59
Maize	7.30	10.45	26.30	9.00	46.39	29.93	19.76
Bread	3.03	11.37	10.10	22.82	2.05	7.24	11.86
Noodles	4.76	10.66	9.76	9.36	3.89	3.71	6.16
Potatoes	11.93	24.28	83.76	82.09	42.46	45.83	56.11
Plantains	104.30	101.96	39.17	37.30	86.39	58.79	68.89
Cassava	72.62	42.26	39.00	23.50	35.41	12.50	25.47
Beans	4.25	4.74	4.68	4.80	12.51	10.45	7.22
Peas	0.80	1.32	8.18	7.65	1.98	3.82	4.66
Beef	29.99	46.02	23.04	34.90	30.60	31.92	31.72
Pork	1.46	1.68	0.16	0.43	1.19	2.57	1.38
Poultry	1.42	2.95	0.98	1.43	1.10	2.24	2.25

1/Includes the departments of: Cordoba, Sucrè, Magdalena, Atlantico, Bolivar, Cesar and Guajira.

2/Includes the departments of: Norte de Santander, Santander del Sur, Cundinamarca and Meta.

3/Includes the departments of: Antioquia, Caldas, Huila, Tolima, Quindio and Risaralda.

4/Includes all cuts of beef and offals.

Source: Estimates based on the 1981 DRI-PAN nutrition survey of Colombia.
Sanint, L.R., L. Rivas, M.C. Duque and C. Sere, 1984.

The efficiency of rural-urban food marketing systems has been studied frequently. Most of these investigations questioned the ability of the traditional marketing channels to effectively transfer the demand for food and the resulting supply between producer and urban consumer. As stated by van Tilburg (1981), many people suspected the marketing channel of giving undue profits to food traders at the expense of the farmer and the consumer. Some studies gave particular attention to the applied marketing technology and proposed rather large capital investments (Harrison et.al., 1974). Other studies focused on the assembly stage (e.g. Southworth et.al., 1979) , the wholesale stage (Mittendorf, 1978), the distribution stage (Bucklin, 1977 and Kaynak, 1981) or the role that government could have in improving food marketing systems (Lele, 1977). The rising consumption of imported cereals and of imported feed grains has emphasized the impact of efficient marketing. In many countries of the developing world it appears to be cheaper to import cereals from ten thousand kilometers away than to produce them at home. At the same time, many countries wonder whether an increase in the efficiency of the national market system might induce higher national production.

Little attention has been paid to the impact of the changing structure of agricultural product demand on the development potential for agriculture. The changing structure of demand has probably had great allocative effects on agricultural production. In his study on food-price policy and income distribution for India, Mellor (1978) observes the effect of agricultural prices on cropping patterns, concluding that changes in these cropping patterns could affect the employment situation. In a situation where farmers have different factor endowments the allocative effect of changing agricultural demand will result in strongly diverging income growth. This is true in the comparison of domestic production development with imports and in the comparison of differential development per farm type within one country.

The allocative effect of changing agricultural demand

Income growth and urbanization lead to decreasing consumption of starchy crops and some grains--such as maize-- whereas the consumption of wheat, vegetables, fruits and animal proteins tends to increase. This increased consumption of animal proteins heightens the demand for feed grains, such as maize and sorghum, and vegetable protein sources such as soybeans. In countries with specific rice producing areas, rice consumption may decrease at high income levels, and increase through urbanization. For maize, the increased demand for its use as animal feed will offset a decrease in human consumption.

Changing consumption patterns affect the domestic agricultural sector, especially when new or increased demand for a product cannot be satisfied in-country, resulting in importation, as with wheat in the tropics. Other newly desireable products could be produced domestically, but with suboptimal suitability, as with soybeans or sorghum. Production growth of these crops may be rapid but will be based on area expansion rather than on yield increases (Table 1.6). Developing countries do not normally compete well with temperate growing areas, and importations result to satisfy demand. The changing composition of agricultural demand towards non-traditional products reduces the ability of many developing countries to increase agricultural production.

Table 1.6. Sorghum production and imports in Mexico and Colombia, 1970 - 1983.

	MEXICO				COLOMBIA			
	Area harvested (000 ha)	Yield (kg/ha)	Production (000 tons)	Imports (000 tons)	Area harvested	Yield	Produc-tion	Imports
1970	920.9	2829	2747	12.1	n.a.*	n.a.	118.0	-
1971	935.8	2689	2516	8.8	n.a.	n.a.	239.6	14.2
1972	1108.9	2355	2612	221.3	n.a.	n.a.	210.0	20.9
1973	1184.6	2760	3270	-	n.a.	n.a.	280.2	36.9
1974	1155.7	3028	3499	473.8	n.a.	n.a.	336.6	0.2
1975	1445.1	2855	4126	844.6	134	2500	335.0	-
1976	125.1	3219	4027	-	173.6	2464	427.0	-
1977	1313.4	3060	4325	749.2	189.5	2144	406.2	125.8
1978	1399.3	2997	4193	922.0	224.8	2299	516.7	50.6
1979	1162.2	3437	3994	1174.4	221.2	2266	501.3	170.5
1980	1543.1	3039	4689	1340.5	206.0	2090	430.5	207.5
1981	1767.3	3562	6296	2062.3	231.3	2300	532.0	55.0
1982	1275.2	3699	4717	137.09	291.2	1936	575.5	132.9
1983	n.a.	n.a.	n.a.	n.a.	280.0	2204	617.3	97.9

Source: Mexico: Econotecnica Agrícola, Vol. V, No. 9. Dirección General de Economía Agrícola. Secretaría de Agricultura y Recursos Hidraulicos, Sept. 1981. Colombia: Oficina de Planeación del sector agrícola: cifras del sector agropecuario, various years. And: IDEMA, Internal Statistics.

* n.a. = Not available.

Apart from its impact on national agricultural production versus imports, the changing demand structure will have consequences for the development of agricultural regions or distinct farm sizes. Agriculture close to the urban centers will intensify and become directed towards fruit, vegetable, milk, and meat production. This offers the opportunity for small farmers in these areas to increase their on-farm employment possibilities, cash incomes, and standard of living. Urbanization and income growth will have considerable impact on agricultural employment in the regions close to the urban areas.

Agricultural development along the frontier depends on two factors. The first factor is the existence of efficient marketing channels to transfer products to the urban centers. Since the physical infrastructure at the frontier is poor by definition, production will concentrate on commodities that have low marketing costs, e.g., beef. The second factor that determines frontier development is the speed at which agricultural development progresses in older production areas. Although land is cheap at the frontier, labor might be scarce and productivity low, resulting in an inability to compete with non-frontier agricultural zones.

A dualistic agricultural structure will strongly influence the pattern of agricultural development in older agricultural areas not affected by the proximity of urban centers. The small farms characteristic of much of Latin America concentrate on the production of traditional food crops, such as potato, cassava or maize. This reflects the comparative advantage that these crops have in the specific agro-ecologic environment of the region. These small farms will be subsistence or semi-subsistence oriented, with any marketable surplus directed towards the urban markets. Assembly costs for their products are relatively high, and the limited market size makes producers' prices instable. Large farms concentrate on commercial, mechanizeable crops or cattle holding. The big marketable surpluses produced by these farms suppress assembly costs. Price variability for large farm production is limited because of better integration of the markets for commercial products and because of more frequent intervention policies.

The changing demand structure will favor the large and harm the small farm. Large farms can respond with relative ease to the growing demand for animal feed. Improvement of technological practices following the diffusion model of agricultural growth can create rapid adaptation of production techiques. Extra land can often be brought under cultivation at limited cost. The low marketing costs that result from the larger scale of production facilitate competition with imports. Political pressure by a large farmers' lobby might be effective for obtaining preferential treatment of national production (Pachico, 1981). The growing animal feed market offers limited potential to small farmers because the production technology for feed grains is not appropriate on small labor-intensive and capital-extensive farms and because the marketing costs for assembling small quantities of produce are high. Depending on the speed of income growth and urbanization, the demand for traditional staples will decrease or stabilize. Small farmers will be confronted with markets that do not offer growth potential.

Within a Latin American context, the different market perspectives for small and large farms strongly influence the demand for new technology. According to the induced innovation model, it can be expected that technology development will be biased towards large farms. Small farms face decreasing demand and will not be interested in production-increasing technology if the extra production cannot be sold. In addition to factor endowments, market potential plays a role in determining the direction of induced innovation (see Ben-Zion and Ruttan, 1978, for a treatment of this issue at aggregate level).

In a dualistic agricultural structure, the decreasing market perspectives for traditional food crops restrain small farm development. In this way the production potential of a considerable part of the agricultural sector is neglected. This has several implications:

First, aggregate agricultural production will be lower than possible which will either diminish the export potential or increase the import needs of a country, thereby making agriculture's contribution to the balance of payments somewhat lackluster.

Second, the small farmer will rapidly decide to give up agriculture and migrate to the urban areas.

Third, the potential of the agricultural sector to absorb population growth and to provide employment will be reduced.

Fourth, agricultural development will draw more heavily on capital investment than it would when small farm development would be fostered. This will constrain the growth of the industrial sector. Much of the material goods needed for large scale agriculture will be imported, which will further constrain the ability to finance growth with foreign exchange.

The changing structure of agricultural product demand determines the potential of the agricultural sector to contribute to overall economic development. Part of the demand growth is in products that do not have a comparative advantage in domestic agriculture. Growth in imports is caused not only by the spectacular development of demand to which supply reacts with a considerable time lag (Mellor and Johnston, 1984) but also by a problem in producing the products to which new demand is geared. When the agricultural sector of a developing country is characterized by a dualistic structure, increasing demand favors the large over the small farm sector. This can lead to deviations from an optimal development path.

1.4 Small farm market improvement

If difficult market perspectives constrain the development potential of the small farm, market improvement might contribute to improved agricultural development policies. The importance of agricultural markets for the small farmer has been recognized before, and the performance of agricultural product markets has been studied (Harriss, 1979). Most studies, however, have only considered the efficiency of transferring demand and supply, and were mainly concerned with the static efficiency of the marketing channel. The improvements proposed on the basis of these studies might be effective in increasing the share of the farmer in the final price, in decreasing the price to the consumer, or in improving the service level of the marketing channel. Nevertheless those marketing channel improvements would only be marginally effective in improving the long-term income perspective for the small farm if final demand continued to decrease. Complementary to the improvement of the static efficiency of the marketing channel, efforts could be made to improve the access of small farmers to promising markets. These measures could be directed towards improving the dynamic efficiency of agricultural development.

What forms can agricultural market improvement for small farmers take? Ansoff (1957) describes a strategy matrix which distinguishes between current versus new products, and between current versus new markets (Figure 1.1). <u>A first strategy</u> (market penetration) would be to increase the effective demand in the present markets for the products presently grown. The viability of this alternative depends on the factors which determine the demand for these products. If demand for a traditional farm product does not increase because preference for the intrinsic qualities of the product is lacking, and

	Present Product	New Product
Present Market	Market penetration	Product development
New Market	Market development	Diversification

Figure 1.1. A strategy matrix for agricultural market improvement

because rising incomes permit the acquisition of more expensive and more preferred foods, the expected success will be low. If demand does not rise because of deficient marketing resulting in irregular availability or unacceptable quality, marketing channel improvement or product improvement strategies could be very effective.

<u>The second strategy</u> (market development) would be to position traditional products in non-traditional markets. This strategy depends on the processing and utilization flexibility of the product and on the presence of promising markets that can be entered profitably. Milk is a perfect example of a product with extreme marketing flexibility. The demand for fresh milk in many rural areas does not increase, but the demand for milk to be processed into products such as milk powder, condensed milk, butter, and cheese grows. Maize and cassava are other products with processing and utilization flexibility. They can be used as animal feed, a starch source, a sugar substitute, or a processed food base.

<u>The third strategy</u> (product development) would be to introduce new products to be sold in the traditional final markets. The critical factors in this strategy are the suitability of the product to the agro-ecological circumstances of the region and the ability of the marketing channel to promote the new product successfully. The shift that many Andean highland producers underwent, from growing potatoes for the urban markets to growing vegetables and fruit, is an example of this strategy.

<u>The last strategy</u> (diversification) would be to introduce new products to be sold in new markets. The viability of this strategy depends on the suitability of the new product to the environment, on the ability to create a new marketing channel, and on the level of acceptance in the final market. According to Kotler (1984) this strategy is the most difficult one to pursue. If implementation is successfully executed the benefits can be very large. Outstanding examples of this strategy are the introduction of cassava production for the European animal feed market in Thailand (Mathot, 1974) and of soybeans for the world animal feed market in Brazil.

The choice of strategy to pursue is dependent on the specific circumstances, but some general remarks can be made. First, those strategies that request less production and market integration have a higher chance of success because fewer things can go wrong. Second, market improvement should be consistent with production potential. Many agroindustrial projects have failed because they overestimated the supply to be channeled into new markets (Austin, 1981). Third, market improvement will benefit the agricultural sector through increased use of inputs, as described in the high-payoff input model. Integration of market improvement with credit programs, input marketing, and extension will increase the benefits of market development. Fourth, the ability to shift crops or agricultural activities can be limited because of the existing agro-ecological conditions. If farmers are restricted in their cultivation by agro-ecological conditions, then the current activities offer an advantage to other activities. Market improvement programs built on the present products appreciate their proven suitability, while avoiding the learning lag involved in the change of agricultural production patterns.

1.5 Cassava: its development potential and its demand perspectives

Cassava (Manihot Esculenta Crantz) is a starchy tropical root crop, with its probable center of origin being the Amazon area of Latin America. Cassava was distributed around the world during the colonial era, and is now grown in Latin America, Africa and Asia (Table 1.7). The plant is mainly grown for its edible roots, which contain up to 35% carbohydrates and between 0.5 and 1.5% protein, but its protein-rich leaves are also eaten in certain parts of Africa, Indonesia and the Amazon. Cassava is the fourth most important source of calories for people in the tropics, after rice, sugar, and maize (Cock, 1982). Besides its daily contribution to the diet in many areas of the world, cassava has an important function as a famine food in areas where food security is low.

Cassava's role as a famine food is due to some specific characteristics. The crop adapts very well to marginal growing

Table 1.7. Cassava production in the different continents, 1980-1982.

	Area planted (millions of hectares)	Yield (kg/ha)	Production (millions of tons)	Percentage of global production
Africa	7.42	6383	47.38	38.0
Asia	3.93	11808	46.60	37.3
Latin America and the Caribbean	2.72	11320	30.79	24.7

Source: FAO, Production Yearbook, various years.

conditions, with an altitude range of from zero to 1800 meters above sea level on the equator, and flourishes in other tropical and subtropical areas as long as the temperature stays above zero degrees. Cassava is remarkable in the following ways:

Firstly, the crop is drought tolerant. Around 750 mm of water spread over its eight-to-twelve month production season is sufficient to produce adequate yields (Cock, 1985).

Secondly, the crop maintains itself on very poor quality acid soils, and does not suffer strongly from the absence of fertilization (Howeler, 1980) or other inputs. In this respect there is a strong contrast with potato, the most frequently grown highland root crop, which needs large amounts of inputs (van der Zaag and Horton, 1983).

Thirdly, cassava does not have an optimum harvest period and can be stored in the ground for extensive periods without quality loss, given acceptable soil quality (Carter, 1985).

Finally, cassava is planted by cutting its lignified stem in 20 cm. pieces that will sprout and produce new plants (Lozano, 1977). There is no need to save part of the economic yield for future cropping.

Cassava can flourish under conditions that would be intolerable to most other crops, although, like any crop, it will yield more in more favorable conditions. Cassava appears to be one of the most efficient carbohydrate producers of the tropics (de Vries, Ferwerda and Flach, 1967). Under suitable climatic conditions with proper cultivation techniques yields may reach 25 tons per hectare (Agricultural Compendium, 1981), the equivalent of around ten tons of grain. Grain grown under similar situations only yields a maximum of 5 tons per year. Due to its long growing period, cassava is very appropriate for mixed cropping systems (Leihner, 1983).

Cassava's production potential contrasts with its post harvest qualities. First, cassava contains certain quantities of linamarine-bound cyanide (Gomez, Santos and Valdivieso, 1982). Numerous methods have been developed to rid cassava of its cyanide, ranging from simple cooking or sun-drying to ingenious and very laborious processes (Weber et.al., 1978). Second, cassava only stays edible for one to three days, once harvested. Physiological reactions in the root that start up after harvest render the roots inedible after this period (Wheatley, Lozano and Gomez, 1982). Third, cassava is a bulky crop with roots containing up to 60% water. This inhibits transport over long distances. Fourth, the nutritional role of cassava roots is limited to the supply of calories. For balanced nutrition it is necessary to complement cassava with protein providing products.

Cassava's high yield potential in unfavorable conditions, its low input needs, its suitability for mixed cropping systems, and its high labor demands have each contributed to making it a typical small farmer crop in most countries (for data on Latin America, see Lynam and Pachico, 1982; for Asia, see Lynam, 1983; for the sparse evidence on Africa, see Cock, 1985). Cassava fulfills several needs for the small farmer. It satisfies a large part of the caloric needs of its producers, especially when the availability of other products is limited. In Latin America cassava often is used for on-farm swine feeding. If the crop is processed at the farm, it offers post-harvest employment. Often a considerable part of the harvest is sold to obtain cash income. The importance of cassava for many small farmers underscores its potential for agricultural development.

Throughout the world cassava enters the market in a number of different forms. Considerable quantities are marketed in fresh form and boiled before consumption. Other amounts are dried and sold as human food, for example, gaplek in Indonesia (Nelson, 1984), or as animal feed. A fermented or non-fermented flour is important in many countries, like farinha in Brazil or gari in West Africa (Cock, 1985). A fourth important derivative from cassava is its starch, to be used in human food, as in krupuk in Indonesia, (Nelson, 1984) or pan de bono in Colombia (Salazar de Buckle et.al., 1978), or in industrial applications. A last derivative of cassava that could have importance is alcohol. During the 1970's Brazil studied the possibility of using cassava for alcohol production as a substitute for auto fuel. Beside these five product forms, cassava is marketed in a large number of other product forms with regional or national importance. Cassava utilization over the world was estimated by Cock (1985) and is shown in Table 1.8.

Table 1.8 World utilization of cassava, 1975-1977 (Data presented as a percentage of total production).

	Human food		Animal Feed	Industrial use and starch	Export	Waste	Change in stocks
	Fresh	Processed					
World	30.8	33.8	11.5	5.5	7.0	10.0	1.4
Africa	37.9	50.8	1.4	1.0	1.0	9.5	1.0
Latin America and the Caribbean	10.5	23.9	33.4	9.6	1.0	14.0	1.0
Asia	33.6	21.7	2.9	8.6	23.0	6.3	3.9

Source: Cock, 1985

The different forms in which cassava is utilized indicate the various roles that the crop plays on different continents. In Africa, cassava's main contribution to development in the short run lies in its use as a subsistence and food security crop. In Asia, cassava processing into starch or animal feed are of primary importance; additionally the crop may play a role in the diets of the rural poor. In more highly developed Latin America, cassava has to acquire its income potential through the market. To optimize the contribution of cassava to development in these different circumstances, different strategies are needed. This document is concerned with cassava in Latin America and will study the market potential of the crop.

Many traditional cassava markets suffer from demand deterioration due to urbanization and income growth. Fresh cassava consumption per capita diminishes in the urbanization process, as was shown for Indonesia by Dixon (1984) and for Latin America by Janssen and Wheatley (1985). However the same data suggest that this decrease is not caused by the income increase. Fresh cassava does not appear to be an inferior good. Dried cassava for human consumption, such as gaplek consumption in Indonesia decreases from rural to urban areas and falls with rising incomes, and thus is clearly an inferior good. Data from Brazil (Gray, 1982) suggest the same for cassava flour. Dried cassava for animal feed has successfully entered the European Common Market and appears to have potential in many developing countries because of the rapid growth of the animal feed industry. Cassava starch faces strong competition from corn starch, the more so because of the growing capacity to change chemical properties of different starch types (Whistler and Paschall, 1967). Increasing the market share of cassava starch will depend on the ability to decrease production costs. Many of the regionally or nationally important cassava products also face decreasing market perspectives.

The adaptation of cassava to the agro-ecological conditions of many areas where it is grown; its importance among small versus large farmers; and its low potential for growth in many of its traditional markets underline the importance of market improvement strategies. Successful market improvement, be it by upgrading the present markets or by opening non-traditional markets, could improve the income potential and the employment opportunities for large groups of small farmers. This could make a significant contribution to balanced agricultural development in many tropical countries.

1.6 The potential of market improvement for cassava: objectives of this study

The first objective of this study is to estimate the impact that the present market conditions have on the income potential for small farmers. On the basis of this knowledge, the effect that cassava market improvement can have will be estimated. Towards this end, a region where cassava has traditional importance--the Atlantic Coast region of Colombia-- was selected for study. Two market improvement strategies will be evaluated:

The first one concerns market penetration: the improvement of the traditional market of fresh cassava for human consumption, which appears to lose importance in the urbanization process. It is assumed that the improvement of the fresh cassava market can be reached by improving the storage capability of the fresh roots. Since the available data do not suggest that fresh cassava is an inferior good, this strategy could have long term benefits.

The second strategy concerns market development: the possibility of selling cassava to a new market. The potential for processing cassava for use as an animal feed in the quickly growing compound feed industry of Colombia will be studied. In the case of fresh cassava market penetration, the final consumer market will be examined. In the case of dried cassava market development, the animal feed raw material market will be studied.

The nature of the study is <u>ex-ante</u>, e.g., the study will try to forecast the effects of successful future change on the basis of presently available information. Even though an <u>ex-ante</u> study suffers from the disadvantage that its conclusions depend on hypothetical developments, its advantage is that it can have influence on the direction development might take, and in that sense it deals with the real problem (Dillon, 1975). Due to the many methodological issues in the analysis of the effects of cassava market improvement, the main part of this study will be dedicated to the estimation of potential benefits.

Apart from an analysis of the net effects of cassava market development in the Atlantic Coast region of Colombia, identification of the major issues in the proposed market improvement strategies will be made. The identification will be based to a large extent on the evaluation of cassava projects that are pursued by CIAT (Centro Internacional de Agricultura Tropical) in cooperation with national government institutions in different regions of Colombia and other Latin American countries.

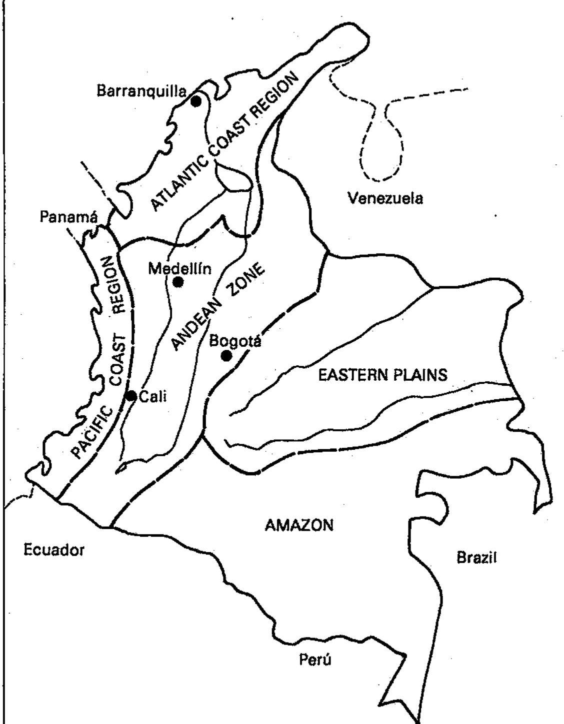
The methodology applied and the strategies proposed in this study focus on cassava and the Atlantic Coast region of Colombia. Conclusions drawn in this study will be extrapolated to other crops and to other areas as well. The concept of market improvement in agricultural policy in developing countries is, as far as the author knows, relatively new. Therefore, it is of critical importance to see if the proposed strategies can be generalized in a broader context.

Chapter 2 : THE ATLANTIC COAST REGION OF COLOMBIA AND THE IMPORTANCE OF CASSAVA WITHIN THE REGION

2.1 The Atlantic Coast region within Colombia

Colombia, located in the upper northwest corner of the South American continent, is a country of great contrasts. Five zones can be distinguished within the country (Hulsbosch, 1981): The most important zone of the country is the Andean region (Figure 2.1). This zone is made up of three high and parallel mountain ranges that cross the country from the southwest to the northeast. Fertile valleys with technified agriculture lie between the mountain slopes, cropped with coffee. Colombia's agricultural wealth is based on the coffee production in the

FIGURE 2.1: THE FIVE MAJOR GEOGRAPHIC ZONES OF COLOMBIA



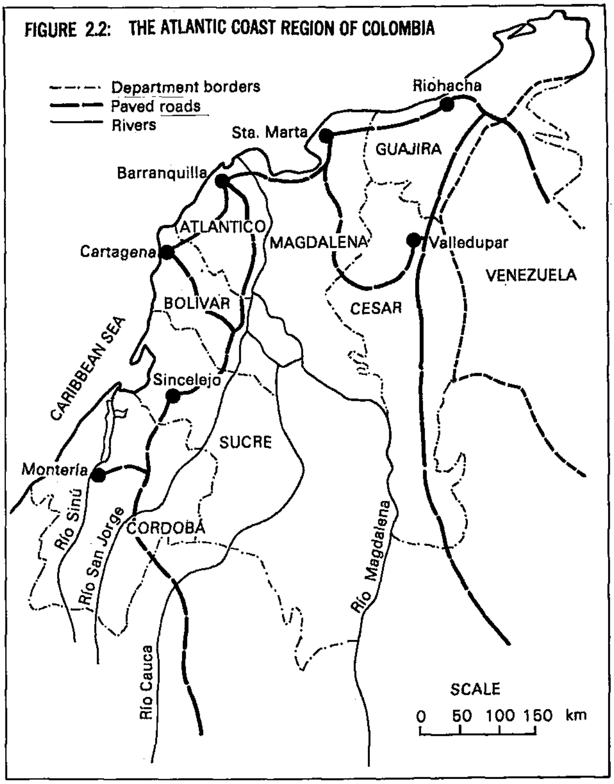
Andean zone. The three major cities of the country are found in this zone, each of which has a different altitude and climate. The capital of the nation, Bogota, has between four and five million inhabitants and is located at 2600 meters above sea level in the center of the country. It has a cool and wet climate. Government institutions and manufacturing industry form the basis of Bogota's economic activity. Medellin, the second largest city of the country (population: 2 million), is located in the west of the country at 1500 meters altitude. It has a temperate climate with moderate rainfall. Medellin has a strong textile industry. Cali, in the southwest of Colombia, is the third largest city of the country and has about one and a half million inhabitants. It is situated at a 1000 meters above sea level and has a hot and dry climate. The economy of Cali is based on agriculture, but there is some industry. Many smaller cities, towns and villages are found in the Andean zone, and although it comprises an area less than one-third the size of the country, the Andean zone hosts more than eighty percent of Colombia's thirty million people.

The second zone of the country is the Eastern Plains region. This region consists of infertile, acid, and extensively grazed pasture land. The historical importance of this zone has been limited, but the frontier development in the area has increased its political importance. The population in this zone is below half a million.

The third zone is the Amazon rain forest in the southeast. This zone is sparsely populated by Indian tribes, who live from fishing, hunting, and slash-and-burn agriculture.

The fourth zone is the Pacific Coast region, an extremely wet zone (rainfall over six meters per year) with high temperatures. This region is sparsely populated and underdeveloped.

The last zone of the country is the Atlantic or Caribbean Coast region. The region covers some one hundred thousand square kilometers and is crossed by rivers originating in the Andean highlands, such as the Rio Magdalena and the Rio Cauca (see Figure 2.2). This region is characterized by large plains, rolling hills, and an incidental mountainous zone. Soils are



intermediately fertile and soil textures vary considerably. Temperatures are high (averaging 28 degrees Celsius), and rainfall is low (from around 500 mm per year in the northeast to around 1500 mm in the southwest of the region). Rainfall is concentrated in the periods from April to June and from August to November. The low to moderate, but concentrated rainfall and the large rivers that cross the region result in periodic drought and flooding of large areas. Some five million people live in the Atlantic Coast region. The population is concentrated in the urban centers of Barranquilla, which is the departmental capital of Atlantico (around one million inhabitants), and in Cartagena (around six hundred thousand inhabitants), the capital of the department of Bolivar. Both cities have large slum areas, which host the many poor people who migrated from the countryside and did not find work in town. The region has four urban centers of secondary importance: Monteria, the capital of Cordoba; Sincelejo, the capital of Sucre; Santa Marta, the capital of

Magdalena; and Valledupar, the capital of Cesar. Their populations vary between one and two hundred thousand inhabitants. On the basis of statistical sources (DANE, 1974; Interamerican Development Bank, 1981; DRI, 1983) and interviews in the region it is estimated that around one and a half million people live in the smaller towns and villages of the region, while another million people live in the countryside.

The Atlantic Coast is the second most important zone of Colombia, but is less developed than the Andean zone. There is almost no coffee production, which keeps the region outside the mainstream of Colombia's development. The importance of Barranquilla and Cartagena as ports for the Andean hinterland decreased with the silting up of the Rio Magdalena, which had previously been navigable for some 700 kilometers upstream. Many areas in the Atlantic Coast region are inaccessible by road. GNP per capita in this region is far below the average of 1180 US dollars estimated for Colombia in 1982.

The economic basis of the Atlantic Coast region is agriculture, dominated by cattle production. Rivas (1974) estimated that 50% of the Colombian cattle stock grazes in the region, providing 47% of Colombian beef. Cotton, sorghum, rice, maize, cassava and plantain are the major crops grown. Industries in Cartagena and Barranquilla include the petrochemical industry, agro-industrial processing, and the assembly of vehicles and domestic appliances. In the smaller urban centers, the informal sector is important, producing folk art products and all kinds of services. Tourism provides income and employment along the coast. In the department of Cordoba a large scale nickel mine was opened in 1983, and in the department of Guajira a very large open cast-coal mining project is taking off. International energy prices have put the feasibility of the second project in great doubt, and the employment effect of both mining projects is limited.

The people of the Atlantic Coast region consider themselves Colombians but different from the Andean Colombians, with whom they have little contact or affective ties (Spijkers, 1983). The exotic tropical nature of the Atlantic Coast people contrasts with the introvert character of the Andean people. This distinction can be extended to economic development. The national macro-economic setting influences the events in the Atlantic Coast to a large extent and there is considerable trade between the two regions. However the development of the two regions follows separate paths and with minimal interaction. The differences in resource endowments, climate, and people justify an analysis of development options within the context of the region where it takes place.

2.2 Agriculture in the Atlantic Coast region

Three types of agricultural production are found in the region. The first type is cattle holding. Farms of this type often comprise several hundreds or thousands of hectares of pasture land, extensively grazed by Zebu cattle. Most of this land is owned by the tenant. The second type of agricultural production is the semi-subsistence farm, devoted to labor-intensive food crops, such as cassava, plantain, yam, maize and small-scale intensive cattle holding. These farms hardly ever have more than 20 hectares of land, and it is often rented. The third type is the market-oriented, mechanized cultivation of cash crops, the most important of which are: cotton, sorghum, maize, and rice. Borren (1984) states that many commercial farmers own their machinery but rent their land. The size of these farms is from some 30 to 300 hectares. Most large commercial growers own the land. Table 2.1 gives production data from 1983 for the most important crops. Data on small farm crops are not very reliable and should be interpreted with caution.

The subsistence farm and the large cattle holding farmers have been interacting since the colonization of the region (Spijkers, 1983). Large landlords allowed landless peasants to clear the forest and to cultivate the land for a number of years. Afterwards, the peasant would sow pasture and hand the land back to the owner and, thus, the region was put into pastures. In areas where land rights were not distributed, peasants moved in and cleared the forest without knowing their status, a process that still continues in the far southwest of the region. Many of these peasants were driven off the land, some were able to sell, and others kept the land themselves. Although the colonization process has been almost completed, the traditional relationship

Table 2.1. Production of major agricultural commodities in the Atlantic Coast region, 1983.

	Atlantico		Bolivar		Cesar		Cordoba		Guajira		Magdalena		Sucre		Total		
	Area[1]	Production[2]	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	Yield[3]
Cotton	0.9	1.1	3.8	4.6	17.5	19.6	6.5	9.8	-	-	-	-	5.6	8.4	34.3	43.5	1.27
Rice	-	-	14.2	60.0	105.7	275.3	12.2	51.5	-	-	12.9	65.9	9.3	35.2	154.3	487.9	3.16
Sorghum	3.9	6.2	5.9	11.7	31.1	101.1	22.3	24.9	1.0	1.7	10.4	16.4	11.3	22.3	85.9	184.3	2.14
Maize	5.5	7.2	17.8	23.0	15.3	34.6	60.8	96.2	3.4	4.8	22.4	28.5	7.3	14.1	132.5	208.4	1.57
Sugar Cane	0.4	1.9	1.8	5.6	1.2	4.8	0.2	0.6	-	-	-	-	2.2	9.0	5.8	21.9	3.78
Plantain	0.8	5.5	15.4	107.8	10.9	65.4	15.0	120.0	1.1	5.5	5.0	30.0	2.5	15.7	50.7	349.9	6.9
Cassava	11.0	99	14.0	140.0	9.1	91.0	11.0	99.0	0.8	8.0	21.0	147.0	9.7	106.7	76.6	690.7	9.0
Yam	-	-	2.6	23.4	-	-	2.5	17.5	-	-	-	-	7.0	56.0	12.1	96.9	8.0

[1] Thousands of hectares

[2] Thousands of tons

[3] Tons/hectare

Source: Ministerio de Agricultura: Oficina de Planeamiento del Sector Agropecuario. Cifras del Sector Agricola, Bogota.

between the peasant and the landlord continues to exist. To clear the pasture from new secondary growth, it is put into crops once every seven years (Boering, 1984). The possibility of clearing the pasture mechanically diminishes the importance of this rotation.

The decreasing importance of the pasture-crop rotation and the atomization of small property through inheritance has increased the pressure on the land. In the beginning of the seventies, this led to small farmer land invasions. Afterwards some land was officially redistributed by INCORA, a government office, but the land distribution has only slightly decreased the land concentration in the region (DANE, 1974).

The large farm has extra resources which can be diverted into easily manageable cattle holdings. The small farm concentrates on food production to feed the family and to sell the surplus. Cattle will be found on the small farm if the land resources exceed the needs for cropping. Notwithstanding the different factor endowments, both farm types have developed along the principle of substitution of cattle for cropping with rising farm size.

Commercial cash cropping developed with the establishment of a textile industry in Colombia, the opening of international cotton markets, the growth of urban consumption centers, and the demand increase for feedgrains. Commercial cropping, though different in nature, forms an important bridge between the small and large farm types. Large farms that want to intensify plough their pasture land for crop production. Small farmers who want to increase their production make the shift from traditional food crops to less labor-intensive cash crops and invest their surplus in machinery. The market perspectives for these commercial farmers are good, especially when there is considerable government price support. Many cash croppers use rented land and prove to be severe competitors in the land rental market for the small farmer.

Although the population density in the Coast is low (less than 40 persons per square kilometer), the pressure on agricultural land is high. Most land is in the hands of a limited group of landowners, while little land is shared by many small farmers (Figure 2.3). Large landowners do not exploit their land intensively. Small farmers exploit their land intensively but face decreasing market opportunities. Employment opportunities offered by the large farms are decreasing and the competition for land with the commercial farms is increasing. The difficulties of earning a living in the countryside have resulted in rapid rural-urban migration and in growing dissatisfaction with the distribution of resources. The duality of agricultural production takes its toll in the form of wide spread poverty and continued social destabilization.

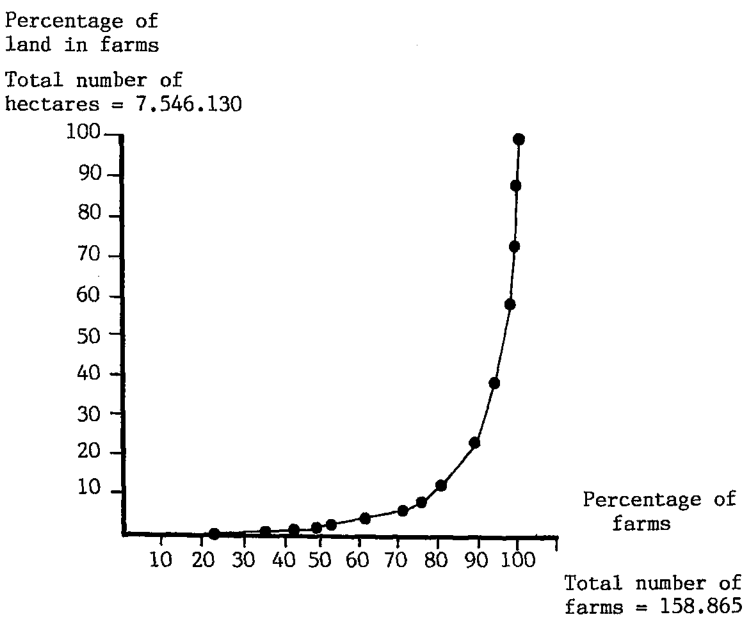


Figure 2.3 Cumulative land distribution in the Atlantic Coast Region, 1971.

Source: DANE, 1974

2.3 Small farm development in the Atlantic Coast region

As a reaction to the decreasing income basis of the small farmer, the Colombian government established the DRI-program in 1977 (Desarrollo Rural Integrado; Integrated Rural Development). The DRI-program objectives are: to increase production of food crops; to increase income and employment for the small farmer; to improve rural marketing of food products; and to improve access of the rural population to health care, education, electricity and water (Lopez, 1983). In spite of its name the DRI-program is not really integrated rural development. Its emphasis is on production increases through credit facilities. The DRI-program covers farms with between 1 and 20 hectares of land. The emphasis on credit has meant that DRI benefits credit-worthy farmers most, leaving large groups of the very poor outside the development process. Still, the Colombian government considers DRI to be a partial alternative to land reform programs (Piedrahita, 1981).

Large parts of the Atlantic Coast region are covered by the DRI-program. It concentrates on medium-term cattle loans and short-term cropping loans. Crops that are financed include cassava, plantain, yam and maize. Available data show that the increased credit availability had a marked effect on intensification of production by the farmers included in the program (Table 2.2). Nevertheless, the program only covered a limited part of the peasant population. In 1982 for example, cassava credit supplied by the DRI-program was only 14% of all cassava credit, and covered 5% of the total area planted with cassava (Table 2.3).

Once production started to increase, commercialization became a long-lasting headache for the executing officers of the DRI-program. The large national demand for maize could absorb increased production easily by reducing the level of imports. Yam had been exported for a certain period to Venezuela, the neighboring country, but this market did not prove to be reliable. Plantain and cassava, both crops with limited and traditional markets, faced strong price decreases. In 1981 cassava production was very high; many farmers could not find buyers for their crop and plowed the land without harvesting.

Table 2.2. Changes in land use: % farmers that answered positive to the question in four different coastal departments, 1985.

	Did you plant more than three years ago?	Did you plant less than three years ago?	Did you plant the same as three years ago?
Cassava			
Atlantico	43	28	28
Bolivar	16	34	50
Cordoba	37	26	37
Sucre	38	18	43
Maize			
Atlantico	52	23	25
Bolivar	41	25	34
Cordoba	40	20	40
Sucre	36	15	49
Yam			
Atlantico 1/	-	-	-
Bolivar	13	30	57
Cordoba	38	27	35
Sucre	28	24	48
Plantain			
Atlantico 1/	-	-	-
Bolivar 1/	-	-	-
Cordoba	31	7	62
Sucre	25	0	75
Pastures			
Atlantico	55	7	38
Bolivar	44	15	41
Cordoba	52	10	38
Sucre	42	6	52

Source: Producers questionnaire (Table 3.1).

1/ Insufficient data available for reliable values.

The limited markets disturbed the basic premise of the DRI-program, i.e. that production increases lead to income increases. After the 1981 debacle, farmers were afraid to grow more crops. It is clear that small farm development in the region cannot depend on production increases alone but has to consider marketing. If not, the increased burden of credit payments might have an adverse effect on the potential for small farm development in the region.

Table 2.3 Sources of financing for cassava cultivation in different departments of the Atlantic Coast region, 1982.

	Atlantico	Bolivar	Cordoba	Sucre	Total
Estimated area cultivated with cassava (ha)	10958	14510	16000	12400	53868
Area financed (ha)	3098	4780	5800	4204	17882
% financed	28.2	32.9	33.9	33.2	33.2
% financed with ordinary production credit	97.7	91.7	91.7	89.5	92.5
% financed with FFAP-credit	0.3	5.1	0.8	5.6	2.9
% financed with DRI-credit	2.0	3.2	7.5	4.9	4.6

Source : Internal documents, Caja Agraria of Monteria, Sincelejo, Cartagena, Barranquilla.

2.4 Cassava and cassava development in the Atlantic Coast region

Cassava has a long history in the region. It was already marketed in Cartagena in the eighteenth century (Spijkers, 1983). Cassava was one of the subsistence crops of the colonizers, and has kept its importance for the small farmer ever since. Within the small farm system more than 40% of all cultivated land is estimated to be in a cassava cropping system (Table 2.4). Cassava provides almost 40% of the crop income of small farmers, and is also important for on-farm consumption. Its production creates around 20,000 man-years of employment in the region.

Present cassava production and utilization

Most cassava in the Atlantic Coast region is intercropped. In the northern part of the region it is often cultivated with maize

Table 2.4 The importance of cassava in the small farm in various departments of the Atlantic Coast region, 1982.

	Atlantico	Bolivar	Cordoba	Sucre
Average farm size (ha)	5.5	7.1	6.5	6.0
% of land cultivated	40	51	23	30
% of crop land planted to cassava	48	44	42	50
Area planted with cassava (ha)	1.06	0.7	0.61	0.9
% of cash income from crops, coming from cassva sales	46.4	24.5	29.9	31.4

Source: Atlantic Coast region reconnaissance survey (Table 3.1). Producers questionnaire (Table 3.1).

(Zhea mays L.), but is also cultivated in a more complex association with maize, millet (Panicum miliaceum L.) and pigeon pea (Cajanus cajan L.). In the southwest, where rainfall is higher, cassava is grown with yam (Dioscorea alata L.) and maize. Cassava is also sometimes grown with plantain (Musa sp. L.) or cowpea (Vigna unguiculatta L.). Cassava monoculture is not widespread in the region.

Most cassava is planted at the start of the rainy season, in April or May, but where soil moisture is not a limiting factor cassava can be planted in other periods. Land is prepared by tractor when possible, and by hand, using machetes or hoes, when topography is rugged. Fertilizer is almost never used in the cassava cropping systems--soil fertility is maintained by rotations with pasture land or by fallowing.

Cassava is weeded three or four times during its production cycle. The weedings are concentrated in the first months after planting until enough of the crop covers the ground to prohibit the growth of weeds. Weeding can take up to 80 man-days per hectare. Lately herbicides are becoming more popular, to be applied before as well as after the planting. Herbicide use strongly decreases the labor needs per hectare, especially for contracted labor. Pest and disease problems are not common in the region; ants or termites might damage planting material however, and mites or hornworms might constrain the growth of the plant. Pesticides and fungicides are applied in limited doses when a specific problem is occurring.

Cassava harvesting is rather well spread over the year. In large areas of the region (Atlantico, Sucre and parts of the other departments) cassava that is not harvested before the end of the dry season loses its value for human consumption because of renewed sprouting and the consequent loss of starch in the roots. Cassava from these areas is supplied through the dry season. In other areas, where the crop can be maintained through the dry season, harvesting is often delayed to reap the benefits from the increasingly higher price outside the main harvest season. Cassava harvesting is very labor-intensive, as one person can harvest only 300 to 400 kg per day.

In the Atlantic Coast region most cassava is sold fresh for human consumption. Small quantities are used in starch production or to prepare traditional snack foods. To supply the urban markets, a marketing channel exists which transfers the cassava roots from producer to consumer in a very short time. Often the cassava rural assembly agent arranges sales with the farmer before harvest to be sure of fresh merchandise. Urban wholesalers and retailers might also arrange purchases in advance. The crop travels quickly through the marketing channel, but its poor storage quality still makes the marketing of cassava a very risky business. Losses are high and daily price fluctuations are large. Cassava margins are often more than double the producer's price. The result is that cassava is a cheap crop to produce, but an expensive one to buy, especially in urban areas. The high marketing margins have not benefitted the many small cassava traders. This risky marketing makes cassava a difficult crop to sell, especially in areas far from the urban consumption centers.

The unfavorable marketing characteristics make cassava unattractive for urban consumption. Aside from the quality risk and the high price, cassava consumption involves a considerable buying effort, because the product has to be bought on the day of consumption. Cassava consumption decreases with rising urbanization (Table 1.5). Data from the southwestern city of Cali show that cassava consumption decreased strongly between 1972 and 1982 (Pachico, de Londono and Duque, 1983). While other products, e.g. rice, experienced price decreases, cassava became more expensive. Concurrently, it lost terrain to more convenient products.

The present fresh cassava production-trading-consumption system appears to be losing importance in the Atlantic Coast region. The present system appears to be unstable, expensive and with little income potential. A successful contribution of cassava to small farm development in the region is critically dependent on the availability of promising output markets.

Potential cassava markets in the region

Several cassava market opportunities can be identified in the region (Table 2.5). Improved fresh cassava for human consumption is a first opportunity (Table 2.5.A). This marketing channel already exists, and most cassava is presently sold through it. Increased penetration in the fresh cassava market could probably be achieved at a low cost and with strong impact. A fresh cassava marketing strategy should begin by improving the storage quality of the crop. The hypothesis is that part of the present high marketing costs are caused by: the bad storage capability of the product; the subsequent high risk; the relatively small volume per trader; and pressure on the consumer to purchase the product on the day of consumption. Since at present farmers' prices are at US \$ 0.08 per kilogram and the final consumer price at US \$ 0.24 per kilogram, there appears to be considerable room for decreasing the cost of marketing. Consumption of fresh cassava could rise because of increased convenience and because of decreasing consumer prices. This would strongly improve the demand situation for the farmer. The development of low cost storage techniques is presently far under way. At CIAT, cassava was stored successfully for up to three weeks in sealed plastic bags that prohibit physiological deterioration. To prevent rotting (microbial deterioration) roots were treated with a fungicide inoffensive to humans. Field trials with this storage method have been executed successfully in the region. The cost of the technique is estimated at around two US dollar cents per kg (Janssen and Wheatley, 1985).

Starch is a second option. Demand for starch is income-elastic and will grow in the coming years. Starch production, however, needs considerable amounts of high quality water, which is in short supply in the region. This constrains the accelerated development of the existing starch industry. Additionally it appears improbable that cassava starch will be able to compete successfully with corn starch in the near future (Table 2.5.B.).

The market of traditional snack foods based on cassava appears to have a reasonable future, since snack food consumption will rise at higher income levels. However the absorption capacity of this market is not currently very large, thus limiting its potential (Table 2.5.C).

Dried cassava or dried cassava flour for human consumption are inferior products. These products were never important in the region and it is not expected that they could be introduced successfully. Even if they could be, market size would only decrease in the course of the development process (Table 2.5.D).

Inclusion of cassava flour in wheat flour for bread baking or pasta making might have potential. Wheat consumption in Colombia is growing and has a high income elasticity (Hall, 1980). Successful introduction of cassava flour in wheat flour depends on: the production of high quality flour at a competitive price; successful integration with the wheat-milling or bread-baking industries; and; consumer acceptance of bread or pasta containing cassava flour (Table 2.5.E). Bread baking on the basis of wheat-cassava flour mixtures has proven to be feasible in Brazil, where for a long period the mixing of the two was ordered by government decree.

A final market opportunity would be dried cassava as an animal feed raw material. The Colombian animal feed industry has been growing very quickly. Domestic production of raw material receives strong price support but has not been able to keep up with demand, and this limited availability of raw material is a major constraint for the growth of the animal feed industry. If dried cassava could be produced at a competitive price, a large and expanding market would open up. Preliminary studies showed that cassava would be competitive at around $ 0.06 per kg. of fresh cassava, which was above cost of production (Pachico, Janssen and Lynam, 1983). This would involve using the low-cost solar drying technology developed in Thailand (Table 2.5.F).

Because of the ready availability of drying technology, cassava as an animal feed appears a more attractive market development option than cassava as a wheat flour substitute. Although the price at which dried cassava would be sold to the animal feed industry would be below the average fresh market price, this would be compensated for by lower quality exigencies. The dried cassava market could absorb growing volumes of production in the future and could provide more stable prices than the fresh market, because the dried cassava prices are linked with grain support prices. The low but secure price could establish a price floor for cassava. Also, the drying industry would create employment in the dry season, when little employment is available.

Considering the potential of cassava as an animal feed, the DRI-program started a modest effort to develop the dried cassava market with small farmer associations at the end of 1981. By the middle of 1985 twenty drying plants were established and around 4000 tons of dried cassava were supplied to the animal feed industry. Plans for further development were elaborated by the DRI-program, while spontaneous development of drying plants took place. Cassava drying looked well on its way to becoming an important source of rural income in the region.

Table 2.5: Cassava market improvement options in the Atlantic Coast region of Colombia, 1986

Markets option	Potential Market Size	Factors that limit realization of market potential	Chance to overcome limiting factors	Additional benefits of strategy
A: Fresh cassava for human consumption	Improvement of fresh market has very large potential, given the large numbers of consumers and the traditional importance of the crop	Storage quality of fresh cassava is very bad	Technical solution is developed. Implementation strategy under development. Overall chance reasonable	Decreasing acquisition costs to the consumer
B: Cassava starch	Market size is large and grows relatively quickly in Colombia's industrialization process	Water availability, severe competition from maize starch	Very hard to overcome water availability problems	Could reduce maize imports
C: Cassava snack foods	Small but probable high value market	Improvement of processing methods	Very good, but will have little impact on income potential from cassava because of small market size	
D: Dried cassava for direct human consumption	Small, because of inferior characteristics of the product	Consumers' acceptance of the product, appropriate processing methods	Consumers' reluctance will not be overcome easily	
E: Dried cassava flour for inclusion in bread flour	Reasonably sized, growing market, because of growth in bread consumption	Consumers' acceptance of composite-flour bread, appropriate processing and baking methods, acceptance by millers and bakers	Overcoming these constraints will be hard without government intervention	Could reduce wheat imports, could stabilize farmers' cassava prices
F: Dried cassava as a raw material for animal feed industry	Market size is large and growing	Appropriate processing methods, acceptance by animal feed industry	Processing methods can be copied from other countries, animal feed industry is interested. Market has very good perpectives	Reduces sorghum imports, could stabilize cassava prices, creates off-season employment

Chapter 3 : ANALYZING THE ROLE OF MARKETS: TRADITIONAL AND NEWLY PROPOSED METHODS

3.1 Structure conduct performance methodology

Agricultural market analysis in developing countries has its origins in the preoccupation with the efficiency and effectiveness of the exchange processes between producers and consumers. The most popular method for these market studies has been the structure conduct performance method. This method originated in the fifties in the industrialized countries from the awareness that the analysis of the behavior of a certain industry could not be founded on the (neo-)classical principles of perfect competition versus monopoly. Deviations of all kinds from perfect competition or monopoly were encountered in industrial and labor markets, and the economic discipline needed a way to analyze these situations. Clodius and Mueller (1961) describe how structure analysis can orientate agricultural economics research. The key concept is the causal relationship between structure, conduct, and final performance of the industry.

Market structure can be described in the following terms: the number and size distribution of sellers and buyers; the degree of product differentiation and market information availability; and the conditions of entry into the market. Volumes traded is another important structure characteristic (de Morree, 1985). These structure characteristics influence the behavior of the market agents, and market conduct is defined by the following variables: methods to determine price and output; product and promotion policies; coordination of policies between market agents; and, presence or absence of predatory tactics against rival market agents. The result of the market agents' conduct within the market structure is the market performance. Bain (1959) mentions the following criteria for market performance: price versus cost of production; efficiency; promotion costs; product characteristics; and the rate of progression of the market system. Structure conduct performance analysis has helped to explain striking agricultural developments such as vertical integration, price stability, and the role of conglomerates. A major conclusion has been that non-perfect competition can be more beneficial than perfect competition, because in the latter economies of scale and amounts needed for investments in innovations are not taken into account (Marion and Mueller, 1983).

Most structure conduct performance analysis in developing countries has been pointedly directed towards the question whether the markets studied were efficient enough. A number of criteria was developed to judge the quality of the marketing channel. Harriss (1979), in her review of structure conduct performance analysis in West Africa, mentions the importance of time series analysis for performance judgments: through calculation of correlation coefficients between prices in spatially separated markets; through relationships between transport costs and intermarket price differences; and, through relationships between seasonal price fluctuations and storage costs. In a development context, the structure conduct performance method has often been reduced to correlational time series and margin analyses.

Judging market performance by comparing price formation with perfect competition price formation presents a number of methodological as well as conceptual problems. Methodological problems described in detail by Harriss (1979) include: the research problems; the lack of definition of the correlation coefficient; and the problem of margin measurement in a situation with changing directions of trade flows.

The reduction of structure conduct performance analysis to correlational and margin analysis also brings up a number of conceptual problems. A first conceptual problem is that the method falls back to its beginnings in the (neo-)classical principles of market understanding, which it considered too simple in the first place. Consequently, judgments on market performance become simplistic and do not thoroughly consider the wide range of possible improvements.

A second conceptual problem is that the development of marketing channels often appears to move away from perfect competition. Stern and Ansary (1982) describe in great detail the advantages of vertically integrated marketing channels, be they administered, contractual, or corporate. Their conclusion is that product, price, promotion, and distribution policies can be executed more accurately in administered marketing systems, to the benefit of all marketing channel participants.

A third problem is that the comparison of marketing systems with the perfect competition model stresses price formation processes at the cost of other aspects of the marketing mix. This draws the attention away from other criteria, such as product characteristics, stability, and the rate of progression of the marketing system. The analysis has a static nature and is not useful in changing situations. The method does not serve to analyze or forecast the impact of changes in marketing on development.

A last conceptual problem that results from the reduction of structure conduct performance theory to correlation and margin analysis, is over-focusing on trade processes at the expense of producer or consumer aspects. However, trade is not an isolated activity as its significance is measured by how it correlates consumption and production. The system of production, trading, and consumption should be analyzed as a whole within the context of development objectives of the country in question. Isolated analyses of trading does not give enough weight to the potential contribution of marketing to development, because it does not consider how markets integrate production and consumption.

The usefulness of an empirical method has been reduced by simplistic comparison with, and lack of evidence for, the superiority of perfect competition; biased attention to price formation; and relative isolation of the analysis. As stated by Harriss (1979), the low discriminating potential has often been compensated for by ideological values of the executing researchers. By incorporating structure conduct performance analysis in a broader and more powerful analytical framework, market research and market policy could be improved.

3.2 A systems approach to market studies

Harriss (1982) suggests a first step towards improving structure conduct performance analysis. She distinguishes three spheres to be studied in market research: the production sphere; the exchange (trading) sphere; and the distribution (consumption) sphere. The spheres are interrelated and have to be studied together. The recognition of these spheres does not result in further methodological digressions.

Goldberg (1968) defines a more concrete method. He uses a systems approach to study wheat, soybean, and oranges in the United States. He relates developments in production and consumption with the evolution of the agroindustrial complexes in between. Goldberg reaches broad policy conclusions by the integrated analysis of production, processing, trading, and consumption while treating only one commodity at a time. This is because relationships within the marketing channel are more important than relationships between marketing channels. A comprehensive systems analysis of tropical food marketing in Latin America has been made by Harrison et.al. (1974). Here again marketing channels per product were analyzed.

The present study treats the impact of markets on cassava's development potential, using a systems approach. Systems are often divided into lower level components or subsystems (Churchman, 1968). Within the cassava system of the Atlantic Coast region of Colombia three subsystems will be distinguished according to the main activities performed: production, trading and processing, and consumption. Boundary lines between subsystems are not always clear in real and analyzable terms, for example a farmer who sells his cassava as well as growing it. Such a farmer is involved in production and trading at the same moment. The fact that people combine several activities stresses the importance of the interaction and integration of different activities. Explicit attention will be given to those cases where persons who belong to one group perform an activity of another group (e.g. the case of the farmer who trades his cassava) and to the cases where different groups are interacting with each other. The subsystem grouping allows researchable factors to be more easily identified and associated under one of the three headings.

The analysis of each of these subsystems will lead to the expression of their behavior in a number of mathematical equations. An imaginary system based on the integration of these mathematical equations will be used to simulate the behavior of the real system in different situations that might occur in the future. The mathematical expression of the Atlantic Coast cassava system allows for the integrated analysis of the effect of possible developments on the different components of the system.

Different segments are distinguished within the subsystems. Production is differentiated according to farm size and marketing according to type of consumption, and to the function of the market agent. Consumption is divided into: fresh consumption by humans, dried animal feed, starch, snack foods, and on-farm swine feeding. Segmentation within the subsystems serves two basic purposes. First, it indicates the analytical divisions to study the role of cassava in the region and, second, it helps to forecast the impact of marketing changes on different groups. In Figure 3.1 a schematic presentation of the Atlantic Coast cassava system has been drawn.

3.3 Evaluating the performance of the cassava system in the Atlantic Coast region

To evaluate any system successfully, its objectives have to be defined. In a hierarchical structure, the objectives of a system are determined by systems higher in the hierarchy (Dillon, 1975). For an analysis with a development focus, it is logical that development objectives be the evaluation criteria. In the case of cassava in the Atlantic Coast, it appears reasonable to adopt the development objectives of the agricultural sector. The following objectives are often proclaimed:

Acceptable producers' income. This would mean cassava prices that offer the producer a reasonable return on his investment while providing a sufficiently big market to generate sufficient income.

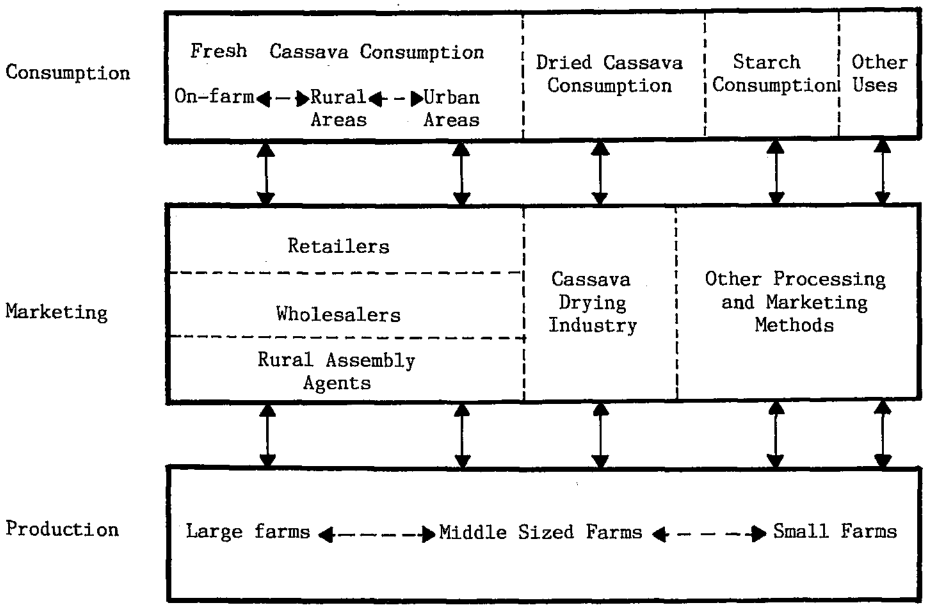


Figure 3.1 A schematic presentation of the Atlantic Coast Cassava System.

Acceptable prices for the consumer. The cassava price has to allow the product to play an important role in the diet of the consumer and should not have an inflationary impact.

Employment creation. The cassava system should create productive employment to provide income to the rural and urban poor. For the rural poor, employment will be generated by production, processing, and marketing. Marketing will provide employment to the urban poor.

Effective and equitable distribution of production among consumers and of value added among producers and market agents. Producers should have good access to cassava markets regardless of the size or location of their holding. The marketing system should provide the service level that different consumers and producers desire at minimum cost while supplying a reasonable income to its traders. Cassava should be provided at equal cost to different consumer groups. Special attention should be given to poor consumers and to poor producers.

<u>Stable prices, production, and incomes</u>. The availability of, the price paid for, and the incomes obtained from cassava should be stable and secure in order to guarantee its usefulness as a source of income to producers or of calories to consumers.

<u>Positive contribution to the balance of payments</u>. The cassava system should be able to satisfy internal demand for the product. For fresh cassava, which is a non-tradeable item, this objective is difficult to interpret and of limited relevance. For dried cassava it would mean that importations of substitute products would be reduced.

<u>Dynamic efficiency of the agricultural sector</u>. The cassava system should maintain or increase its role as a producer of income and calories. If possible, the cassava system should help to accelerate the speed of agricultural development.

The difficulties in satisfying all these objectives simultaneously are well-documented. Terms such as "growth with hunger" and "squeezing" indicate the seriousness of the problem of maintaining acceptable food prices while concurrently providing acceptable income levels to producers (Lipton, 1975; Schneider, 1984). The balance of payments problems of many countries are caused by the desire to maintain low food prices and wide food availability. Efficient and labor-saving marketing was often considered an excellent strategy to increase producers' prices and domestic production while decreasing acquisition costs for the consumer. The growing awareness of the important role trade plays in providing employment and income to many poor people has, however, cooled enthusiasm for this strategy. Although marketing could be carried out in a more efficient way, this would eliminate the employment and income source of many poor people. This in turn might aggravate rather than alleviate the problems of the hungry urban dwellers.

The employment problem that arises when marketing becomes more efficient illustrates the difficulty in determining the value of specific marketing channel improvements. In the end this decision depends on the relative weight given to the different objectives of the agricultural sector. This study will not explicitly try to define these weights. However, in Chapter 7, by evaluating different marketing improvement programs on the stated criteria, conclusions on their appropriateness within different development policies will be drawn.

To evaluate the cassava system in the Atlantic Coast region a three-step methodology has been developed. First, the individual activities (production, trading, consumption) are studied. Next, the interaction of production, trading, and consumption is studied. The study of the interactions is essential to the understanding of individual as well as total market behavior. Finally, the knowledge gleaned from investigations of the separate subgroups and their interactions are integrated so that the behavior of the total system can be understood. The integration of the different subsystems will take place in a simulation model, which predicts the state of the cassava system in different conditions.

In each step of the analysis, special attention will be given to the estimation of the changes that could occur through increased market penetration (fresh cassava storage) or market development (dried cassava as animal feed). The overall evaluation of the cassava system and of the proposed market improvement schemes will be made largely on the basis of the integrated system analysis.

Since the cassava system forms part of the wider regional economy of the Atlantic Coast region, outside relationships must be examined as well. Nevertheless, the study assumes that the interactions between the cassava system and other economic systems are of less importance than the interactions within the system. When outside events directly affect the cassava system, they will be explicitly analyzed.

The following sections will indicate the salient methodological issues in the analysis of the distinguished activities of the Atlantic Coast cassava system. These issues will be briefly linked to research reported in the literature. Afterwards the interactions between the subgroups will be discussed and the structure of the simulation model will be outlined. The last section of this chapter will discuss the data requirements necessary to complete the proposed analysis.

3.4 Issues in the analysis of cassava production

Cassava is produced by small farmers in the Atlantic Coast region. The average cassava grower controls less than 20 hectares of land. He devotes a considerable portion of his land, labor, and capital resources to cassava production. For these farmers cassava plays a leading role as a source of income and as a source of food calories for their families, thus it is important to understand the role of cassava within the farm household. The farmer performs a variety of cropping and (possibly) livestock activities. The cropping variation provides security to the farmer by: allowing for self-sufficient feeding of the family; providing dietary variety, and consequently, better nutrition; spreading labor resources out throughout the year; guaranteeing an even cash flow since there is always a farm product ripening for sale; and alleviating the risk inherent in monocropping. The small farmer will likely react positively to increases in cassava prices and grow more cassava in such a situation in order to obtain a higher cash income. Cassava marketing involves high risks. The limited size of the dominating fresh cassava market and the relatively inelastic demand create sharp year-to-year price fluctuations. Small farmers tend to be risk-averse and their reaction to unstable prices should be included in the study. The major issues in the analysis of cassava production pertaining to the impact of market changes include the role of cassava within the farm and the price and price risk reactions.

The role of cassava within the small farm

The role of cassava in the farm is defined by a large number of variables. A first important variable is land use. Because of its ability to produce on exhausted soils, cassava has a specific role in rotational patterns. Roche (1984) reports that on the Indonesian island of Java, cassava is often the last crop grown before the land is left to fallow. For small farmers land is often in short supply. Land use in small farms in the Atlantic Coast was estimated by Boering (1984) to be near the limit of its capacity. Spijkers (1983) and Bode (1984) write on the role of land-renting for small farmers to increase land availability.

A second important variable is labor use. Labor can be scarce in the planting and weeding period. Temporary migration (e.g. to Venezuela, the neighboring country with a prosperous oil economy) further diminishes labor availability (Doorman, 1982). Labor availability over the year influences the cropping pattern to a large extent.

A third important variable is the money available on the farm. For many small farmers production and marketing opportunities and the resulting farm plan are constrained by cash flow problems and limited access to credit.

A fourth important variable is the utilization of farm production. While certain crops may be grown solely for home consumption, others will be exclusively grown for sales. The value of production for on-farm consumption will normally be slightly above the sales value.

Cassava producers' reactions to changing prices

The reaction of small farmers to changing output prices has long been a theme of discussion among agricultural development economists. This discussion stems from the theories on agricultural growth that were mentioned in chapter 1. Some economists felt that the small farm did not react to price changes. Others reasoned that the objectives of the small farmers are so remote from profit maximization that there would be no *a priori* reason to assume positive supply elasticities. In the 1960's and 1970's a number of empirical studies found that the small farmer would react positively to price changes (e.g. Behrman, 1968, for supply of rice, cassava, kenaf, and maize in Thailand). A summary of most supply studies until the mid-seventies is given by Askary and Cummings (1976). They note the dominant position of Nerlove's distributed lag model in explaining supply conduct and growing elasticities with decreasing importance of the product within the farm. At present, the dominant opinion is that small farmers will react positively to changing prices, but that the size of the reaction is constrained by the resources available to them.

The price-supply relationship for cassava in the Atlantic Coast region has never been measured, probably because of absence of time series. The only estimates of cassava supply elasticities in the literature have been made by Behrman (1968), who reports a short- as well as a long run price elasticity of 1.09 in Thailand; and by Pastore (1971), who estimates a value of 1.0 in Brazil. The lack of estimates of cassava supply elasticities is probably due to bad statistics and to the incorrect opinion that cassava is mainly produced for on-farm consumption.

Cassava producers and price instability

Similar to the discussion on the price-responsiveness of small farmers, the impact of price instability has been a theme of considerable study among economists. Two aspects of the instability of prices deserve attention. The first aspect is the reaction of producers towards price instability. The second aspect is the welfare effect of price instability.

With regard to the first aspect, empirical studies on the effect of price variability conclude that it is inversely related to the observed supply in the market (Behrman, 1968 and Just, 1975). Risk aversion causes decreases in production intensities from the optimum level in case of uncertain price or demand perspectives, as was proven theoretically by Sandmo (1971) and Leland (1972). A question which was not resolved by the last two authors is where price or demand uncertainty comes from.

The negative causality of production on prices has been observed in the literature on welfare effects of price stabilization. Here it is often stated that the farmer does not face much income risk, since prices tend to move in the opposite direction from supplies (Robinson, 1975 or Newbery and Stiglitz, 1979). From a welfare point of view, stable prices are of doubtful value for consumers (Shalit, 1984) or producers (Turnovsky, 1974) depending on the source of instability. Nevertheless, most stabilization analyses only consider the welfare effect of stable prices but do not study the simultaneous impact of changing income risk on production intensity. Bigman (1982) makes a simulation analysis of the effect of price stabilization for an unnamed large country. In this analysis he does consider the supply shift that results from more secure market perspectives. He suggests that price instability is caused by production instability. In that case there is no evidence that price stabilization will decrease the income risk of the farmer, and it is unsure whether price stabilization will have a positive effect on supply.

It appears that the literature on price uncertainty does not integrate the supply reactions of risk-averse farmers and the welfare effects. Where the reaction to price uncertainty is considered, the source of the uncertainty is often undefined and the welfare effects are not taken into account. Where the welfare effect of price stabilization is measured, the supply reaction is not taken into account. Newbery and Stiglitz (1979) define at what time a rational farmer should react positively to price stabilization, concluding that if price stabilization increases welfare, it also increases supply. They do not, however, measure the simultaneous effect in an empirical analysis.

In the Atlantic Coast region price risk for cassava is a common and frequently mentioned problem (Doorman, 1982; Boering, 1984; and Borren, 1984), but the problem has not been studied in any detail. To study the effect of price risk on cassava production, one has to define how production and price variability interact at the level of the individual farmer, and how the different market improvement programs change this interaction. Certainly in the case of cassava drying, considerable price stabilization will occur through the linkage of the dried cassava price with the government supported grain prices.

3.5 Issues in the analysis of cassava trading and processing

Cassava trading in the study region can be categorized according to the final consumption purpose. At present, fresh cassava trading is most important. Some production is sold for starch, but in a limited market with little growth potential. Dried cassava processing and marketing appears to have a promising future in the area.

The natures of fresh and dried cassava differ greatly, and these differences strongly influence the actual patterns of commercialization. Fresh cassava trade is carried on by a number of traders each of whom performs different functions in the marketing process. Within this study three types of traders are distinguished: rural assembly agents (traders who buy cassava from farmers and sell to another trader), wholesalers (traders who buy from traders and sell to traders, institutional buyers, or industry) and retailers (traders who sell to the final consumer). For many of these traders cassava forms an important part of their income. Their relative strength in the marketing channel is determined by how they perform their marketing functions.

Dried cassava trade resembles grain trade. The product is easily stored and the volumes traded and transported are larger than for fresh cassava. Farmers sell cassava directly to the drying plant and drying plants sell directly to animal feed producers. The marketing channel is short and does not contain intermediaries.

The analysis of the cassava marketing channels can be based on the criteria used in analyzing market structure and conduct. Identification of the nature of the product is critical to understanding market structure and conduct.

The relationship between cassava characteristics and its marketing channel

Most marketing channel analyses in developing countries treat grains (see Harriss, 1979). The storage quality of grains and their high value per volume influence the functioning of grain markets. Arbitrage over space and time are important characteristics of grain marketing channels. For bulky products such as cassava, however, few studies have been reported. Southworth et. al. (1979) report a study for yam in West Africa, and Harrison et.al (1974) treat cassava in one group together with fruits, vegetables, potato and plantain. Both report highly complex marketing systems, difficult to understand at first view. Harrison et.al. (1974) mention the dominance of small firms, frequent and small transactions, low levels of quality control and high margins with low returns.

Cassava has some other characteristics that influence its marketing. Its production costs are low, since it hardly needs inputs and grows where other crops can barely survive. The crop can be stored in the ground over a relatively long period without losing its quality. Once harvested it deteriorates within three days. Contrary to the grains, fresh cassava is stored outside the marketing channel and is not strongly influenced by specific harvest periods. Seasonal prices should not reflect increasing storage costs as in the case of grains, but market organization and marketing margins will reflect the pressure to transfer the product rapidly to the final consumer. The inability to store the product within the marketing channel will prohibit short-term price stabilization. Fresh cassava is more appropriate for the rural areas, where production cost advantages outweigh marketing problems. On the other hand, dried cassava, which shares a lot of characteristics with grains, will have a market structure comparable to them. To obtain these more favorable trade characteristics, the fresh product has to be assembled to be sent to the plants to be dried afterwards. Cost and efficiency of assembly and processing should therefore be analyzed.

Structure and conduct of cassava trade

Structure and conduct characteristics generally concern one market at a time, treated in isolation (de Morree, 1985; de Haan, 1985). Fresh cassava trading in the Atlantic Coast of Colombia involves various trader types who distribute cassava to different areas. The fresh cassava marketing channel consists of a number of markets that are sequentially integrated, but often spatially separated. A systems approach to the study of the cassava economy of the Atlantic Coast region recognizes the fact that these markets have to be studied simultaneously: that is, the performance of the cassava marketing channel is not determined by the structure and conduct of the market at one level or at one place, but by the interactions between different levels and different places.

To analyze the fresh cassava marketing channel, the function of distribution needs extra attention. Distribution of cassava to different areas takes place at very different costs and the performance of the marketing channel cannot be considered to be equal in all areas.

The coordination mechanisms between different traders form an important characteristic of the behavior of the marketing channels. In administered marketing channels, coordination is arranged from a central point. In a non-administered marketing channel this is not the case, and detailed analysis on the quality of supply and demand coordination is therefore essential for forming a reliable judgment of the behavior of the marketing channel.

The performance of the marketing channel depends on the effective distribution and coordination of marketing functions and market power. To evaluate this performance it is necessary to analyze different market levels simultaneously and to identify coordination mechanisms between traders in order to arrive at well-established conclusions on the total marketing channel.

3.6 Issues in the analysis of cassava consumption

Consumer behavior can be studied from two focal points. One method of analysis involves the use of economic parameters. These studies focus on the role of price, income, and (possibly) degree of urbanization. Consumer budget surveys and time series analyses are examples of this type of analysis. The popularity of these methods for demand analyses in developing countries has been high, and numerous studies appeared that take one of these approaches (see Pinstrup-Andersen et.al. 1976, or Raj, 1972 for consumer budget surveys; Janssen, 1981 for time series analysis). A second way of analyzing is behavioral(e.g. Engel and Blackwell, 1982 for consumer behavior; or Sheth, 1973 for industrial buyer behavior). Applications of this approach to food consumption in developing countries are rare.

In this study, fresh cassava for human consumption and dried cassava for animal feed are the most important consumption segments. These segments have very different characteristics and their most important features will be discussed below.

Dried cassava consumption

Dried cassava consumption can be analyzed with Sheth's (1973) industrial buyer behavior model. Expectations regarding the product form a decisive element in this model. Product quality, delivery time, quantity of supply, and price, each influence the final expectation. In the animal feed industry expectations regarding raw material focus on the nutritional value of the product. The relationship between prices and nutrients can be evaluated precisely in minimum-cost feed mix models. Since raw material costs are about 85 % of total costs of the industry (FEDERAL, 1984), the price-nutrient relationship will dominate the formation of expectations.

In Sheth's model the expectations regarding the product, plus the so-called product, and company-specific factors, interact in a decision-making process in which various people participate. As far as product-specific factors are concerned, dried cassava is not more risky than other products; nor does it form a special type of purchase, or involve time pressure. Regarding company-specific factors, the Colombian feed industry has always faced great supply problems (FEDERAL, 1984) and is strongly oriented towards securing its supply.

The dried cassava market operates on rational, economic considerations because raw material prices largely determine the demand for a certain product. Availability throughout the year, handling costs in the mixing process, and product quality will have additional effects on demand. The orientation of the feed industry towards guaranteeing its supply suggests high competition for raw materials within the limits of the price-nutrient relationship and possible forward contracting of supply. The dominant position of the price implies that the analysis of dried cassava demand can be made largely in traditional economic terms.

Fresh cassava consumption

For fresh cassava consumption, traditional economic terms also play an important role. Poor consumers make consumption decisions on the basis of price and income. However, those decisions will be strongly influenced by additional, not a priori defined factors. For example, Branson and Norvell (1983) mention ten motives that guide consumers' behavior toward agricultural products, such as: taste and preference, health , saving time, saving money, information, entertainment, dependability and the desire to experience change. It is critical to understand the importance of each different motive regarding fresh cassava consumption; and its analysis should emphasize social as well as economic factors.

Fresh cassava consumption is a low-involvement decision-making process (Figure 3.2, Engel and Blackwell, 1982). The decision to consume cassava is not perceived as being a risky one (affecting the self-concept of people or creating anxiety as a result of consumption). In such a case the decision-making process is simple: on the basis of available information, problem recognition takes place; a choice is made and afterwards evaluated; the evaluation feeds the beliefs and attitudes with regard to the product consumed; these beliefs and attitudes define the intentions to consume the product again.

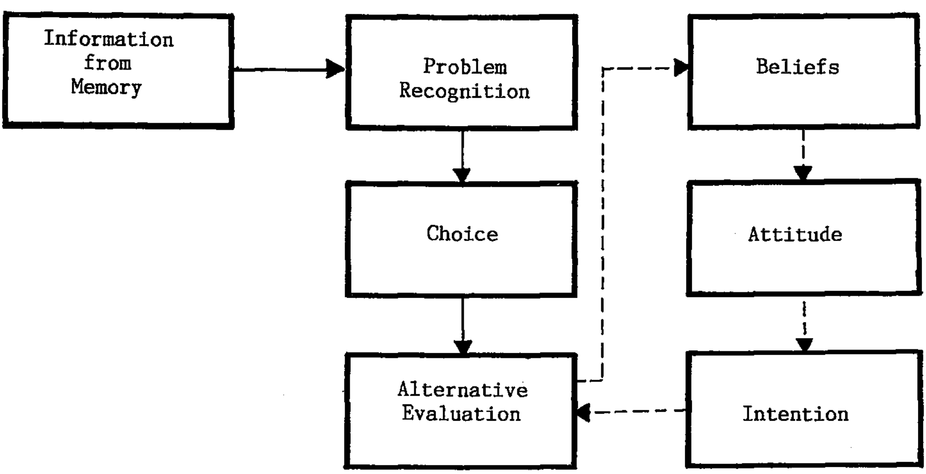


Figure 3.2 The low-involvement decision-making process according to Engel and Blackwell.

The beliefs and attitudes of consumers regarding cassava are formed by their experience with it, and these formed attitudes then influence future consumption. Attitude measurement can strongly increase the understanding of the consumption process. First, it indicates consumers' appreciation of certain product characteristics. Secondly, in line with the model of Lancaster (Ratchford, 1975) attitude measurement allows to measure the value of the product to the consumer, as expressed in its consumption.

Attitudes measured depend on consumer characteristics on the one hand and product characteristics on the other. Explanation of consumption through the attitudes would allow to relate consumption with specific consumer and product characteristics. In this way the effect on consumption of changes in the consumer population and of changes in product characteristics can be estimated.

Fresh cassava consumption should integrate traditional economic factors with a behavioral approach. Since cassava consumption is a routine decision process, knowledge of the attitudes towards the crop will improve the understanding of present consumption and the effect of changing storage characteristics on future consumption.

3.7 Interactions in the cassava system

The cassava system can be divided into three subgroups: producers, traders and processors, and consumers. Interactions exist between producers and traders, between producers and consumers and between traders and consumers, and these interactions are essential to an understanding of the dynamic behavior of the whole cassava system. Market penetration or market development will have an effect on the interaction between the different groups and this can be studied by considering the different marketing functions. The effect of market penetration or market development will not be equally strong on all different market functions. It is expected that the credit and grading and sorting functions are not strongly influenced; nor will long-term storage or quality control be strongly influenced. However in the case of cassava market penetration through improved storage capability, the short-term storage function will change and consequently the assembly and distribution function may change. In the case of market development through cassava drying, the price formation and stabilization as well as the price-risk absorption will be altered.

An important interaction between producers and traders is through the producers' cassava sales. Marketing strategies of small farmers for selling and of traders for buying should be studied. The risky nature of cassava trading suggests that strategies will be directed towards diminishing or sharing market risk.

The main reason for the price variability of fresh cassava is the restricted and isolated market that it faces. Although improved storage could increase the transportation time and therefore the distance to the market, the costs for transporting cassava outside the region will be prohibitive due to cassava's bulky nature. Fresh cassava storage will not eliminate weather variability or break the isolation of the market, so the impact on price stability will be low. For the agricultural trader fresh cassava storage will decrease risks, because the need to sell quickly will become less important. As long as there is competition, the decrease in risk for the cassava trader will then result in a lower marketing margin.

The dried cassava market will have a strong impact on the market risk for the producer. The price for dried cassava is dependent on the price for sorghum, the dominant animal feed raw material. Government price support for this feed grain gives it a price stability greater than that for fresh cassava. Through the linkage with the sorghum price, cassava prices could be stabilized and market risk for the farmer diminished. Stabilization of cassava prices would increase the attractiveness of the crop and might stimulate production.

For many producers cassava plays an important role for on-farm consumption. On-farm consumption can be divided into two categories: human consumption and animal consumption. Commercial quality cassava roots are generally reserved for people, while animals are fed the roots too thin or small to be sold. It is important to understand how on-farm consumption influences the decision to sell or produce cassava.

Traders and consumers meet in the purchasing process of the consumer. Purchasing habits differ considerably between fresh and dried cassava consumers. The bad storage quality of the fresh product forces the consumer to purchase his cassava no longer than a day before consumption. To facilitate this, many retailers are selling small amounts of cassava to the consumer through a well-developed network. Improving the storage life of cassava will allow the consumer to decrease his purchasing effort, making the product more attractive and potentially increasing consumption levels.

The nature of dried cassava trading is dictated by the rules and norms for trade of other animal feed raw materials as determined by the consumption patterns of the animal feed industry. Supply is arranged at several weeks notice in order to manage storage capacity; prices are arranged over longer periods and quality control takes place on a sample basis in the laboratory. The consumption of dried cassava is also critically dependent on the processing capacity of the incipient drying industry.

3.8 The integrated analysis of the cassava system

The integrated analysis of the cassava system is executed with a simulation model. In this model the major points of analysis and interaction of the different subsystems should be properly included. The following requirements were formulated:

-Cassava production has to be related with the role of cassava within the farm and with the farmers' reaction to changing prices and to changing market risk situations. The model should express the yearly cassava production variability.

-The modeling of cassava marketing should take into account the perishable nature of the crop.

-The modeling of cassava consumption has to reflect the decision-making process of dried or fresh cassava consumers. For dried cassava the decisions will be led by economic parameters, especially relative prices. For fresh cassava the attitudes towards the product should be included.

-The model should be able to describe the effects of changes in one stage of the marketing channel on the other stages. The implications should be made specific for different producer or consumer segments.

-The simulation model should predict the effects of the proposed market improvement strategies on the different subsystems and on the total Atlantic Coast cassava system. The growth of the cassava drying industry, the realized dried cassava consumption, and cassava production are mutually interdependent. The interdependence should be expressed by relating the growth of the drying industry with supply and demand conditions.

-Major exogenous variables should be included for prediction about future performance of the cassava system. If exogenous variables are hard to predict, alternative assumptions on their development should be evaluated.

-The simulation model has to elucidate how the proposed market improvement strategies would contribute to the development of the agricultural sector.

The parameters for the simulation model define to a large extent its specification. The ex-ante nature, the expression of the year-to-year production variability, and the need to describe the future development of the cassava industry demand a multi-year horizon. The model was written in FORTRAN, a readily available and relatively easy to learn, computer language. (Dent and Blackie, 1979). A last decision is on the mathematical representation of the behavior of the subgroups. It was decided that linear equations for their behavior was appropriate. Three reasons influenced the decision: linear specifications simplify the transformation of the model from its structural form (the actual expression of the behavior of the sub-systems) to its reduced form (the algorithm that guides the simulation process);

the use of more sophisticated specifications is not justified by the quality of the data while the robustness of the equations is little affected because of the limited degree of extrapolation; and, where more sophisticated specifications were used (e.g. double logarithmic), these did not improve the quality of the estimations.

3.9 Data collection

Four factors determined data collection: First, the study had to cover the complete marketing channel. Second, a virtual absence of reliable time series and other statistical sources existed (only one set of acceptably reliable time series was found, regarding retail prices of cassava and other staple foods in the major urban centers of the Atlantic Coast region). Third, the lack of general information did not permit a streamlining of the quantity of issues to be studied. Fourth, the region was too large to be covered satisfactorily with the resources available for this study.

This last problem was alleviated by limiting the research area to the Coastal departments west of the Rio Magdalena, an area of around 65000 square kilometers. This still massive area was reduced by concentrating production research in the zones where the DRI-program is working. These are the zones where small farmers are concentrated and registered. Although it created a bias to farmers who have better access to credit or extension, it facilitated the survey procedures and also helped the DRI-program in planning further developments in these zones.

In order to obtain statistically reliable and representative data on the different subsystems throughout the Atlantic Coast region, it was decided to execute relatively large surveys with broad geographical coverage on a non-repetitive base. Table 3.1 shows the main characteristics of the different surveys conducted.

The absence of general information was alleviated by conducting a reconnaissance survey on cassava production and marketing in the selected zones (Table 3.1.A). In this survey some 60

Table 3.1. Main characteristics of the executed surveys

Survey	Number of interviews	Way of sampling	Geographical Coverage	Date (months/year)	Execution by:
A: Reconnaissance Survey	60	Identification of key informants	Atlantic Coast region west of Magdalena River	9-12/82	Author
B: Production and Farm Marketing Survey	400	Cluster-approach to select villages and hamlets, random within the hamlet	DRI-municipalities in the Atlantic Coast region	3-6/83	Author and extension agents
C: Market Risk Survey	190	Stratification according to market-urbanization to select municipalities, random selection of hamlets and farms within hamlets	8 DRI municipalities spread through the Atlantic Coast region	3-4/85	4 Trained interviewers
D: Cassava Marketing Channel Surveys					
Assembly Agents	140	Stratification according to market-access and cassava production systems to select villages, complete sample within the village	8 DRI municipalities spread through the region	8-11/83	5 Trained interviewers
Wholesalers	110	Stratification according to degree of urbanization to select towns and villages, complete sample within the village or town	12 municipalities spread through the region	8-11/83	5 Trained interviewers
Retailers	250	Stratification according to degree of urbanization to select towns and villages, random selection of neighborhoods and retailers	12 municipalities spread through the region	8-11/83	5 Trained interviewers
E: Cassava Human Consumption Surveys					
On-farm Consumption	160	Stratification according to market access of villages, random selection of hamlets and farms	8 municipalities spread through the region	8-11/83	5 Trained interviewers
Consumption by Purchasers	320	Stratification according to urbanization degree to select villages and towns, random selection of neighborhoods and respondents within village or town	12 municipalities spread through the region	8-11/82	5 Trained interviewers
F: Dried Cassava Consumption Survey	60	Mailed survey to all balanced feed producers and to half the population of integrated poultry and pig producers	Complete country	9-12/84	Author and statistical assistant

interviews were held with people that were considered to be knowledgeable about the area. On the basis of this information the importance of cassava in the different zones and departments could be determined, and a first profile of cassava in the Atlantic Coast region drawn up.

The reconnaissance survey was refined with a descriptive production and farm marketing survey for cassava (Table 3.1.B). The author held some 80 detailed interviews with farmers on the role of cassava in the farm system and on their sales habits. These interviews were supplemented with 320 more general interviews that were executed by officials of the DRI-program. Respondent farmers were selected from the registration lists of the DRI-program. This procedure created a bias towards farmers that receive more government attention, but was inexpensive, and focused effectively on the small farmer.

The importance of market risk became obvious in these surveys and it was decided to supplement the descriptive survey with a market risk survey (Table 3.1.C). Four zones that were appropriately representative of the existing market situations were selected; within each zone fifteen hamlets were randomly selected; and in each hamlet three or four interviews were conducted, for a total of two hundred interviews.

To study cassava marketing channels, assembly agents, wholesalers, and retailers were interviewed (Table 3.1.D). Since the study had to cover rural and urban cassava marketing, four areas that could represent the rural-urban spectrum were selected. Each area included one major urban center, one minor urban center, and one village. Interviews of all the functioning assembly agents, all the functioning wholesalers, and a selection of retailers (eighty per zone) were attempted in each area. Only in Barranquilla was it not possible to interview all functioning cassava wholesalers. In total around five hundred cassava traders were interviewed. The cross-section information from the marketing questionnaires was supplemented with a time series analysis of the retail prices for cassava and other starchy staples. Additionally, a feasibility study on the costs of cassava drying was carried out.

Consumption surveys were administered concurrently and in the same zones as the marketing surveys (Table 3.1.E). On the basis of the available socio-economic indicators, neigborhoods were selected in the different towns and villages. Within these neighborhoods streets were selected and in each street one interview was held. In each of the four zones, eighty interviews with cassava-purchasing households were held. A comparison with national survey data of 1981 indicates the sample is acceptably representative, except that it is inclined towards households where the housewife is at home and the family size bigger than average. In each zone forty interviews on cassava consumption were held with households that produce their own cassava. To accomplish this, eight hamlets were chosen from each zone. The interviewer was instructed to select one household in the center of each hamlet and one household in each one of the north, east, south, and west corners of the hamlet. Since within most hamlets household characteristics do not vary strongly, the procedure was considered appropriate. In total, 480 interviews on cassava consumption were done.

Dried cassava is a storable product with a better value-volume ratio than fresh cassava. Its consumption can extent beyond the the Atlantic Coast region. Dried cassava demand was measured through a mailed survey (Table 3.1.F) for three reasons. First, given the high motivation of the Colombian feed industry to assure feed supply, it was expected that the response to a mailed survey would be good. Second, the different industries are spread throughout the country and personal coverage would have been time-consuming and expensive. Third, with a mailed survey the engaged companies could discuss the questions among the different decision-makers involved. Mailing lists were compiled from industry associations' member lists, yellow pages, and registers from the Chamber of Commerce. All possible compound feed producers plus half the number of integrated egg, poultry, and pig producers were included. One hundred and fifty interviews were sent and 60 were returned. The survey answers cover about 80% of the total compound feed industry capacity.

Three case studies were elaborated to explain cassava production and marketing in more detail. The first case study was on the interaction between cassava cultivation and cattle holding in the small farm. A second case study tried to identify the impact of land and labor markets on cassava production. The last case study analyzed the perspectives of sorghum production versus dried cassava production to determine product competition in the raw material market and the national economic attractiveness of cassava drying.

The issues of analysis, the interaction between subgroups, and the methods for data collection are shown in Table 3.2. The following three chapters will be devoted to the analysis of producers, traders, and processors and consumers. Afterwards Chapter 7 will demonstrate the integrated analysis of the cassava market system by means of a simulation model.

Table 3.2. Methodological development of the study of the Atlantic Coast Cassava System.

	RESEARCH AREAS	RESEARCH ISSUES	INFORMATION SOURCES 2/	TYPE OF ANALYSIS 1/
1) Subsystems	A) Cassava Production	(1) Role of cassava in farm system	Production and farm marketing survey (1)	Analysis of risk and price impact on supply within farm systems context (1, 2, 3)
		(2) Price reaction	Market risk survey (2, 3)	
		(3) Market risk reaction	Case studies (1, 2, 3)	
	B) Cassava marketing	(4) Impact of product characteristics on cassava marketing	Market agents survey (4, 5)	Structure conduct analysis, special attention for ability to change and coordination mechanisms (4, 5, 6)
		(5) Structure and conduct description	Retail price time series (4, 5)	
		(6) Processing-costs calculations	Processing feasibility study (6)	
	C) Cassava consumption	(7) Industrial consumption of dried cassava	Dried cassava demand survey (7)	Economic demand analysis (7)
		(8a) Fresh cassava consumption by producing families	Cassava consumption surveys * purchasers (8b)	Mixed economic-behavioral demand analysis (8)
		(8b) Fresh cassava consumption by purchasing families	* producers (8a) - Case studies (8a)	
2) Interactions	A) Production-Marketing	(9) Farmers marketing strategies	Production and farm marketing survey (9)	Supply-shift estimation (10, 11)
		(10) Price stabilization	Market risk survey (10, 11)	
		(11) Dried cassava capacity	Case studies (9, 10, 11)	
	B) Production-Consumption	(12) Relation between production and consumption	Cassava consumption survey among producers (12) Case studies (12) Production and farm marketing surveys (12)	
	C) Marketing-Consumption	(13) Fresh cassava purchasing behavior and market supply	- Cassava consumption survey * purchasers (13)	Demand shift estimation (13, 14)
		(14a) Dried cassava purchasing behavior	- Dried cassava demand survey (14a)	
		(14b) Dried cassava capacity	- Case studies (14b) - Retailers survey (13)	
3) Integrated system analysis	A) Evaluation of performance of the system under different conditions	(15) Measurement of systems contribution to agricultural development goals	- Simulation model (15, 16)	- Modeling (15, 16)
		(16) Conditions for equilibrium of the cassava system		

1/ Although not mentioned, descriptive analysis forms an important additional type of analysis in most of the described research areas.

2/ Reconnaissance survey and available secondary sources are not mentioned for reasons of brevity.

Chapter 4: CASSAVA PRODUCTION AND SUPPLY IN THE ATLANTIC COAST REGION

4.1 The role of cassava within the small farm

Cassava provides 35% of the total income received from agricultural activities that take place on the small farms of the Atlantic Coast region of Colombia. The current and potential role of cassava in these farms is tightly interwoven with the roles of other crops, cropping patterns, and, most importantly, cattle holding. Studies of the value of cassava in this region must begin with an examination of the merits of cropping versus livestock holding for the small farmer, to understand what parameters a farmer uses when deciding how best to exploit his limited land resources.

Land use within the small farm

Land use is strongly influenced by the land tenancy situation of cassava farmers. Land which is insecure because of short-term tenancy (one-year renting) will mostly be used for cropping purposes, whereas land in a secure tenancy form can be used for cropping as well as for cattle holding. Tenancy differs considerably between farms of different sizes: most smaller farms are on rented land, while the large farmers tend to own their land (Table 4.1). Two conclusions follow from this observation. First, small farms will be directed almost completely towards crop production, as the insecurity of their land access prohibits cattle exploitation. Second, the flexibility of the small farms to increase or decrease cultivation is determined by the land-rental market. Within the larger farm, substitution of farm activities is less constrained and will be most strongly determined by the attractiveness of cassava and other crops versus cattle.

Data from Table 4.2 confirm that small farms are almost completely directed towards crop production. In the department

Table 4.1. Land tenancy in farms of different sizes in the Atlantic Coast region, 1983.

Farm size (ha)	0-3	3-5	5-10	10-20
Average size (ha)	2.36	4.35	7.86	14.62
% Land assigned or in property	20	33	58	70
% Land rented	69	53	31	14
% Land in other tenancy forms	11	14	11	16
Average number of tenancy forms per farm	1.2	1.15	1.36	1.21
Sample size	95	74	132	103

Source: Production and farm marketing survey, 1983 (Table 3.1).

where the average sample farm size was lowest, the percentage of land dedicated to agriculture was highest. Table 4.2 also indicates that fallow land has considerable importance in the region, as even within the small farm 20% of the land is always in fallow. The fallow system maintains soil fertility and helps to explain the virtual absence of fertilizer use in the region. Rotational systems are not very important, except for the maintenance of pasture systems. Fifty-nine percent of the pasture land was brought into pastures less than ten years ago, having been planted with crops previously. The relatively short establishment of most of the pasture land, and the importance of crops as the preceding activity tend to indicate the importance of the crop-pasture rotation for improving pasture quality. Data from a case study in San Juan de Betulia confirm the importance of this rotational system, which seems to become increasingly essential when land use is more intensive. Data from Table 4.2 also show that the area planted per farm with cassava does not vary strongly in the different departments. Given that cassava's importance rises with decreasing farm size, however, its relative

Table 4.2. Land utilization in small farms in different departments of the Atlantic Coast region, 1983.

Department	Atlantico	Bolivar	Cordoba	Sucre
Farm size (ha)	6.1	11.2	9.7	7.4
% farms with crop land	100	100	100	100
Land under crops (ha)	2.7	3.3	3.3	2.8
Area under crops in cassava (ha)	2.0	1.7	2.1	1.5
Area under crops in maize (ha)	2.6	3.1	3.1	2.5
% farms with pasture land	50	42.4	74.8	66.4
Area in pastures (ha)	2.2	3.7	4.5	3.9
Number of cows	1.5	1.6	4.2	3.4
Liters of milk/day	5.9	4.8	10.9	9.0
% farms with land in fallow	46	58	58	31
Area in fallow (ha)	1.2	4.1	1.8	0.7
Sample size	60	65	153	134

Source: Production and farm marketing survey, 1983 (Table 3.1).

value is highest in the department of Atlantico, which hosts the smallest farms in the region.

Cassava is rarely cultivated alone in the Atlantic Coast. Most often it is intercropped with yam and maize (40% of the time) or with maize alone (about 25% of the time). At present cassava monoculture is a second best alternative, which is practiced only if intercropping is not possible because of credit shortages. Table 4.3 shows that plots cropped only with cassava were smaller, less often financed with official bank credit, more often prepared by hand instead of by tractor, and yielded less economic return, than intercropping systems. Intercropping

Table 4.3. Characteristics of cassava monoculture and cassava intercropping systems in the Atlantic Coast region, 1983.

	Cassava monoculture	Cassava intercropping
Plot size (ha)	1.3	1.7
% of cultivated area in cropping system	5	50
% of area in cropping system prepared by tractor	33	44
% of area financed	34	71
Realized yield in last year 1/ (tons/ha)	5.1	4.0
Number of observed plots	42	355

Source: Production and farm marketing survey, 1983. (Table 3.1).

1/ This applies to 1982/1983 which was a production season with very low yields.

reduces risks, provides a higher income per hectare of land, and consequently, frees more of the land for pastures and cattle.

The most important secondary crops planted in the small farms of the Atlantic Coast are maize and yam, with plantain and tobacco being important in specific ecological zones. Cassava, maize, and yam and/or cattle holding dominate the land put to agriculture in this region. Cattle holding is an extensive activity as can be seen by the numbers of animals that are grazing and by the milk production that results (Table 4.2), and the final gross income per hectare of cattle stays far below the gross income per hectare of crops. Transferring land from cattle exploitation to crops could improve the income potential of small farms.

Labor use in the small farm in the Atlantic Coast region

The average number of persons living on a small farm unit in the Atlantic Coast region is slightly below seven. Four hundred days of agricultural employment per year exists for these seven persons, implying that an even distribution of the labor needs would supply one and a half man-years of employment (Table 4.4). Besides the on-farm employment, members of the farm household find employment outside the farm, about 150 days of the year.

Table 4.4. Employment within the small farm system in different coastal departments, 1983.

	Atlantico	Bolivar	Cordoba	Sucre
Number of persons living on the farm	7.3	8.3	6.9	8.9
Employment within the farm (man-days)	336	403	442	483
Employment in cassava cultivation (man-days)	120	102	126	90
Employment per hectare (man-days/ha)	62	31	37	53
Employment off farm (man-days)	163	144	63	124
Income from off farm (US-dollars/year)	678	571	218	477
% of families with off farm employment	70	68	55	44
Occupation degree 1/ of the household	0.20	0.26	0.28	0.26
Number of observations	20	16	20	25

Source: Production and farm marketing survey, 1983 (Table 3.1).

1/ Occupation degree = $\frac{\text{total employment in man-days}}{\text{family size * 260}}$

This off-farm employment only involves half the families, however, with the other families totally reliant on the farm for employment. Cassava cultivation takes some 70 man-days per hectare, but in mixed cropping the total labor need per hectare easily rises to 120 man-days. Cassava cultivation creates 25 to 30 % of the total employment within the farm. The remuneration per day of labor spent in cassava cultivation for an efficient farmer is between 10 and 12 dollars , more than two times the market wage. The labor needs for cassava, however, are concentrated around the April-July planting and weeding period, when day laborers are needed to complete the farm activities. Demand for day laborers is high in these months (Figure 4.1) and cassava cultivation is constrained by a farmer's ability to pay for labor. Although labor needs during the rest of the cropping season are smaller, most farm operators say that, from the end of the dry season in March to the beginning of the next dry season in November-December, they are occupied full time on their farms (Figure 4.1).

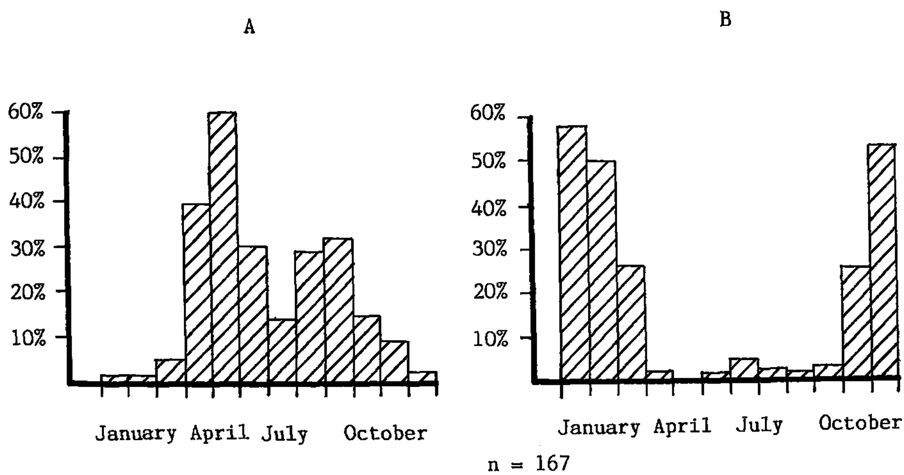


Figure 4.1

A: Percentage farmers that agrees to the statement that day laborers are difficult to contract in certain months.

B: Percentage farmers that agrees to the statement that they are not full time occupied on their own farm in certain months.

Source: Production and farm marketing survey, 1983.

Most cropping activities have a rather rigid labor pattern, concentrated in the rainy season. Cattle holding, on the other hand, has a flexible labor pattern and the cattle are usually cared for by in-house laborers, i.e. women and children. Although the relatively low labor need (30 man-days per hectare) in cattle holding would not make it an attractive option within farms where labor is abundant, its flexibility turns it into an attractive complementary activity within the farm. The return to the farmer per day of labor in cattle holding is some seven US dollars, still well above the current day wage rate of four dollars. Cassava cultivation is more labor-intensive and has a higher pay-off than cattle holding, but cattle holding can effectively employ surplus labor outside the cropping season. Small farms will tend to concentrate on cassava growing, but with growing farm size cattle holding will gain importance. Increasing cassava cultivation in farms having excess land depends to a large extent on the ability to overcome constraints in the labor peak of April and May. Labor needs could be decreased by the use of mechanization, but most mechanizable land is already prepared by tractor. The most feasible way then to decrease labor needs would be through chemical rather than manual weed control. A second way would be to shift to cropping systems needing less labor per hectare (e.g. from cassava/ maize/ yam to cassava monoculture). These cropping systems could then be planted in larger areas than the present cropping systems.

Capital within the small farm of the Atlantic Coast region

Three sources of financing are potentially available to farmers: official credit through banks or similar institutions; informal credit from other persons in the community or from traders; and, self-financing.

Bank loans for cassava cultivation are available, but many farmers have little access to this form of credit. Often the collateral is insufficient or the procedure to obtain credit is time demanding and costly. Many farmers state that the agricultural credit bank is not reliable. Agricultural credit is available at rates of 18 to 35% per year. The lower rates compare favorably with the yearly inflation of about 25%, but farmers complain that credit is expensive. The perceived distortion is caused by high inflation and the uncertainty of product prices at harvest moment. Around 36% of cassava production in the region is financed through bank loans.

In the Atlantic Coast region, informal credit is of little importance, except for short-term pre-harvest advances, or in the form of small loans to buy food.

Livestock plays an important role in the financing of cassava production. By selling an animal at the beginning of the production season a farmer will have the money available to finance one or possibly two hectares of agricultural production. Farmers who do not maintain cattle often have pigs to finance production. Livestock also serves to accumulate income through the purchase of new animals. Farmers do not trust banks, and prefer to put their money into cattle rather than into unattractive savings plans. Also, cattle accumulation means that the farmer always has his money on the hoof when he needs it.

The popularity of intercropping in this region is also relevant to self-financing, as multiple cropping systems include a crop that can be harvested after four months (maize or cowpea), which enables the farmer to recover most of his previous costs.

The poor credit and savings possibilities in the region underscore the interdependence of cattle and cropping. As long as borrowing and saving facilities are not improved, increases in small farm productivity should be simultaneously pursued in both areas. Increased productivity in cropping activities will then lead to more capital accumulation in cattle. In turn this will lead to increased land needs for livestock and diminish land availability for cropping purposes. The establishment of a reliable credit and saving facility could break the low productivity deadlock, caused by the need to save and finance through cattle. Such a facility should charge and pay interest rates that are realistic in comparison with the inflation rate and should have an efficient and low-cost withdrawal/deposit system. Ideally credit ceilings per farmer should be based on the savings made. Increasing trust in banking facilities would aid and augment agricultural productivity and income.

Utilization of farm produce

The small farmer in the Atlantic Coast region can be classified as a semi-subsistence farmer. For a number of products a marketable surplus will be produced, but the size of it depends on the needs for home consumption. The importance of home consumption in the farmers' production decisions is reflected in the diversity of production that he pursues. Most farmers will at least grow one bulky calorie staple, like cassava, yam, or plantain. Most farmers will also grow a grain crop, either maize, rice, or millet. Farmers with land resources above their needs for cropping activities will maintain cattle to assure a milk supply. Smaller farmers and renters who do not own cows, will try to grow a legume crop (either cowpeas or pigeon peas) to provide more protein. Finally many farmers have a small plot with a variety of fruit trees and some vegetables close to the house.

While commercial planting times are determined by the soils and climate regime of the zone, some non-commercial planting may take place at other times to assure continuous food supply for the family. Special plots, often with better water retention, are selected for this purpose. Since cassava can be stored in the ground longer than any other crop as long as the soil does not dry out, it is often the crop chosen for these special plots to insure a year round supply of calories to the farmer's family. Its drought resistance increases its importance in the diet in dry years when other crops fail to produce. In years with high rainfall and water logging, its importance decreases in relation with the cereal crops.

The importance of cassava in home consumption contrasts with the problems that many farmers face in selling their surplus. This can be illustrated by a comparison with maize marketing. Some maize is retained after the first as well as the second semester harvest, for human and animal consumption, and the rest is sold at stable prices, supported by the government. Maize is easier to sell than cassava. In Table 4.5 farmers are distinguished according to market access, as determined by the infrastructure of the areas surveyed, the distance to, and the size of, the urban markets available. Farmers with bad market access produced some forty percent less cassava and sold some sixty percent less than farmers with good market access. For these farmers cassava functions primarily as a subsistence crop. Maize production by these farmers is bigger than by farmers with good access to markets and maize sales diminish the difference in cash income. Because of low production in the year of interviewing, the problems of selling cassava were not strongly expressed in the

Table 4.5. Cassava and maize cultivation in areas with good and bad market access in the Atlantic Coast region, 1983.

	Good market access	Bad market access
Farm size (ha)	7.6	8.4
Cassava production per farm (tons)	8.3	5.1
Cassava on-farm consumption (tons)	2.3	2.8
Cassava sales (tons)	6.0	2.2
Cassava sales price (US-dollars/ton)	0.104	0.104
Income from cassava (US-dollars)	620	231
Maize production per farm (tons)	1.2	1.6
Maize on-farm consumption (tons)	0.5	0.5
Maize sales (tons)	0.7	1.1
Income from maize (US-dollars)	154	242
Sample size	179	156

Source: Production and farm marketing survey, 1983 (Table 3.1).

price received. In years with normal or good production, prices are bound to be lower in the areas with bad market access while the effort to find purchasers will be bigger.

Of the yam harvest some 500 to a 1000 kilograms are kept for planting material and a similar quantity for human consumption. The surplus is sold quickly after the harvest. Yam marketing is a risky activity because the limited market for the product causes prices to fluctuate strongly. Rice, when grown, is stored in the roof of the house, in a quantity sufficient to feed the family almost for a whole year. The remainder is sold at relatively stable prices.

If a small farmer has livestock he will always try to have at least one cow lactating. The three liters of milk per day that he obtains from one lactating cow contribute considerably to the protein supply of the family. Only when he has more than two cows lactating at the same moment will he feel secure enough to sell milk or fresh cheese. Finding buyers for the milk or cheese is normally very easy.

Farm production satisfies great parts of the food needs of the family through the year. Cassava's drought resistance and harvesting flexibility give it a special position in the consumption habits of the small farm, since it is consumed when other products are less available. In a similar sense cattle play an important role because they can provide an almost constant animal protein source in the form of milk or cheese. The small farmer in the Atlantic Coast region will try to earn a cash income with his agricultural activities, but only after his family's food needs are satisfied.

Cassava versus cattle in the small farm system

The role of cassava within the farm system is strongly complementary to the role of cattle. Any effort to improve the income of small farmers by cassava cultivation has to take into account the interactions with cattle production. Table 4.6 compares livestock holding on a number of criteria with cassava monoculture and cassava/ maize/ yam intercropping.

Table 4.6 The merits of cattle holding versus cassava intercropping versus cassava monoculture.

	Cattle holding	Cassava intercropping	Cassava monoculture
Profits per hectare	- 1/	+	±
Profits per day of labor	-	±	+
Need to contract labor	+	±	-
Financial costs per hectare	+	-	±
Cash-flow distribution	+	±	-
Capital-accumulation	+	-	-
Contribution to family nutrition	+	+	±
Production risk	+	±	±
Sales risk	+	±	-

1/ + = Activity has a favorable score on this criterion.
± = Activity has a neutral score on this criterion.
- = Activity has a negative score on this criterion.

Profitability per hectare is highest for cassava intercropping, wherein profits can rise to 700 US dollars per hectare. Cassava monoculture generates profits of about 400 dollars per hectare, while cattle only provides an income of some 130 dollars per hectare. Profitability per day of labor is highest for cassava monoculture which generates 11 dollars per day, while cassava intercropping produces 9 dollars per day and cattle 7 dollars per day. These profitability data imply that monoculture is probably most interesting for farmers with limited labor availability, while intercropping is most interesting for the ones with limited land. From a profitability point of view, cattle is not very attractive. Cropping activities form the major income source of the farm system.

Contracting labor is of least importance for cattle holding followed by intercropped cassava and cassava monoculture.

Respectively 2%, 37%, and 60% of the needed labor has to be contracted. Partly because of the costs of contracting labor, the financial costs of cattle are lower than those for inter- or monocropped cassava. This is also due to the costs of land preparation and occasional input use in the cropping systems.

The cash flow that results from cattle holding is very favorable. Milk forms an income source during most of the year, while animals can be sold off when necessary. Cassava intercropping requires major expenditures in the beginning of the cropping season and generates income at the harvest time of the different crops. Since the maize income compensates for most of the expenditures for planting and weeding, the cash flow of the intercrop is negative only during four months. On the other hand, cassava monoculture has a negative cash flow until the moment of harvesting, 8 to 12 months after planting.

Cattle holding is important for the accumulation of capital, as well as being an important source of financing. Neither cassava intercropping nor monoculture fulfill this function.

The contribution of cattle to the adequate nutrition of the family members is considerable, as is the case for the intercropping system. Cattle provides milk, while the intercrop provides cassava, yam, and maize. Cassava monoculture only produces one product that plays a role in the family diet.

Production and marketing risks are very important criteria for the small farmer to determine farm organization. Production risk is very low for cattle. The risk is acceptable for monocultured cassava, since the drought resistance of cassava permits an economic yield in almost any circumstances. In intercropping, the production risk of cassava is low again, but the risk for maize and yam are considerably higher. Maize can be badly affected by drought in the flowering period, in which case its economic yield might be nil. Yam is sensitive to many diseases and does not tolerate low soil humidity. Within the intercrop, cassava plays an important role as a compensator for the production risks of the other products.

Marketing risk for cattle is low as well. Cattle markets in the Atlantic Coast region are well-organized and supply beef to the rest of the country. The high value of the animals decreases the importance of transport costs. For maize, the government supported price and the large demand in the center of the country assure easy sales. For yam, market perspectives are unstable because of the limited market size. Cassava markets are also very unstable. Price variability is large, and for those farmers living far from the markets, transport costs in years with bad prices can be prohibitive. The intercrop combines one securely marketable crop with two insecure crops to reduce overall market risk. In cassava monoculture, there is no such way to avoid market risk. The problems of selling cassava underscore the advisability of growing it with other crops.

Growing more cassava to improve small farmers' income would mean an intensification of the farm system and higher labor needs. In this case one would expect a shift from the intercrop to monoculture since in this system the amount of labor needed per hectare is lower and the remuneration higher. The larger amount of hired labor and the higher market risk for cassava monoculture imply that increasing the role of cassava in the income of the farmer depends strongly on guaranteeing adequate financing of production and on improving its marketing possibilities.

4.2 Farmers' cassava marketing strategies in the Atlantic Coast region

Since cassava does not have a strict maturation period, it can be harvested and marketed throughout most of the year. On the other hand, once harvested the product becomes inedible within three days. The product has to be marketed quickly to reach the consumer in acceptable conditions, especially for fresh consumption. The marketing channel for cassava is adapted to these characteristics. Post-harvest storage does not take place, but the urban markets are continuously supplied by different production zones in different periods of the year. Cassava is harvested in most cases only after an agreement with a buyer has been reached.

As shown in Table 4.7, more than seventy percent of the farmers arranged their sales transactions before harvesting. When the arrangements with the trader are finalized, the trader gives sacks to the farmer for cassava packing. For the farmer this is the equivalent of a guarantee on his sales, but increases the costs of cassava marketing, since he spends considerable time and travel in making the arrangements. Most farmers have had problems, at least once, in finding a buyer for their saleable cassava. A small number of farmers retails their cassava in the village or town close to where they are living.

Sales periods differ between the departments. Cassava from Sucre and Atlantico must be sold before or during the dry season (December to March), as the soils of these regions are too sandy and arid to permit in-ground dry season storage. In the surveyed areas of Bolivar and Cordoba water retention was often better and cassava quality stayed acceptable through the dry season. Since prices rise outside the dry season, this often implies a premium price for farmers from these areas.

In Atlantico and Bolivar the farmer is responsible for transporting the cassava to the market place, often on donkey or by rented jeep, whereas in Sucre and Cordoba it is more common for a rural assembly agent to pick up the cassava on the farm. The quantities sold at a time are small, on the average less than a thousand kilograms. Cassava farmers prefer to sell small quantities as they are easier to transport, and cash flow is distributed throughout the year. Moreover, this sales spread reduces the effect of rapid price fluctuations and diminishes the sales risk.

Most cassava is paid for at the moment of the transaction. In some cases the farmer advances the cassava until the trader has sold and is able to pay. In other cases the harvest is bought in advance by the trader, in order to assure supply. Production credit is only rarely part of the transaction. Most farmers state that their primary reason for selling cassava at a specific moment is money shortage. A secondary reason was that the land was needed, either to return it to the owner or to plant again.

Table 4.7 Characteristics of farmers marketing their cassava, 1983.

	Atlantico	Bolivar	Cordoba	Sucre
% farmers that arranges sales before harvesting	81	62	79	64
% farmers that (at one or more times) tried to sell but could not find a buyer	60	42	61	64
% farmers that retailed cassava	-	-	7	7
Major sales period	October to December	March to June	June to September	October to January
% farmers that sells cassava:				
In the farm	35	33	54	58
In rural market	43	39	19	28
In regional market	22	28	27	14
Average transaction size (kg)	700	579	1712	342
% farmers that is paid:				
Cash	69	86	86	77
After the trader has sold	15	3	11	9
Before he harvests	8	8	3	12
% farmers that say that they sell cassava because:				
They need money	75	71	51	35
They need land	7	5	23	32
Sample size	40	38	74	57

Source: Production and farm marketing survey, 1983 (Table 3.1).

Fixed relationships between farmers and traders are not common in the region. Over 80% of the farmers interviewed arrange their sales transactions with whomever offers the best price. Quality appreciation in the fresh market is greatly dependent on area of origin and varietal characteristics. Most traders will open some bags with cassava and break some roots in two to check for origin and variety. They will judge the size of the roots and possibly the cooking qualities. The smaller volume of cassava sold for industrial purposes is only controlled for starch content. Roots that are too small for the fresh market will be fed to animals or processed into starch or a traditional snack food. Nevertheless, considerable quantities of non-commercial cassava are lost due to lack of markets, and the availability of an extra outlet for non-commercial cassava would abet the incomes of many small farmers.

Cassava sales are spread through the year in order to limit the price risk in the market for fresh human consumption and to maintain a small but gradual cash flow during a number of months. Although the quantities that are offered for sale are small, the small farmer is not in a disadvantageous negotiating position in the market. Nevertheless, the restricted size of the market plus the costs that a farmer incurs in arranging his sales makes cassava marketing a difficult activity. 42% of the farmers interviewed stated that the reason they did not grow more cassava was because of marketing problems. This figure stands out against the 38% of the farmers who said that they lacked the land or the 11% who said that they did not have sufficient credit to extend cassava cultivation.

4.3 Cassava's price and income variability and marketing costs

Fresh cassava marketing, the dominant sales form at the moment of the study, is a risky and costly affair and limits the area planted with cassava. A survey was executed to assess the cassava marketing risk and to measure its effect on cassava supply. To do so cassava's price variability was estimated. Farmers were asked to define the price of cassava in years with good, normal, and bad price perspectives. Afterwards they were asked to define the probability of a year occurring with good, normal, or bad price perspectives. A three-point price distribution was obtained in this way for each farmer, which was used to estimate average expected price and price variability. Since price variability in itself does not imply increased income variability, it was also necessary to measure production variability and its relationship with price variability. Farmers were asked to define their cassava yields per hectare in years with good, normal, and bad yield perspectives. Afterwards they were asked to define the probability that a year with good, normal, or bad yield perspectives would occur. In this way the average expected yield and yield variability were estimated. The relationship between yields and prices can be measured through the covariance. To obtain the covariance between yields and prices, the conditional probabilities of certain prices given certain yields were estimated. Farmers were asked to indicate the chance of a good, normal, or bad price, if the yield in a certain year was good, normal, or bad. To facilitate this elicitation procedure, little flashcards were used that indicated price or yield situations. Ten maize grains were supplied that could be distributed along the probable events. On the basis of this procedure a yield/price distribution for each farmer is estimated. The average outcome of the probability elicitation is shown in Table 4.8.

Table 4.8 Subjective yield and price probabilities for cassava.

	Average yield: good year (10545 kg/ha)	Average yield: normal year (7293 kg/ha)	Average yield: bad year (4181 kg/ha)	Overall average price probabilities
Average price: good market year (0.114 $/kg)	7%	12%	17%	36%
Average price: normal market year (0.083 $/kg)	16%	14%	7%	37%
Average price: bad market year	18%	8%	2%	28%
Overall average yield probabilities	41%	34%	26%	

N=189

Average price	=	US$ 0.085/kg	c.v. = 0.28
Average yield	=	7780 kg/ha	c.v. = 0.33
Average income	=	US$ 653/ha	c.v. = 0.36

Source: Market risk survey, 1985 (Table 3.1)

This table shows that there is considerable price variability through the years. Prices are twice as low in a year with bad as in a year with good prices. The coefficient of variation for the price was 0.28. There is also considerable production variability over the years. Yields in a bad production year are less than half the yields in a good production year. The coefficient of variation for yields was 0.33. However, a bad yield does not mean a good price. The coefficient of variation of cassava income per hectare per year is bigger than the individual values for yield or price, 0.36.

Since cassava is sold in small quantities through the year and since the within-year random price fluctuation is considerable, the farmer actually perceives even more risk. On the basis of the analysis of the variability of retail prices and their relationship with farm gate prices, it was possible to estimate the random within-year price variance at farm gate level (see Chapter 5). Since the random within-year price variance is independent of the year-to-year price variance, the within-year income variance is also independent of the year-to-year income variance. In this case the two income variances can be aggregated to obtain a value for the short-term income variance, facing the farmer. On the basis of this short-term variance it appears that cassava income has a coefficient of variation of about 0.40.

The procedure involved in measuring yield and price variability and the correlation between the two is tedious and some doubts existed as to whether farmers could reasonably understand and answer these questions. A Chi-square test to validate the elicitation procedure was executed. This test compares the directly elicited price distribution with the indirectly elicited distribution. The indirectly obtained price distribution is obtained from the questions to farmers on the chance of a good, normal, or bad price, given a good, normal, or bad yield. The indirectly calculated probability on a year with good prices is the chance of a good price given a good yield plus the chance of a good price given a normal yield plus the chance of a good price given a bad yield. In the same way indirect probabilities for normal and bad prices are calculated.

Let the chances of a good, normal and bad price, obtained in the direct elicitation be called "CG," "CN," and "CB"; and the chances of a good, normal and bad price obtained in the indirect way be called "MG," "MN," and "MB"; and the Chi-square value, at which pairs of observed frequencies from a distribution with three states of nature deliver a sum of squared differences bigger than this value, with a predefined probability be called "CHI"; then the similarity of the distributions can be measured with the following formula:

$$(CG-MG)^2 /MG + (CN-MN)^2 /MN + (CB-MB)^2 /MB \quad (1)$$

With two degrees of freedom and a predefined probability of 0.80, the test value of formula (1) should be below 0.446 to determine that the compared distributions are similar. For over 70% of the farmers, the obtained test value was below this value. For these farmers there is little reason to doubt the consistency of the answers. For another 20% of the farmers the test value would have been satisfactory if a predefined probability of 0.70 were chosen. This strongly suggests that farmers understood the elicitation procedure and have a clear idea of the probabilities that they face in cassava production.

Cassava prices as measured in the market do not give a clear idea of the attractiveness that the crop has for the farmer. This is because the farmer incurs many expenses in the process of selling his product. In the Atlantic Coast, the following costs are made by the farmer when marketing cassava: transport of the farmer to the market to arrange sales; transport of the farmer to the market to deliver the product; transport of the cassava from the farm to the market; time spent in arrangements and in supply of cassava; selection of non-commercial cassava that has a low opportunity value; and (if farmers did not arrange their sales beforehand) the loss of cassava not able to be sold. As shown in Table 4.9, the subtraction of these costs from the market value of cassava diminishes the price per kilogram of produced cassava by some twenty percent. In the department of Sucre, most cassava within the survey was sold on the farm, so transport costs for these farmers are lower. This compensates to a large extent for

Table 4.9. Observed versus corrected cassava prices, 1985.

	Atlantico	Bolivar	Cordoba	Sucre
Observed price (US $/kg)	0.092	0.093	0.089	0.069
Corrected price (US $/kg)	0.070	0.071	0.068	0.065
% difference	24	24	23	5
Sample size	47	45	54	43

Source: Market risk survey, 1985 (Table 3.1).

the lower market value of cassava in Sucre. The conclusion is that the price that the farmer receives in the market gives a far too favorable impression of the attractiveness of the crop.

4.4 Measuring cassava farmers' price and risk response

To understand the functioning of the cassava market system in the Atlantic Coast region the relationship of supply to expected price, and price variability, has to be analyzed. The expected price indicates the merits of cassava production while the price variability forms a major determinant of the risk that the farmer faces. Both price and price variability are important determinants of the conduct of the farmer. The two particular methods of improving cassava markets-- fresh cassava storage and cassava drying-- would both change expected price and price variability and therefore would also change supply.

Since reliable time series on farm level prices and cassava production of the region are absent, econometric estimation of supply conduct with historical data was not possible. Therefore farmers' price and price variability response had to be measured in a different way. Two methods were elaborated for this purpose, one that follows an elicitation approach and another that follows a programming approach.

4.5 The elicitation approach of price and price risk response measurement

The elicitation approach tries to derive, for each individual farmer the difference in area planted when production would be contracted at a guaranteed price and the area planted given the presently expected price. In the case of a guaranteed price, price variability would be zero. The difference between the area planted in the situation with guaranteed and with normal prices is then assumed to be caused by the elimination of the price risk.

In this method farmers were first asked what area they planted given their present price expectations. Afterwards, they were asked what area they would plant at four different levels of guaranteed cassava prices. Since it is relatively easy to imagine that production would be contracted at a fixed price, these questions were answered without problems. The resulting answers are presented in Table 4.10. From these answers, a linear equation that expresses the relation of area planted and expected price in the case without market risk can be estimated, for each individual farmer. With this equation it can be calculated what area the farmer would plant if the expected price, corrected for marketing costs, would have been a guaranteed price. The elimination of price risk causes the difference between the area planted at the expected and at the equal but guaranteed price, as the only difference between the situations centers on price risk. For each farmer, the subjective yield and price distributions and their covariance had been measured, and the difference in the area to be planted with cassava can be regressed on these terms. Since risk-aversion has been observed to decrease with wealth (Arrow, 1965), farm size was included as an additional factor to explain area differences. Prices received in the year of

Table 4.10. Farmers' reaction to guaranteed cassava prices, 1985.

	Very small farms	Small farms	Intermediate farms	Big farms
Farm size (ha)	2.52	5.56	9.08	17.31
Area planted in ha's at a guaranteed price of:				
US $ 0.042/kg	1.42	1.64	1.16	1.83
US $ 0.05 /kg	1.66	1.82	1.84	2.23
US $ 0.058/kg	2.33	2.45	2.69	3.20
US $ 0.064/kg	3.09	2.99	3.40	4.08
Estimated area elasticity	1.74	1.37	2.17	1.77
% increase over currently planted area at the presently expected price	100	65	80	86
Area planted at present (ha)	1.54	1.83	1.98	2.23
Sample size	47	47	47	43

Source: Market risk survey, 1985 (Table 3.1).

measurement were normal according to most farmers and the procedure does not appear to suffer from biased price perception by the farmers. The mathematical procedure for the estimation is as follows:

Define:

AMR_f = Area planted at the existing price expectation by farmer f

AWR_f = Area planted at the present price if this price would have been guaranteed by farmer f

ADM_f = Difference in area planted because of the elimination of price variability

$E(P)_f$ = Expected price for cassava by farmer f

PR_f = Subjective cassava price variance for farmer f
YR_f = Subjective cassava yield variance for farmer f
COV_f = Subjective covariance between yields and prices for farmer f
OTH_f = Other factors that influence area planted for farmer f
$AREA_f$ = Farm size for farmer f
e_f = Error term in the area planted equation
e_{fn} = Error term in the area planted equation for each farmer in the absence of price risk

The equation to express the area planted per farmer could have the following specification in the case of a normal price risk situation:

$$\begin{aligned} AMR_f = {} & a_f + b_f*PR_f + c_f*YR_f + d_f*COV_f \\ & + (e_f + f_f*PR_f + g_f*YR_f + h_f*COV_f)*E(P)_f \\ & + i_f*OTH_f + e_f \quad (2) \end{aligned}$$

where a to i are coefficients in the supply equation.

This specification assumes that the area planted with cassava depends on the price, on other factors not yet identified (yield, fertility, time of planting), and on the income variance of cassava production. The income variance is divided into three components; yield variance, price variance, and covariance between yields and prices. This specification is comparable to the one used by Behrman (1974), who applied it to estimate rice supply in Thailand. It differs from the approach of Behrman in the inclusion of yield variance and price/yield covariance. The subjectively estimated variances influence the slope of the supply function (through the first four right hand terms of the equation) as well as the intercept (through the terms within brackets). The effects of the included variables are assumed to be additive.

To include the effect of farm size, b_f can be replaced by a second degree polynomial in the following way:

$$b_f = b_1 + b_2*AREA_f + b_3*(AREA_f)^2 \quad (3)$$

and the same can be done for c_f, d_f, f_f, g_f and h_f. The polynomial specification allows the variance and covariance parameters to obtain a maximum or minimum at a certain farm size, and to decrease or increase at both sides of it. This allows specific measurement of the farm size at which risk-aversion is greatest. According to the theory it is expected that risk-aversion decreases with farm size, but that the relative change is smaller with increasing farm size. The inclusion of single and squared terms of the same variable in one equation might cause problems of multicollinearity. In this case it might be necessary to exclude the transformation of equation 3. If this transformation is omitted, it can be expected that for large farms the single variance and covariance terms do underestimate the planned change. This can be prevented by elaborating the analysis on a relative basis, thus the change in relation with farm size.

The resulting equation could have been estimated directly, but this would involve the use of at least 21 explaining variables and the precise definition of the other variables to be included in the model. Since this could cause the measured effects to be weak, badly distinguishable, and with low significance it was decided to divide the estimation procedure in two parts.

For each individual farmer, the following area planted equation (without price variability) was estimated on the basis of the reactions to the guaranteed, contracted prices:

$$AWR_f = a_f + c_f*YR_f + (e_f + g_f*YR_f)*E(P)_f + i_f*OTH_f + e_{fn} \quad (4)$$

In this equation the price variance term falls out, having been eliminated through the contracting. The covariance term falls out as well, because there is no covariance of price with yield if there is no price variance. Since for each farmer the subjective yield variance and the other factors do not change at different expected prices, these factors are estimated together in the intercept.

Equation (4) AWR_f facilitates the estimation of the area planted at the farmers expected price, in the case without price variability. This enables the estimation of the difference in area planted because of the elimination of price risk.

Define: $ADM_f = AMR_f - AWR_f$ (5)

By subtracting equation (4) from equation (2), the left hand side of the equation produces the difference in area planted because of price risk elimination, while the right hand side produces the terms that are responsible for this difference. The following equation results:

$$ADM_f = b_f{*}PR_f + d_f{*}COV_f + (f_f{*}PR_f + h_f{*}COV_f){*}E(P)_f - e_{fn} + e_f \quad (6)$$

in which the difference in area planted due to price risk is expressed as a function of the observed price variance and price-yield covariance. This equation cannot be estimated for each individual farmer, because only one value of ADM is available per farmer. However the equation can be estimated for the total interviewed population. For correct estimation, the resulting error term has to be independent of the explaining variables and of the dependent variable. The term e_f is independent of the explaining variables because of the definition of equation 2; it can be assumed to be independent of ADM because there is no _a priori_ relation between this error term and the difference in area planted with and without market risk. Similarly there is no _a priori_ relation between e_{fn}, estimated for the situation without price risk and the price variance, and covariance terms. Additionally error terms are independent of each other. In this case estimation with OLS is correct.

This equation allows the estimation of the shift in the average intercept and average slope of the individual area equations because of price risk. In turn, this makes possible estimation of the difference in the price elasticity of area planted with and without market risk. The equation has been estimated in different functional forms for the 189 farmers that were successfully interviewed in the market risk survey.

Estimation results from the elicitation procedure

Table 4.11 shows the six estimated specifications. Mean values and correlation coefficients of the variables used, are presented in Appendix 1.

In regressions 1 and 2 farm size was included as an explaining variable. Here the difference in area planted was related with price variance and price/yield covariance, using the same terms, but multiplied with the price. The single price variance and covariance terms indicate the change in the intercept of the area planted curve. The price variance and covariance terms multiplied by the price, indicate the change in the slope of the area planted curve (see equations 2 and 5 in the previous section). When these terms are in turn multiplied with the area, or the area squared term, the way in which the farm size changes the effect of the variance and covariance terms is indicated (equation 3 in the previous section). Contrary to regression 1, regression 2 was based on the assumption that price risk only changes the slope of the supply curve and not the intercept.

In regression 3 the explaining variables were the same as in regression 1 but the dependent variable was changed. Instead of the difference in area planted, the difference in expected production was taken as the dependent variable. This was calculated by multiplying the difference in area planted with the expected yield.

Since the use of single and quadratic terms of the same variable often gives rise to multicollinearity problems, regressions 4 to 6 do not include either the single or the quadratic farm size terms. To avoid heteroscedasticity problems the dependent variable was divided by the farm size variable. In regression 4 the dependent variable is the difference in area planted divided by the farm size and the explaining variables are price variance and covariance terms, single, and multiplied by price.

In regression 5 the dependent variable is the same as in regression 4 but the explaining variables have been transformed according to Goodman's formula on the variance of the product of

Table 4.11 Regressions to estimate the impact of price stabilization on the area planted with cassava, Atlantic Coast region, 1985.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Reduction in area	Reduction in area	Reduction in expected production	Reduction in area/ farm size	Reduction in area/ farm size	Reduction in expected production/ farm size
Average value of dependent variable	-1.49	-1.49	-14422.50	-0.32	-0.32	-2857.5
Explaining variables regarding the slope of the supply curve:						
Price x Price Risk	-0.0519 (3.06)	-0.015 (3.24)	-502.50 (3.00)	-0.004776 (2.64)	-2.89×10^{-7} (3.37)	-0.00372 (4.13)
Price x Price Risk x Area	0.0048 (1.85)	0.00062 (1.12)	45.5 (1.77)	-	-	
Price x Price Risk x $(Area)^2$	-9.9×10^{-5} (1.10)	-1.09×10^{-5} (1.13)	-0.85 (0.94)	-	-	
Price x Covariance	-0.00409 (1.42)	-9.44×10^{-5} (0.16)	-36.0 (1.26)	-0.000409 (2.43)	-2.37×10^{-7} (2.10)	0.003215 (2.72)
Price x Covariance x Area	0.00064 (1.59)	6.57×10^{-5} (1.06)	5.035 (1.21)	-	-	
Price x Covariance x $(Area)^2$	-1.316×10^{-5} (1.21)	-1.185×10^{-6} (1.01)	-0.0825 (0.77)	-	-	
Regarding the intercept of the supply curve						
Price Risk	0.354 (2.27)	-	3380 (2.19)	0.025 (1.43)	1.74×10^{-6} (2.03)	0.02335 (2.59)
Price Risk x Area	-0.0395 (1.55)	-	-349.5 (1.39)	-	-	-
Price Risk x $(Area)^2$	0.000855 (0.90)	-	6.85 (0.73)	-	-	-
Covariance	0.0377 (1.44)	-	335 (1.30)	0.0042 (2.14)	2.09×10^{-6} (1.71)	0.02655 (2.08)
Covariance x Area	-0.0055 (1.40)	-	-43.5 (1.12)	-	-	-
Covariance x $(Area)^2$	0.00011 (1.01)	-	0.75 (0.68)	-	-	-
R^2	0.44	0.44	0.60	0.16	0.28	0.32
F - value	13.7	25.8	25.3	9.9	19.6	21.8
	1.17	1.40	1.16	1.31	1.39	1.48
Area increase by establishment of drying industry in farms of						
3 ha:	29%	46%		34%	25%	27%
8 ha:	26%	31%		23%	38%	56%
15 ha:	13%	22%		24%	44%	72%

n = 189, t = values in parentheses.

* Explaining factors are weighted according to the formula of Goodman (1960) on the variance of the product of two random variables.

two stochastic variables. According to Goodman (1960), the variance of the product of two stochastic variables P (price) and Q (yield) can be written as follows:

$$\mathrm{var}(P*Q) = P^2*\mathrm{var}Q + Q^2*\mathrm{var}P + 2*P*Q*\mathrm{cov}(P,Q) - \mathrm{cov}(P,Q)^2 \quad (7)$$

in which the last term is usually negligible (Hazell, 1982).

The variance of cassava income per hectare planted can be decomposed in this way and the difference in area, with and without price risk, would be caused by the second and third term of the formula. If the effect of price risk elimination through contracting can be directly expressed by the income variance reduction, then sign and size of the price variance coefficient (i.e. the coefficient of the second term) and of the covariance coefficient (i.e. the third term) should be the same in this specification. Regression 6 makes estimates on the basis of the same explaining variables but with the expected production difference divided by farm size as the dependent variable.

From a theoretical point of view the different specifications have different advantages. Specifications 1 to 3 consider the relationship of price risk-aversion with farm size, but have the disadvantage with specification 4 to 6 of complexity and probable multicollinearity. Specifications 1, 2, 4, and 5 have the advantage that they estimate on the basis of the actual questions asked to the farmer. However, where yield levels depend on intercropping systems, it can be reasoned that the area planted is not an appropriate approximation of supply. In that respect specifications 3 and 6 are better. Specification 2 concentrates on how price risk changes the reaction to price differentials, but the theoretical value of the estimation is reduced by omitting intercept changes. Specification 5 and 6 define the correct weights for the variance and covariance term, and establish an additional criterion for measuring the quality of the estimation, but need considerably more data manipulation. The relatively simple specification and the correct weighing of variance and covariance terms make regressions 5 and 6 the most attractive ones.

In all equations, the signs of the coefficients are as expected. The effect of price risk on supply can be appreciated through the coefficient of the "Price*Price Risk" variable for the slope and through the "Price Risk" variable for the intercept. The coefficient of the variable that affects the slope is negative, which implies that price risk causes producers to react less to changing prices. The coefficient that affects the intercept is positive in all cases. This implies that at lower prices the effect of the price risk-aversion would be less than at higher prices. A conclusion that can be drawn on the basis of these data is that if price stabilization is coupled with some price increase, the increased price reaction will cause a more than proportional increase in production.

In all cases the covariance coefficients have the same sign as the variance coefficients. The covariance terms themselves have the opposite sign of the variance terms (see Appendix 4). This implies that the negative covariance between yields and prices diminishes the supply reduction effect of the price variance. This confirms that it is not the price variance that is important but the income variance. If price variability would be completely compensated by yield variability (as would be expressed in a large negative covariance), then the reduction of price variance would not have any result. In the situation in the Atlantic Coast region, price variability is only partially compensated for by yield variability (expressed through a moderate negative value of the covariance) and elimination of price variability would have a positive effect on supply.

Regressions 5 and 6, that use the weighted price and covariance parameters, show clearly that it is the income variance reduction that matters. In case of slope and intercept, the coefficients obtained for price variance and covariance effect, were very similar. If their actual difference is zero, the probability of obtaining a difference larger than the ones observed would be more than 60% for the slope and more than 40% for the intercept coefficients.

The effect of farm size on the degree of risk-aversion is not very clear. The coefficients for the area and area squared terms, that try to capture this effect, are only incidentally significant and do suffer from multicollinearity. The reduction in supply, caused through price risk, appears to be consistent with Arrows' statement that wealthy farmers are less risk-averse; however, the evidence is weak and depends on which of the three specifications is used.

By correcting the average supply curve in the case of zero price risk, with the effect that was measured for the price variance and covariance terms, the estimation results can be used to estimate price elasticities of area planted or supply. The elasticities that result are presented towards the bottom of Table 4.10. The values obtained are around 1.3. These values are reasonably high but do not compare unfavorably with the long-run price elasticities of supply that are reported by Askary and Cummings (1976).

On the basis of the estimated regressions, it is possible to predict the effect that the establishment of cassava drying will have on cassava supply. If a drying plant is established in a certain zone, a price floor for cassava will be established. This price floor prevents cassava prices from falling in the way it happens at present in the fresh cassava market. As a result the average expected price will rise, while the price variance will fall. The effect of establishing cassava drying plants has been measured by substituting (in the subjective price distributions of the 189 farmers interviewed) the drying plant price for all prices lower than that. As a result the average price increases from US$ 0.068 to US$ 0.075 while the coefficient of income variability decreases from 0.395 to 0.342.

Now the average supply curve without risk, (obtained through the questions on contracting) can be corrected for the price risk in the actual market situation to represent a normal supply curve. To do this, the coefficients obtained in the price risk estimation procedure, based on equation (6), and the coefficients obtained in the supply estimation without price risk (equation 3), are incorporated in the supply function as defined by equation (2). The estimated values for the price variance and covariance in the actual market risk situation are the input to obtain the supply function for the situation without drying plants. To obtain the supply function for the situation with drying plants, the price variance and covariance that result after establishment of the drying plant are the input. On the basis of these two supply functions, the supply in the actual situation at the actual price can be predicted and the supply in the partially stabilized situation at the increased price can be predicted.

The increases that would result from the establishment of drying plants are represented at the bottom of Table 4.10. The effect differs considerably with the specification used, as the specifications which consider farm size would predict the biggest changes with the smallest farms, while the other specifications would suggest that the larger farms will probably have a stronger supply reaction. The values obtained oscillate between 13 and 85% and are concentrated around the 30 to 40 % range. This implies that the market stabilization caused by the drying plants will shift cassava supply upwards and will guarantee a great part of the needed raw material for successful operation.

It must be stated that the robustness of the analysis is not optimal. The specifications that use single and squared terms of the same variables suffer strongly from multicollinearity. The other specifications, however, face the same problem since the correlation between the independent variables was rather high anyway. The diverging results of the different specifications are probably related to this lack of robustness. Although the procedure allows for the estimation of price risk impact on the basis of few assumptions and easily obtainable data, it is difficult to obtain data with such a range of variability that the significance of the estimated parameters would be high.

Judging the estimation results of the different specifications, regression 5 appears to be the best regression. All coefficients would be significant at the 90% security level, the F-value is very attractive, and the explanatory power is reasonable, given the simple structure of the equation. Although regression 6 has somewhat higher explanatory power, regression 5 was considered superior because it estimates on the basis of area planted, which was the dependent variable measured originally.

4.6 The programming procedure of price and price risk response measurement

Estimation of price and price risk response has also been undertaken with the help of a programming model. Although the main theoretical value of a programming model is that it tells what should be done, given the decision rules imposed, it also predicts what can happen under changing market conditions, as long as the model sufficiently captures the factors that influence resource allocation and enterprise selection.

Since price risk appears to have an important effect on the production decisions and cassava supply in the Atlantic Coast region, the programming model should explicitly evaluate the importance of price risk versus expected income. Important factors in the resource allocation of the farmer such as capital availability, cash flow considerations, rotational patterns, and nutritional needs have to be considered as well.

Quadratic programming is able to evaluate risk and expected income simultaneously while taking into account additional factors that influence resource allocation. The structure of a quadratic programming model can be briefly described as following:

$$\text{Maximize} \quad E(u) = \underline{r}'\underline{x} + 1/2L\underline{x}'Q\underline{x} \qquad (8)$$

$$\text{subject to :} \quad A\underline{x} \leqslant \underline{b} \qquad (9)$$

$$\underline{x},\ L \geqslant 0 \qquad (10)$$

where $\underline{r}$ is a n x 1 vector, that represents the net income values of the different enterprises. $\underline{x}$ is the vector that represents the level of activity for the different enterprises included in the model. Q is a n x n variance-covariance matrix that provides an estimate of the potential variance of outcomes around the expected net income values of the farm plan and of the covariance between the outcome of different enterprises. The matrix A is a m x n matrix of technical coefficients that describes the resource use in each of the possible enterprises. The vector $\underline{b}$

describes the resource availability within the farm. The weight of the scalar L determines the importance of risk-aversion versus income-maximization.

The quadratic programming model can be considered as a decision theoretic model based on the maximization of a utility function, defined in terms of mean and variance of net income. Anderson (1979) reviews most available methods to study decision-making under risk and classifies this type of model in the group of maximizing methods for single attribute risky decision making. Although Anderson states that its theoretical basis is weak, quadratic programming has been used very often in applied economic studies because of its programming versatility and relatively simple nature. A detailed description on the mathematics of quadratic programming can be found in Agrawal and Heady (1972).

On the basis of case studies data in the village of San Juan de Betulia, and price and yield variance data from the market risk questionnaire, a quadratic programming model was designed. Although the technical coefficients are relatively specific to the village, the model appropriately expresses the market circumstances for most of the study region. The programming model was developed for farm sizes of 3, 8, and 15 hectares. The matrix of linear constraints that expresses the resource set of the farm types is presented in Appendix 2 and will be briefly discussed.

The model considers four agricultural activities: cassava/ maize/ yam; cassava/ maize; cassava monoculture; and, maize monoculture. Cattle can be held on well-drained land, also appropriate for agriculture, or on poorly-drained land, inappropriate for agriculture. The production activities feed into the on-farm utilization and marketing activities. Produce can be sold or kept for home consumption. Home consumption has a slightly higher value than selling, but the amount for home consumption is restricted by the consumption patterns of families in the region. The cassava activities also produce non-commercial roots, which at present have a low opportunity value. Cattle can either be sold early in the season (in which case it serves as credit to finance cropping activities), or at the end of the wet season. Early sales limit the possible growth of the herd.

Credit can be obtained at the Agricultural Credit bank at an estimated real cost of 15% per year. The amount of capital that can be borrowed depends on the size of the farm. Capital needs are defined separately for the first and for the second part of the production season. In both parts about a 100 US dollars of cash are needed to maintain the family. Capital can be transferred from the first to the second part of the production season, but this involves a certain cost because of the relatively high inflation.

Land can be rented in or rented out. Land which is rented in can only be used for agricultural activities. Land use is subject to a rotation restriction to maintain pasture quality. The farm has family labor available and can contract day laborers. For some activities that have to be done quickly, such as planting and harvesting, the farmer is obliged to contract additional labor which is more expensive than using family labor, thus, decreasing available capital. The farmer's self-labor involves an opportunity cost, since the farmer can try to find work as a day laborer and since free time has a leisure value (Squire and van der Tak, 1975). The leisure value has been considered to be lowest for the smallest farm type. Labor constraints have been separately defined for the four most critical periods and for the rest of the year.

Within the model the net revenue of agricultural production or livestock activities only includes the production costs and, therefore, is negative. These production activities are linked to sales activities, which have a positive net revenue. This approach has the advantage that less variable production costs can be distinguished from the gross incomes of the activities, which have a more stochastic nature. It is through the sales activities that the variability in the outcome of the farm plan is evaluated.

Variability of cassava income was measured through the market risk survey. The estimation of variances and covariances of income from other crops, milk, and cattle would have involved more time-consuming and complicated questioning, and was therefore discarded. Arcia (1980) tried to measure similar variance and covariance data for the southwest of Colombia on the basis of time series, but he had great problems in purifying his material. Also, aggregate production and price series for different crops do not correctly reflect the situation facing individual farmers, given the considerable variation in soil types or rainfall parameters that might occur between different micro regions in different years. For these reasons, income variances and covariances for the other commodities were measured with the help of the expert judgment of three researchers who are familiar with the region. The basis for these estimates and the resulting variance-covariance matrices for the sales activities are given in Appendices 3 and 4.

A remaining specification in the model is the relative importance of the risk-aversion versus the income-maximization objective. A common way to estimate this parameter is through elicitation in little money games played with the farmers (Dillon and Scandizzo, 1978, Walker, 1981 or Arcia, 1980). The problem with this procedure is whether the weights obtained in these games hold through at farm level decision-making. However, Binswanger (1980) has shown that most farmers, regardless of their absolute wealth, turn moderately to strongly risk-averse when the money at stake is increased. Dillon and Scandizzo (1978) in their survey of risk preferences in the northeast of Brazil found that if the survival of the farm was at stake, most farmers turned moderately risk-averse. For the specification of the quadratic programming models, no efforts to estimate the degree of risk-aversion in the region have been made, but weights were used that are in accordance with the findings of Binswanger, and Dillon and Scandizzo. With these weights the farmer would trade off a decrease in average income for a decrease in income variability, so that for the worst of every six to seven years he will have a higher income than if he was risk-neutral. With this weight, the initial results of the programming model coincide with the real farm plans observed.

Estimation results from the programming procedure

The quadratic programming model, to simulate optimal farm plans and cassava supply, was run under a number of different assumptions about cassava prices and price variance. In the first scenario, prices and price variance were held constant at the levels that were found in the market risk questionnaire (Matrix A in Appendix 4). The second scenario was that the expected cassava price would stay at the level that was found in the market risk questionnaire, but that all price risk would be eliminated (Matrix B in Appendix 4). The third scenario was that through the establishment of cassava drying plants a price floor would be established. In this case low cassava prices would be eliminated. This causes the price variability to be lower and the average price to rise slightly. The effect of the price floor was estimated by substituting the price paid in the drying plants for all prices lower than that one, in the individual price distributions from the market risk survey, as explained in section 4.5 (Matrix C in Appendix 4). In addition, the price variability reduction effect of drying (Matrix D in Appendix 4) was separated from the price increase effect (Matrix E in Appendix 4).

The model was evaluated for different farm sizes, under the assumption that no land can be rented in, and alternatively, that land for cropping can be rented in.

The quadratic programming models were executed with the "Minos non-linear programming" routine (Murtagh and Saunders, 1983). The main outcomes of the programming models when land cannot be rented in are given in Table 4.12.

In Table 4.12.A the optimal farm plan for an eight hectare farm under different market situations is given. The area that a farmer would plant with cassava according to the model in the presently encountered market situation is some 15% above the actual average area planted in the study region. Since a farmer cannot be expected to follow perfectly an optimal farm plan, primarily due to imperfect knowledge and non-divisibility of certain farm resources, the programming solution appears very realistic. A first conclusion that follows from the results is

Table 4.12A. Optimal farm plan in different market risk situations. Betulia, 1985, eight hectare farm.

	Farm plan without considering risk	Present farm plan A	Farm plan with stabilized cassava prices B	Farm plan when drying industry would support prices C
Area planted in (ha):				
Cassava/Maize/Yam	0.25	2.77	2.08	1.25
Cassava/Maize	4.46	0.07	0.20	1.68
Cassava	1.29	-	2.38	1.06
Maize	-	-	-	
Pastures	2	5.16	3.33	4.01
Cattle stock (no.)	3.6	8.65	5.73	6.8
Credit needed (US $)	875[1/]	354	665	328
Family employment (man-days)	373	360	343	355
Contracted labor (man-days)	184	92	154	114
Total employment (man-days)	557	452	497	469
Cassava sales (kg)	54739	19189	41375	34428
Maize sales (kg)	4663	1975	1525	2450
Yam sales (kg)	385	10476	7745	4406
Dual value of rented land (US $/ha)	226	145	175	177
Farm income (US $)	5126	3942	4920	4746
Coefficient of variation of income	0.44	0.312	0.303	0.305

1/ Maximum value.

that the risk-aversion of the farmer leads to a considerable decrease of the area in cassava in favor of pastures. Most cassava is intercropped with yam and maize, as is common in the studied area. The farm would generate some 450 days of employment and market some 19000 kilogram of commercial cassava.

If the price of cassava would be completely stable, supply would double. Maize and yam supply would fall by some 25%, and the cattle stock would decrease by some 35%. The credit needs of the farm would almost double and the employment offered would increase by 10%.

If a drying industry would partially stabilize and increase the price, the shift to cassava would be less marked and its supply would undergo a 70% increase. This shift is caused not only by an increase in the area planted but also by the change in cropping systems. The intercrop with maize and yam would lose importance in relation with the cassava/ maize, and cassava monoculture systems. The area in pastures would decrease by some 20%. Credit needs of the farm would go down. The total labor needs increase only 4%, completely in contracted labor. Yam supplies decrease strongly, but maize supplies increase. The value of rented land, as expressed by its dual value increases considerably. Finally farm income would increase by some 20%, while the variance of income would decline slightly.

If land rent was possible, the results would have been very comparable. Income would increase slightly more, by some 22%, and the change in cropping systems would be more marked. Livestock would not decrease in importance and the extension of cassava growing would take place on rented land.

Table 4.12.B shows the results for the fifteen hectare farm. The tendencies are very similar to those for the eight hectare farm. The shift towards simpler cropping systems is stronger than for the eight hectare farm, due to greater labor scarcity in the bigger farm. The dual value of land for the fifteen hectare farm is much lower than for the eight hectare farm and indicates the gradual shift from a labor surplus to a land surplus farm.

Table 4.12B. Optimal farm plan in different market risk situations. Betulia, 1985, fifteen hectare farm.

	Farm plan without considering risk	Present farm plan A	Farm plan with stabilized prices B	Farm plan when drying industry would support prices C
Area planted in (ha):				
Cassava/Maize/Yam	0.15	2.66	1.01	0.40
Cassava/Maize	3.08	-	-	0.52
Cassava	2.81	0.42	3.77	3.33
Maize	-	-	-	-
Pastures	3.84	11.92	10.21	10.76
Cattle stock (no.)	6.89	18.8	17.1	18.0
Credit needed (US $)	448	-	332	10
Family employment (man-days)	396	396	394	396
Contracted labor (man-days)	194	273	276	240
Total employment (man-days)	590	669	670	636
Cassava sales (kg)	58216	22353	47082	42459
Maize sales (kg)	3053	1800	3829	-
Yam sales (kg)	-	10056	3453	993
Dual value of rented land (US $)	60 1/	71	81	77
Farm income (US $)	5998	4925	5881	5895
Coefficient of variation of income	0.384	0.273	0.249	0.262

1/ Present market value.

Results for the three hectare farm are shown in Table 4.12.C. Here the increase in market security also causes an increase in the area planted and in the cassava supplied, but it is a smaller increase. Cassava sales only increase by 25% and the area planted with cassava only by 10%. The change in cropping system is less marked. The dual value of land and credit is very high for this farm type, which suggests that land and capital availability limits the potential to react to the changing market situation. Although small farmers might be more risk-averse, their resource availability hardly enables them to pursue effective risk-averse farm management. As a result, the income of the three hectare farm only increases by 8% if extra land can be rented, and by 5% if not.

The results of the quadratic programming models suggest that the reaction to price stabilization in large farms will be larger than in small farms because large farms have more resources to be shifted from one enterprise to another one. Price stabilization would not only cause an increase in the area planted but also a shift in cropping systems. The shift in cropping systems causes the increase in employment to be less than the cassava sales figures would suggest. Supply of other products, such as yam, and the importance of livestock might fall. For farms with sufficient cattle, credit does not appear to be a major constraint for extension of production. Credit programs should be directed therefore, towards the smaller farms.

Care should be taken with the interpretation of the programming results. The models evaluate existing technological packages, for cassava as well as for other crops or activities. According to the induced innovation theory, discussed in Chapter 1, changes in the price and price risk situation for cassava will tend to lead to higher demand and development of improved technology. In such a situation the adverse effects on other activities than cassava production will partly be overcome by the introduction of higher yielding production packages.

Table 4.12C. Optimal farm plan in different market risk situations. Betulia 1985, three hectare farm.

	Farm plan without considering risk	Present farm plan A	Farm plan with stabilized prices B	Farm plan when drying industry would support prices C
Area planted in (ha):				
Cassava/Maize/Yam	1.76	1.76	1.53	0.91
Cassava/Maize	-	-	0.19	1.02
Cassava	-	-	0.08	-
Maize	-	-	-	-
Pastures	1.24	1.24	1.20	1.07
Cattle stock (no.)	2.13	2.13	2.08	1.88
Credit needed (US $)	250[1/]	250[1/]	250[1/]	250[1/]
Dual value of credit	2.14	0.27	0.80	0.74
Family employment (man-days)	181	181	177	178
Contracted labor (man-days)	39	39	39	36
Total employment (man-days)	220	220	216	214
Cassava sales (kg)	11314	11314	12180	14353
Maize sales (kg)	1020	1020	1026	1410
Yam sales (kg)	6445	6445	5504	3025
Dual value of rented land (US $)	436	229	284	281
Farm income (US $)	2217	2217	2187	2321
Coefficient of variation of income	0.330	0.330	0.276	0.288

1/ Maximum value.

4.7 A comparison of the elicitation versus the programming approach

Each of the methods used to measure price and price risk response has its own advantages. The elicitation approach is able to include observations from many different areas and does not need detailed studies of the farms involved to measure the effect of price risk on cassava production. It is not necessary to make assumptions on the variance and covariances of other crops, or to specify beforehand the degree of risk-aversion of the studied farmers. Additionally, the elicitation approach does not need to assume optimal resource allocation. Although considerable data manipulation is needed before the final regressions can be executed, data requirements are simple and can be satisfied with a well designed and implemented survey. The result will be applicable over a large region.

Detail is the biggest advantage of the programming approach. This approach does not only give an indication of how much cassava would be supplied, given certain conditions in the cassava markets, but also suggest how this supply will be produced. A big advantage over the elicitation approach is its ability not only to predict the change in area planted, but also in yield levels that will result because of possible shifts between the different cropping systems. In a similar way it indicates the effect of changing market circumstances on the supply of other products and on the resource utilization within the farm. This makes the programming approach very useful for designing appropriate agricultural policy measures. The importance of the programming model for estimating the aggregate supply shifts of other products than cassava should not be overestimated, since the general equilibrium analysis needed for those estimations is absent.

A comparison of results from the elicitation and from the programming approaches

The shifts in cassava supply, predicted by the elicitation and by the programming approaches in the case of drying industry establishment, are compared in Table 4.13. A first observation

Table 4.13. A comparison of estimation results on the impact of market risk. Atlantic Coast region, 1985.

	Present situations	Situation with price sustained by drying industry	Difference	Explained by price increase	Explained by risk decrease	Estimated supply price elasticity (area or production)
Small farm (3 ha)						
LR 1/ Area planted (ha)	1.54	1.96	27%	18%	9%	1.48
QP 2/ Area planted (ha)	1.76	1.93	10%	4%	6%	0.28
QP Expected supply (kg)	11314	14353	27%	12%	15%	0.65
Middle sized farm (8 ha)						
LR Area planted (ha)	1.90	3.09	56%	17%	39%	1.39
QP Area planted (ha)	2.84	3.97	40%	11%	20%	1.03
QP Expected supply (kg)	19189	34428	79%	22%	57%	2.05
Large farm (15 ha)						
LR Area planted (ha)	2.23	3.83	72%	11%	61%	1.10
QP Area planted (ha)	3.08	4.25	38%	12%	26%	1.12
QP Expected supply (kg)	22353	42459	90%	35%	65%	3.27

1/ Linear regression results.

2/ Quadratic programming results.

is that the areas planted in the present market situation and in the situation with cassava drying plants is larger for the programming models than for the elicitation approach. This is due to the fact that the zone on which the progamming model was based is characterized by more than average dependence on cassava. A conclusion that follows mainly from the programming model is that the reaction to decreased risk and increased prices will be larger with rising farm size. This conclusion is in accordance with the original market risk questionnaire data, presented in Table 4.10, except for the very small farms~~, where~~ farmers stated that they ~~would~~ greatly increase their area planted. For the small farms, area extension will depend critically on the possibility of renting extra land for agricultural purposes. Even if the small farmer could rent in more land, however, his capital availability might still constrain production expansion.

The results from the linear regressions and from the quadratic programming models are roughly comparable. The programming models indicate a smaller area change, but a bigger supply change than the regression. Both approaches lead to the conclusion that for the larger farms the price risk decrease is more important than the price increase to explain supply changes of cassava. For the small farm, the importance of the price risk decrease versus the price increase to explain the area or supply differences depends on the approach followed. The elicitation approach stresses the importance of the price increase, but the programming model puts more importance on the risk decrease to explain supply changes.

The separation of the price increase effect from the price risk decrease effect allows calculations to be made of (arc-)price elasticities of area or supply. The price difference caused by drying industry development was divided by the average price with and without drying industry to obtain the relative price change. The same was done for the area or supply difference, but only after the effect of the price risk decrease was eliminated. The relative (for risk corrected) area or supply change that results is divided by the relative price change to obtain price elasticities of area planted or supply.

The price elasticities that are obtained in this way are shown in the right hand side of Table 4.13. The area price elasticities calculated from the elicitation approach appear very reasonable in comparison with the values of long run elasticities reported by Askary and Cummings (1976). As regards the programming results the area price elasticities obtained for the middle sized or the large farm have reasonable values but the one for the small farm is very low. The supply price elasticity from the programming model appears very high for the bigger farms, but stays low for the small farms. These supply elasticities suggest that, although small farmers are sensitive to changes in prices and price risk, their supply response is small because of the limited resources within the farm, making it difficult to pursue the desired changes. For the larger farmers resource constraints are not as binding and they will show more flexible responses to changing market circumstances.

4.8 Conclusions

Cassava production and marketing issues are strongly interwoven in the Atlantic Coast region. Detailed analyses of cassava production and marketing suggest a number of important conclusions on the interaction between the two.

A first conclusion is that the presently existing cassava markets operate in a fairly competitive way but to the minimal satisfaction of the cassava grower. Although most growers sell to whomever offers the best price and are not restricted through monopsomistic purchasing habits or informal credit, they mention market problems as a major constraint for the importance of cassava within the farm.

A second conclusion is that prices in the market do not accurately reflect the attractiveness of the crop for the producer. Two factors limit the ability of the sales price to function as an attractiveness indicator. The first factor is the price variability. Although the average sales price covers production costs, the enthusiasm of the farmer for producing cassava is greatly constrained by his fear of potential low prices. The losses that a farmer might incur after a year with low sales prices can affect his productive capacity for many years afterwards, e.g. through his inability to obtain credits or to rent land. The second factor that affects attractiveness is the amount of marketing costs that the farmer has. A large percentage of non-commercial roots has to be discarded, transactions have to be arranged beforehand, and roots have to be transported under guidance of the farmer. The result is a 20% gap between the market price and the price per kilogram of cassava produced at the farm gate. Since most often the market price serves as the indicator of the potential for entering non-traditional markets, this price gap obscures the market potential of the crop and constrains spontaneous development of alternative markets.

A third conclusion is that the market circumstances strongly influence the production strategy of the farmer. The intercropping systems that are common in the Atlantic Coast region have an important role in the reduction of the market risk for certain products. In the case of cassava, when market risk is diminished, the importance of monoculture increases. Additionally, the market risk constrains the area planted with cassava and reduces the role of the crop in many farms to a semi-subsistence crop, primarily produced for home consumption. The marketable surplus depends on what is left after home consumption has been satisfied. For many renters it is plausible to assume that the market risk constrains the area they are able to rent. Improved production technology is of doubtful value in such a situation, especially if higher input levels and therefore higher monetary costs would increase the losses in the years with bad prices.

The risky market prospects for cassava force many small farmers to take up low-risk and low-income activities such as cattle holding. Consequently the income-gaining potential of the small farm in the Atlantic Coast region is not fully realized. Market development strategies might have a strong impact on the income and development potential of cassava within the small farm. Cassava drying industries, that would produce prime material for the animal feed industry could have an important function in market development. Through the linkage of dried cassava prices with government-supported feed grain prices, a price floor for fresh cassava could be established. Market risk would be reduced and the average expected price would increase slightly. Results from two procedures to estimate the impact of such a market development program indicate that cassava supply could increase by some 27% for small farms and by some 72 to 90% for larger farms. Especially for the somewhat larger farms market risk reduction is very important since it would allow easier sales of the larger marketable surplus that these farms can produce.

Small farms are not less risk-averse, but the limited resource availability of these farms restrains their reactions to decreased market risk. For the small farms, further increases of cassava supply depend on the ability to rent extra land and to obtain extra credit.

At the moment farmers want to maintain a part of their land in pastures, to facilitate capital accumulation and finance crop production. This could constrain the extension of cassava production in case of improved market access. Appropriate savings and loan institutions, trusted by the farmers, could replace cattle as a means of financing and saving. These institutions should charge and pay real and acceptable interest rates, should minimize the transaction costs for depositing or borrowing, and should define the loan capacity of farmers on the basis of their savings conduct. The establishment of these institutions would form a natural complement to the improvement of cassava marketing possibilities.

Most of the supply shift that the establishment of a cassava drying industry would cause would be explained by the decrease of the market risk. A minor part would be explained by the price increase that would occur. The estimated price elasticities of supply or area planted were moderately above one, and reasonably in accordance with many of the reported values in the literature. The farmers analyzed in the present study appear to be sensitive to changes in the market circumstances they face, with regards to risk as well as expected prices. In this situation improved marketing possibilities could significantly increase productivity of the small farm system, improve food and feed supply, and provide better living conditions for farm operators and their families.

Chapter 5 : CASSAVA MARKETING IN THE ATLANTIC COAST REGION

5.1 Cassava marketing channel analysis

Cassava in the Atlantic Coast region is mainly destined for fresh human consumption, but a number of secondary uses can be distinguished. Some production goes to feed animals, either in fresh form at the farm or in dried form for inclusion in balanced feed ratios. The market for dried cassava is of minor importance at present but its potential is enormous. Another part of the crop is processed into starch or used in traditional snack foods.

The marketing channels for these different uses of cassava function in very different ways. In the previous chapter the degree of price stability in different marketing channels was analyzed. In this chapter other aspects of different marketing channels will be studied: the importance of the nature of the product on the evolution of the marketing channel will be analyzed; price formation processes will be looked at; the role of the marketing channel as a source of employment and as a distribution mechanism will be considered; and, the importance of the marketing channels in stimulating and directing production will be analyzed.

Three methods will be used to analyze cassava trading. First, the structure and conduct of the marketing channels will be described on the basis of secondary information and from interviews with traders. Second, the spatial causality in the price formation process during the last decade will be studied by means of a path analysis of monthly price data. Third, a time series analysis over the same period will be made to analyze trends, seasonal patterns, and possible cyclical tendencies in retail prices. Through these three methods a judgment on the performance of cassava trading will be formed and the opportunities for market improvement strategies will be further identified.

Fresh cassava trading dominates within the region and its marketing channel will therefore receive the most attention. The other marketing channel that will be analyzed in detail is that for dried cassava. Dried cassava marketing is attractive because of the partial price stabilization that it can cause and because of the wide potential market for animal feed raw material.

5.2 A description of fresh cassava trading in the Atlantic Coast region

Fresh cassava trading is strongly influenced by the the fact that cassava can be stored in the field for a long period, but deteriorates within three days after harvest. These characteristics mean that cassava harvesting is spread out throughout the year, but that, once harvested, it must be marketed immediately. This implies that most often cassava is harvested in the daytime, sold at farm level in the afternoon, transported to the wholesale markets at night, traded to the retailer in the early morning and finally bought by the consumer within a day after harvest. The speed of cassava marketing and the inherent risk that cassava will become unsaleable if not sold immediately are the major determinants in the trade process.

In the Atlantic Coast region cassava trading is essentially a free, non-controlled business. The government has little influence on it and has little knowledge of it. In Cartagena and Barranquilla wholesale trade has been centered in a special spot, but there is no obligation to supply cassava through this market and incoming volumes are not registered. Cassava retailing implies no obligations either, with the product being sold tc the consumer through neigborhood shops, market stalls, hawkers, and some supermarkets. Large consumers such as restaurants or institutional buyers will often buy directly from a wholesaler or distributor. The very diffuse nature of fresh cassava markets and the little secondary information available make it difficult to apply a rigid analytical scheme to distinguish types of traders or stages in the trade process. In the following analysis traders have been classified as assembly agents, wholesalers, and retailers: assembly agents are those traders who collect cassava at the farm gate and sell to another trader; wholesalers are those traders who collect cassava at the market from either farmers or other traders and do not sell directly to the individual consumer; and retailers are those traders who sell directly to the public.

Fresh cassava market structure

As shown in Figure 5.1, rural cassava marketing channels are less complicated than are urban ones. In the rural areas retailers or even consumers might buy directly from farmers, whereas cassava marketing in the urban areas involves more traders, with assembly agents, wholesalers, and distributors appearing in the marketing channel. Retailing methods are more diverse; markets and supermarkets predominate in large towns, whereas neighborhood shops and street hawkers are more important in rural areas.

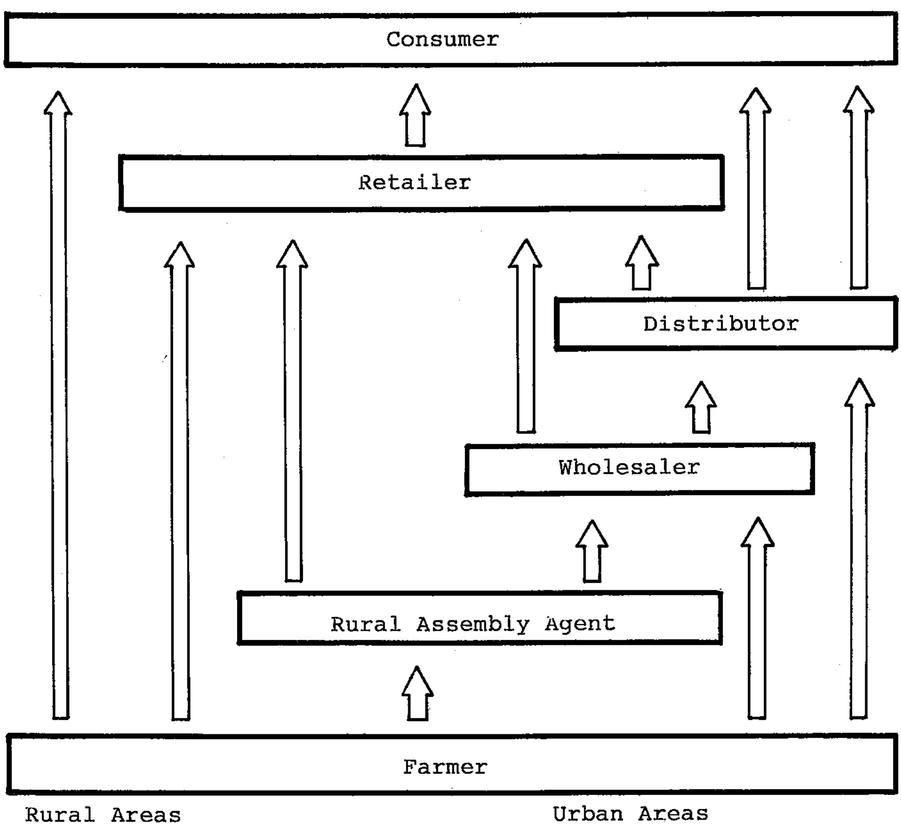


Figure 5.1: Fresh cassava marketing channels in the Atlantic Coast region of Colombia, 1983.

Table 5.1 shows the most important structural characteristics of the cassava marketing channel. The number of cassava traders in each municipality is very high. Even in municipalities not strongly directed towards cassava production a large number of assembly agents can be found. On the average, one assembly agent is present for each 75 to 100 farmers. In the urban areas, up to 40 wholesalers can be active. Cassava retailing is spread well over the consumption areas, with a retailer being found for every 200 to 300 persons, most often at less than 300 meters from the home of the consumer.

At assembly and wholesale levels cassava is often the only product traded. If yam is grown by the same farmers it might be sold at the same time. At wholesale level plantain is often traded with cassava and even more so at retail level. Plantain, yam, and cassava are considered to belong to the same product category and are bought at the same spot. Since plantain is not grown by the same producers, the product has to be assembled by other persons.

Buying and selling transactions and weekly traded volumes are small and decrease in size towards the retail end of the marketing channel. The cassava marketing channel is more geared to the quick distribution of the product than to the concentration of supply and demand. Hours of trade for wholesalers and assembly agents are limited in order to guarantee a fast product flow. The need to move cassava rapidly complicates the handling of large volumes. At assembly level, transport capacity forms another constraint. Average yearly turnovers at different stages of the marketing channel are small.

The number of purchasing and selling contacts per day is limited at most levels of the marketing channel. The assembly agent is only able to collect production at a limited number of farms per day. He spreads his sales to various wholesalers in order to decrease his dependence. Wholesalers sell to less than 40 retailers per day. At wholesale level a reason for the limited number of sales contacts is the inefficient and time- consuming method used to agree on price and form of payment.

Table 5.1. Characteristics of the fresh cassava market structure in the Atlantic Coast region of Colombia, 1983.

	Rural Assembly Agents	Wholesalers/ Distributors	Retailers*
Number per municipality:			
Rural	7-20	1-8	1 retailer per 200-400 inhabitants
Urban	-	15-40	1 retailer per 200-300 inhabitants
% that trades:			
Maize	39	2	24
Yam	43	51	76
Plantain	13	51	69
Other crops	28	14	60
Other products	-	-	50
Size of purchasing transactions (kg)	800	750	68
Size of sales transaction (kg)	750	100	1.55
Volume traded per week (kg) of cassava	9600	7340	320
Turn-over in cassava/year (US-dollars)	55600	64120	4320
Number of suppliers per day	3.7	1.77	1.0
Number of purchasers per day	3.9	13.4	36.6
Capital goods available:	Warehouse - 25% truck - 11%	Warehouse - 30% truck - 12%	Shop: 40% -
% with income from outside trading	42	18	23
Average number of months per year selling cassava	9.08	11.0	10.3
Information Means:	Visiting farmers, personal contacts with wholesalers	Telephone, contacts with retailers and assembly agents	Contacts with wholesalers
Socio-economic class	Low/middle low	Low/middle low	Low/middle low
Average years in business	8.6	n.a	n.a
Sample size	136	83	252

* Supermarkets are excluded.

Source: Market agents survey (Table 3.1).

Investments in cassava trade are small. Some traders have a car but most rent transport. Few traders own a warehouse. At the retail level some 40% of the sellers owns their own shop. The remainder rent a market stall or hawk their product along the houses in wheelbarrows or on donkeys. Only a small part of the profits is reinvested into the cassava trade and this is usually in the form of working capital. The limited capital availability is partly due to cassava marketing being only a supplementary or incidental source of income to many people, as, particularly at the assembly level, many traders have other income sources,(such as farming or day laboring) and only trade actively when the supply is large.

Information in the market is scarce. Most information comes from contacts with fellow traders, suppliers or customers, although some wholesalers have a telephone. Because of the lack of information, rules of thumb become very important in cassava trading. Retailers say they buy according to the day of the week, wholesalers say they buy according to the season and according to "how the market goes." Intuition and experience are important properties for a cassava trader.

Cassava trading is not an easy path to affluence. Most traders are rather poor and belong to the lower socio-economic strata. The cassava market is too atomized to provide wealth to its traders.

Fresh cassava trade has a marginally developed structure. The difficulties in handling the crop keep the traded volumes low, the risk-taking high, and the infrastructure poorly developed. It appears that cassava trading is the bottom rung of the agricultural trading ladder. If a trader is successful in cassava trade he will quickly climb up to other products where bigger volumes can be traded and better profits realized.

Fresh cassava market conduct

Market conduct is to a great extent determined by market structure. If volumes per trader are limited, number of traders is high, and access to the market is easy, then individual traders cannot be expected to have a major influence on market events.

For the determination of volumes traded, available supply and the effort to avoid deterioration losses play important roles. Table 5.2 shows that almost 40% of the assembly agents and 20% of the wholesalers define their volume traded according to prior sales arrangements. The others define their trade on the basis of supply, while some wholesalers state that trade volume is determined by the working capital available.

To determine sales prices, available supply is again the major factor, with prior arrangements being less important. A quarter of the traders determines the selling price according to a fixed margin. The minor importance of prior arrangements for price versus volume does suggest that the main reason for prearranging sales is to avoid the risk of not selling.

Most payments are made in cash. Advancing money is more common at the assembly than at the wholesale level. Advance payments are also common at the retail level. Wholesalers, on the other hand, often pay their suppliers after they themselves have sold the cassava (i.e. delayed) and do not often advance payment. The wholesaler finds most of his operations financed by the other members of the marketing channel.

Purchase arrangements are more often made in the assembly end of the marketing channel than in the retail end. All assembly agents arrange purchases by providing the sacks for packing cassava to the farmer. Forty-five percent of the wholesalers arranges their purchases while at retail level only 19% does so. Further down the marketing channel it is less easy to estimate expected demand, which varies from day to day; it is easier to estimate expected supply, which varies according to season and year.

The product transfer from the producer to the consumer is very rapid. Most cassava is transported overnight by the assembly agent to the wholesale markets. Around 75% of all wholesalers and retailers buys and sells cassava on the same day. Wholesalers and

Table 5.2. Characteristics of fresh cassava market conduct in the Atlantic Coast region of Colombia, 1983.

	Rural Assembly Agents	Wholesalers/ Distributors	Retailers*
% that pre-determines volume to trade according to:			
- Prior arrangements	39	18	-
- Available supply	-	62	31
- Available working capital	-	13	-
- Time of the year/day of the week	61	-	69
% that determines sales price according to:			
- Prior arrangements	21	2	-
- Available supply	52	75	72
- Fixed margins	26	21	28
Moment of purchasing payment:			
- Advanced	30	15	26
- Cash	56	42	56
- Delayed	4	37	15
% that arranges purchases in advance	100	45	19
% that sells cassava at day of purchasing	19	76	75
Post harvest-age of cassava at moment of sales (hours)	19	25	32
% that has frequent problems with deterioration	31	70	66
Use of deteriorated cassava:			
- Animal feed or processing	59	60	51
- Waste	41	28	49
% that gives credit to suppliers	49	45	26
% that gives credit to buyers	56	78	6
% that receives credit	38	46	16
Important quality aspects	Size, skin color	Size, freshness	Size, freshness
Purchasing price (US $/kg)	0.098	0.129	0.182
Sales price (US $/kg)	0.139	0.180	0.309
Sales price as % of farm gate price	141	183	315
Sample size	136	83	252

* Supermarkets are excluded.

Source: Markets agents survey (Table 3.1).

retailers take possession of the cassava for only six to seven hours. When sold to the urban consumer, only 32 hours have passed since the moment of harvest.

The quick handling of the product does not prevent all deterioration. Thirty percent of the assembly agents and around 70% of the retailers and wholesalers have frequent problems with cassava deterioration. Most traders try to develop an alternative outlet for the deteriorated product by selling or using it as animal feed or for processing. Still, considerable amounts are lost as a source of income, especially at retail level, where almost 50% of the persons interviewed have no alternate outlet for deteriorated cassava.

About 50% of the assembly agents gives credit to suppliers or buyers. At wholesale levels some credit is given to buyers but little to suppliers; and at retail level credit is provided to suppliers but hardly ever to purchasers. Most credit is short-term to overcome working capital problems. The fact that credit to suppliers is almost as common as credit to buyers indicates that traders are as concerned about their supply as they are about their demand. Credit is most common among wholesalers, who also most often delay their payments. Many wholesalers use their delayed payments to finance credits to other customers.

Quality control for cassava is simple. A limited number of varieties finds acceptance in the fresh market. Most traders easily recognize these varieties, i.e. within the group of accepted varieties, the ones with a slightly pink skin color are preferred. Small roots have low commercial value, since they are more susceptible to deterioration and since much is lost in preparation. Very large roots are not in high demand either, since these are often old and fibrous. Grading and sorting of different qualities is not common. If the product is fresh enough, quality is sufficiently homogeneous, while the grading and sorting process might restrain the speed of trading.

Marketing margins are high, compared with the on-farm price, as would be expected for a quickly deteriorating product with high transport costs in relation to its value. The assembly agent and the wholesaler each charge 40% of the farm gate price. However, the bulk of the costs for cassava marketing is made at retail level. Although the cassava marketing channel does not fulfill many other functions than rapidly distributing the perishable product and accepting the risks that are involved in it, the marketing margin is high compared to the farm gate price.

The effect of deterioration on the marketing channel

The deterioration of cassava creates a large risk for traders in case they are left with unsaleable roots, and most traders try to limit this risk as much as possible. Consequently, suppliers often want to coordinate their sales with possible clients before taking physical possession of the product. Ordering beforehand is not, however, very appealing to the client since it increases the chance that he receives new cassava before he has his old cassava sold. Payment delays form another way to divert risks. If cassava cannot be sold in time, the financial burden that results can be shared with the supplier.

Deterioration also affects the quantities for sale. Most traders try to limit the risk of being left with unsaleable roots by ordering less than they expect to sell. Therefore oversupply in the market will be less likely than undersupply. Cassava is often sold out before 11.00 a.m. Daily prices above equilibrium level and inflated handling costs are more likely to occur than prices below equilibrium level or low handling costs. At assembly level the same mechanism holds. Any assembly agent who has arranged his sales will only harvest a sufficient quantity to meet the orders. It may happen that he is not able to harvest enough to meet his targets (e.g. when harvests get delayed) but he will never harvest more than his targets.

When the own price elasticity of demand lies between -1 and 0, a restriction of the marketed volumes will lead in the short run to higher money turnovers, favoring market agents as they get more money for less work. Previous studies (Sanint et.al., 1984 or Pachico, Janssen and Lynam, 1983) estimated price elasticities of -0.8 and -0.96 indicating that market restriction favoring traders could indeed be occurring. In the long-run, prices above equilibrium level (given the existing cost structure) might well result in the loss of market share to other products.

In accordance with marketing of most products, deficient infrastructure, small volumes sold per customer, and frequent consumption credits increase the price to the poor consumer. This effect was most strongly observed in the small towns and villages but shows up as well in metropolitan and intermediate towns (Table 5.3). A more striking difference in cassava prices is between different urbanization groups. Cassava is most expensive in the highly urbanized metropolitan areas, as problems with deterioration increase once the distance between producer and final consumer increases, and the marketing channel cannot prevent deterioration without a high cost. Cheap cassava storage methods and improved marketability will have most impact in the highly urbanized areas.

Table 5.3. Retail prices for cassava in different income and urbanization groups, Atlantic Coast region of Colombia, 1983, (US$/kg).

	Metropolitan towns	Intermediate towns	Small towns and villages
High income	0.44	0.27	0.21
Middle income	0.45	0.25	0.23
Low income	0.44	0.25	0.30
Very low income	0.47	0.30	0.29

Source: Cassava consumption survey (Table 3.1).

Deterioration has various effects on the marketing channel. First, it puts pressure on the supply to be below equilibrium level. Prices and handling cost per kilogram increase and leave traders with increased remuneration for the services they provide. Second, the marketing channel becomes labor-intensive. The marketing margin of 22 cents (US-dollar) per kilogram compares unfavorably with the 13 cents marketing margin for potato (van der Zaag and Horton, 1983), an equally bulky but less perishable product. These problems are more heavily felt in the urban than in the rural areas.

Fresh cassava marketing costs

On the basis of interviews with cassava traders, marketing costs have been estimated and allocated to different cost categories (Table 5.4). Labor (including self-labor) is the most important margin component. Labor includes: time spent in arranging transactions; in administration; in transporting or waiting for purchasers or sellers; the costs of loading or unloading trucks. Labor costs are directly related with the volumes traded. At assembly and wholesale level, where volumes are still reasonably high, labor costs are modest. Although at retail level labor costs are allocated to different products according to their sales volume, labor still forms more than half of the total costs. The small volumes traded are directly reflected in the incidence of labor on total handling costs.

Transport costs are the second most important cost component. These are highest for the assembly agent who brings cassava from the production areas to the areas of consumption. A second transport cost is the transportation of cassava from the wholesale market to the retail outlet. Most often retailers are responsible for this, which, again given the small volumes, causes considerable transport costs. The bulky nature of cassava causes high transport costs, aggravated by the fact that only small quantities at a time are distributed.

Deterioration is the third most important cost component. At assembly level deterioration costs are low. At wholesale and retail level deterioration costs increase quickly because more cassava deteriorates, but also because this cassava has a higher acquisition value. Reduction of deterioration can be expected to have most direct effect on the cost structure of the retailer. However it will also have an indirect effect, because the volumes traded per agent can grow, which reduces transport and labor cost per kilogram traded.

Table 5.4. Fresh cassava marketing costs in the Atlantic Coast region of Colombia, 1983.

	Rural Assembly Agents	Wholesalers/ Distributors	Retailers	Costs as a % of total margin
Marketing margin (US $ cents/kg)	4.10	5.10	12.70	
Estimated handling costs (US $ cents/kg)	3.65	4.65	9.78	83
Cost components:				
Labor	0.97	1.16	5.60	35
Transport	1.51	0.60	1.25	15
Deterioration	0.20	1.03	1.82	14
Packing material	0.12	-	-	1
Equipment	0.25	0.60	0.60	7
Working capital	0.22	0.38	0.26	4
Government fees	0.38	0.88	0.25	7
Estimated net profit per year (US $)	1804	1866	439	

Source: Market agents survey (Table 3.1).

The other costs in cassava marketing are relatively minor. The low equipment costs indicate the minimum investments within the channel, while the low working capital costs express the speed of the trading process. The assembly agent provides the packing material (as insurance), and the government charges some trading fees, mainly to the wholesalers who are concentrated in public markets.

The margin for fresh cassava marketing is more than two times the farm gate price. Since the marketing channel is easily accessible for new traders, however, extraordinary profits would not be expected, and indeed, most cassava traders are not rich. Total costs in cassava marketing amount to some 83% of the total marketing margin. Estimated net incomes out of trade are some 1800 US $ per year at wholesale and assembly level, and some 440 US $ at retail level. If the average cassava trader has even one dependent family member, these incomes would compare poorly to the Gross Domestic Product per capita of 1180 US $.

In comparison with trade of other products, labor, transport, and deterioration costs are extremely high for cassava. Working capital costs are low, which expresses the absence of storage. Other costs would be comparable on a kilogram basis. Effective control of deterioration will decrease not only deterioration itself, but also labor and transport costs. Assuming that deterioration control is carried out cheaply, (such as packing in plastic bags) cassava storage would cost two cents per kilogram (Janssen and Wheatley, 1985) and cassava handling costs could fall to levels comparable to those of potato, with the marketing margin falling thirty-five percent.

The study of the fresh cassava trade cost structure leads to the conclusion that traders receive an adequate but not excessive remuneration for their efforts. This is poor comfort if the efficiency of the marketing channel is considered. The costs of cassava trading are very high and change the character of cassava from a cheaply produced calorie source to an expensive urban food.

5.3 Intertemporal retail price development

The attractiveness of cassava as an urban food crop is strongly determined by its long-term price development and by its price stability. This section will analyze cassava price development over the years in different towns. A comparative time series analysis of cassava, rice, potato, yam, and plantain retail price series was done for the towns of Barranquilla, Cartagena, Santa Marta, Sincelejo, and Monteria. Monthly prices from 1970 to 1984 obtained from the DANE monthly statistical bulletins (DANE, various years) were analyzed. Series on yam in all towns and of all products in Sincelejo were only initiated in 1979.

The obtained price series were analyzed in two ways. First, a time series analysis on the individual series was executed to study seasonality, tendency, cycle, and remaining instability of the data. Afterwards, the deflated and detrended data were related with each other to study market integration. This last study could have been better realized with wholesale data, but these were not available.

The time series analysis was executed with the X-11 procedure of the U.S. Bureau of the Census (1967), which studies seasonality patterns. The analysis was completed with a trend analysis and with a procedure to estimate cyclical fluctuations. For well integrated markets it is expected that trends, seasonal, and cyclical movements show up in similar ways. It can also be expected that for a product like cassava, which can be stored in the ground, seasonal fluctuations are less than for other products. To test these hypotheses, the retail price series were decomposed in the following way:

$$Y = T * C * S * I \quad (1)$$

In which:

Y = Original time series
T = Long-term trend in the data series
C = Cyclical fluctuation in the data series
S = Seasonal fluctuation in the data series
I = Irregular variability of the data series

The obtained price series are first corrected for inflation by division with the consumer price index. Afterwards, a twelve-month-centered moving average is calculated to approximate the series which have been cleared from seasonal tendencies. The original data are divided by this moving average to obtain values for the effect of the seasonal deviation, and a regression analysis is executed to estimate the seasonal deviation over the years. Then the seasonally corrected data are submitted to a logarithmic trend analysis to estimate growth rates of the series. The series, corrected for season and trend, are finally submitted to an autoregressive procedure to identify cyclical movements.

Retail price development in the Atlantic Coast region

There were large price fluctuations for the crops during the period studied. For yam, the yearly price series have coefficients of variation of almost 20%. For plantain and potato these values were respectively 17% and 12%. Rice has low yearly fluctuations (coefficients of variation of 8%). For cassava, the coefficients of variation were most comparable to the values for potato, namely 14%.

The standard deviation of yearly cassava retail prices was 4.3 US $ cents per kilogram. The standard deviation of farmers' prices (measured in Chapter 4) was 2.3 US $ cents per kilogram. Price fluctuations are higher at retail than at farm level and the marketing channel reinforces price fluctuations. This suggests that cassava marketing margins are not fixed, in which case standard deviations at retail and farm level would have been the same, but are dependent on the farmer's price. This conclusion is in accordance with Serba's findings (1984) for price fluctuations of vegetable products in West Germany. The potential for increasing margins, when on-farm prices are high and supply limited, allows the trader to compensate for income loss because of less volume.

The stability of the price series did not increase in the period of analysis. Coefficients of variation of the series were higher by the end than at the beginning in 14 of the 25 cases, and price stability increased for only six series. Rice (which had the most stable prices anyway) was the only product whose price stability increased. Cassava prices became more unstable in the larger towns, but more stable in the middle-sized towns.

Seasonal price fluctuations

The within-year price fluctuation for different crops is also considerable. For potato and cassava, the difference between the lowest and the highest average monthly price was close to 20%, while for plantain and yam, the highest average monthly price was double the lowest. Rice has very low within-year price fluctuation and has been omitted from the seasonality analysis.

For plantain, yam, and potato, 55%, 76%, and 24% (respectively) of the within-year variation can be explained by seasonal patterns. For cassava 31% could be explained. The low percentage of the within-year variability that can be explained by the seasonal pattern indicates that short-term cassava price uncertainty is large. If the relationship between the within-year price variability at farm and retail level is the same as the between-years price variability (4.3 versus 2.3 cents), this information could be used to calculate within-year price variability at farm level. On the basis of an unexplained within-year retail price variability of 2.6 cents, the value at farm level would be 1.4 cents. The unexplained within-year price variability considerably increases the risk that the farmer faces and has, therefore, been included in the price risk analysis of Chapter 4.

The seasonal patterns encountered are shown in Figure 5.2. Potato prices everywhere peak around May. Potato patterns are uniform because the crop is not produced in the region but imported from cooler areas in the Andean zone of Colombia. Yam, which has a marked production season and is harvested from November onwards, also shows a strong and uniform seasonal pattern. Although plantain has a less marked harvest period, its prices also show a marked seasonal pattern.

The cassava pattern contrasts strongly with those of the other crops. In Barranquilla and Cartagena, prices peak around

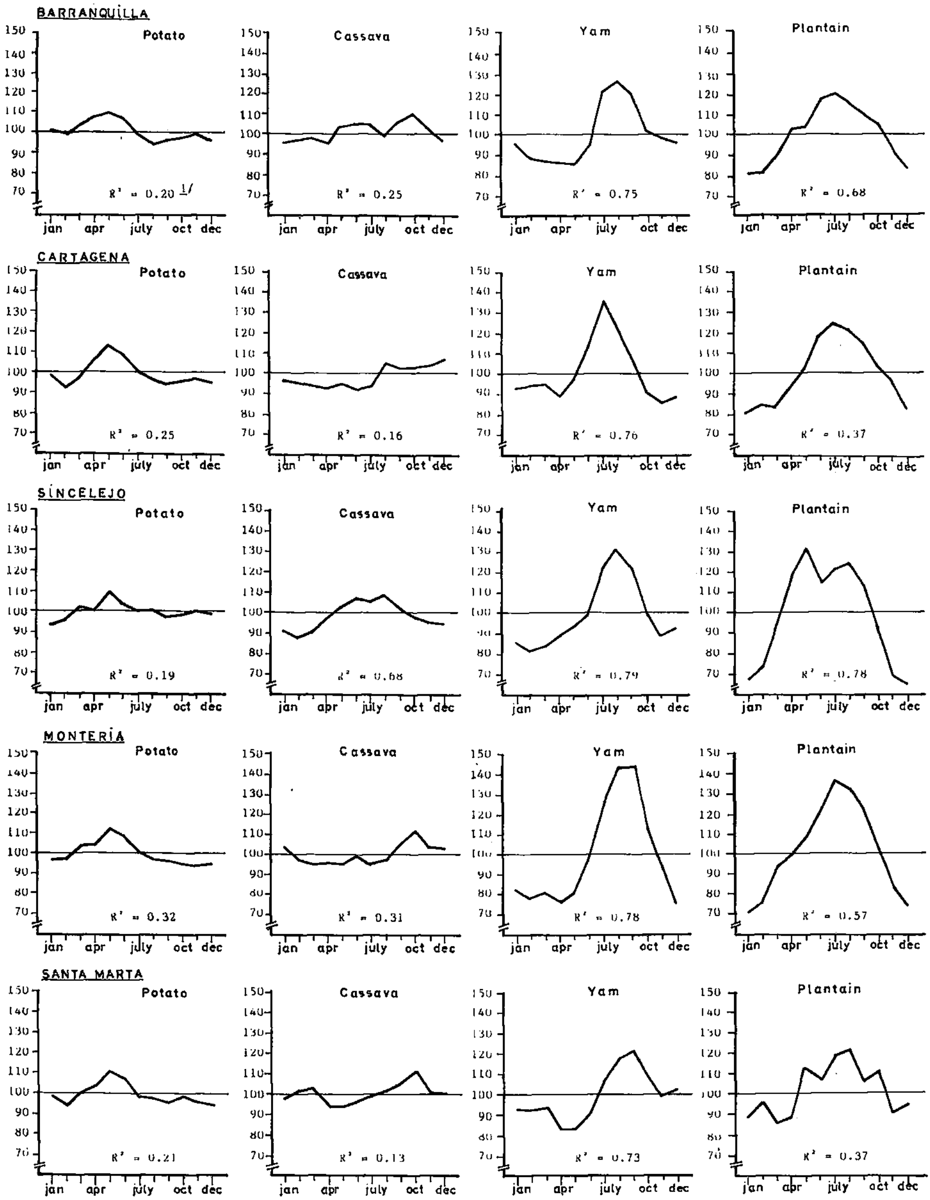


Figure 5.2 Seasonal patterns for four crops in five Atlantic Coast towns, 1970-1984, series for yam and Sincelejo from 1979-1984
1) Within year variability explained by seasonal factors.

December. However, in the three towns close to production areas, the seasonal patterns are different: in Sincelejo, prices are highest in the period from June to August; in Monteria, in the period from October to January; and in Santa Marta, from August to October, with a secondary peak around March. Seasonality changes from area to area, depending on harvesting times. The different harvest periods and the staggered harvest practices make the seasonal patterns in cassava prices weaker and less uniform than for the other staples. It appears that cassava markets function relatively independently of each other.

Price trends

Prices for potato, plantain, and rice decreased in all five towns (Table 5.5). Price decreases for potato have been strongest and most uniform. The price decreases explain a significant part of the variability in the seasonally adjusted potato price series. Almost equally strong price decreases are measured for plantain as for potato, but these are less uniform in the different towns and explain less variability. Rice experienced moderate and not very uniform prices decreases.

Trends in yam and cassava prices are more diverse. Yam and cassava prices went up in three of the five cities. A spectacular price increase for yam was measured in Sincelejo, possibly caused by the short interval of analysis. The t-values for yam trend parameters are low, indicating that the yam price series are not long enough for reliable estimations. The unfavorable price development of yam can be explained by the disease problems that have plagued the crop in the last five years.

Cassava prices decreased slightly in Barranquilla (not significantly) and more drastically in Monteria. In the other towns the retail price of cassava increased. In the largest towns of the Atlantic Coast region (Barranquilla and Cartagena), retail prices of cassava increased more or decreased less than prices of any other product. In the other towns, cassava always followed yam as the product with the least favorable price trend. The evidence of production problems for cassava is very limited. Studies on cassava cultivation conducted in the early 1970's

Table 5.5. Average retail price increases for five different crops in five towns of the Atlantic Coast region. 1970-1984[1].

		Barranquilla	Cartagena	Sincelejo	Monteria	Santa Marta
Potato:	annual increase (%)	-3.16	-3.59	-3.22	-4.06	-4.24
		(11.9)[2/]	(11.5)	(2.01)	(10.3)	(13.9)
	R^2	0.46	0.44	0.07	0.42	0.53
	Expected 1983 Price (US$/kg)	0.33	0.30	0.35	0.32	0.31
Plantain:	annual increase (%)	-2.41	-1.23	-5.67	-5.91	-2.49
		(6.98)	(2.21)	(2.21)	(7.86)	(6.29)
	R^2	0.22	0.03	0.08	0.31	0.19
	Expected 1983 Price (US$/kg)	0.34	0.25	0.24	0.18	0.28
Rice:	annual increase (%)	-1.10	-4.08	-1.97	-2.53	-2.21
		(5.06)	(27.1)	(3.99)	(18.2)	(12.0)
	R^2	0.13	0.81	0.23	0.68	0.46
	Expected 1983 Price (US$/kg)	0.69	0.54	0.59	0.53	0.72
Yam:	annual increase (%)	-2.44	-1.24	+14.17	+0.28	+0.83
		(1.30)	(0.56)	(4.71)	(0.09)	(0.39)
	R^2	0.03	0.01	0.29	0.00	0.00
	Expected 1983 Price (US$/kg)	0.43	0.44	0.50	0.35	0.57
Cassava:	annual increase (%)	-0.12	+2.15	+5.61	-2.18	+0.74
		(0.43)	(4.30)	(2.38)	(4.19)	(2.09)
	R^2	0.00	0.10	0.12	0.11	0.03
	Expected 1983 Price (US$/kg)	0.33	0.34	0.25	0.22	0.30

1 Figures for yam and for Sincelejo only from 1979 to 1984.
2 Absolute t-values in parentheses.

Source: DANE-retail prices.

(Diaz and Pinstrup Andersen, 1977) suggest that yields have been increasing slowly, making it improbable that on-farm cassava prices have been rising; thus, retail price increases might well be due to increased marketing margins.

Expected prices and growth rates vary considerably between towns for all products. This suggests that the quality of market arbitrage or the quality of retail price collection (but most probably the quality of both) is not very high. The obtained conclusions should be weighed cautiously.

Cyclical fluctuations

Evidence of cyclical tendencies in the analyzed price series is almost non-existent. Some weak evidence existed for rice having a long-term cycle of 43 months, but no possible mechanisms to cause such a cycle could be identified. For cassava, certain irregular movements in the price series were identified, but these did not have a cyclical nature and were probably caused by random changes in yearly production circumstances.

5.4 Relationships between different retail price series

Spatial market integration has normally been analyzed by means of correlation analysis of price series in different towns, but only weak conclusions can be drawn on the basis of this method. Ravallion (1984) designed a method to test whether one area has major influence on price development in other areas. However, in the Atlantic Coast several areas can be considered to influence prices in other areas. This calls for a method which is able to simultaneously analyze the effect of different areas.

If the causal relationships between different areas can be defined (i.e. by means of a path diagram), these relationships can be tested with path-analysis (Li, 1977 or Turner and Stevens, 1959). On the basis of the causal relationships expressed in the path diagram, systems of normal equations are formed that can be solved if the correlation coefficients between the involved variables are known. The solutions of the normal equations form the path coefficients, indicating the causal relationship of one variable to the other.

In the case of markets in the Atlantic Coast, path analysis tests whether the price formation in certain markets depends on the price formation in other markets. In this case it is reasonable to assume that demand is rather stable while supply is subject to significant weather variability. The supply instability will cause price changes first in the towns located in the areas of production. In well-integrated markets these price changes should be transferred to towns in non-producing areas. The relationship is hypothesized to be unidirectional; prices in producing areas will set prices in the non-producing areas. In the case of spatially well-integrated markets, such a causality in the price formation should be expressed by positive path coefficients.

Path analysis has been applied for cassava, yam, and plantain, which are all produced in the region. It would have been optimal to use on-farm price series in production areas in forming the path analysis, but on-farm prices were not available, so retail series were used. In the case of products like cassava, which have a rather high margin, retail prices can only be used at the assumption that when on-farm prices rise, margins rise as well. As there is evidence that margins increase when farm prices increase, the use of retail series is appropriate. It is not possible to define production-consumption causality for crops like potatoes and rice which are imported into the Atlantic Coast region. In these cases traditional correlation coefficients are used for comparison.

Path analysis

Barranquilla and Cartagena are consumption centers, which are principally supplied with cassava from other regions. Santa Marta, Sincelejo, and Monteria are located in or close to production zones. The hypothesis would be that price changes in these towns cause price changes in the two cities. The Barranquilla market is the most important wholesale market of the

Atlantic Coast region; its influence on the other cassava consumption center of Cartagena was tested. Correlation coefficients and normal equations under these assumptions are presented in Appendix 5. The path diagram is shown in Figure 5.3.A.

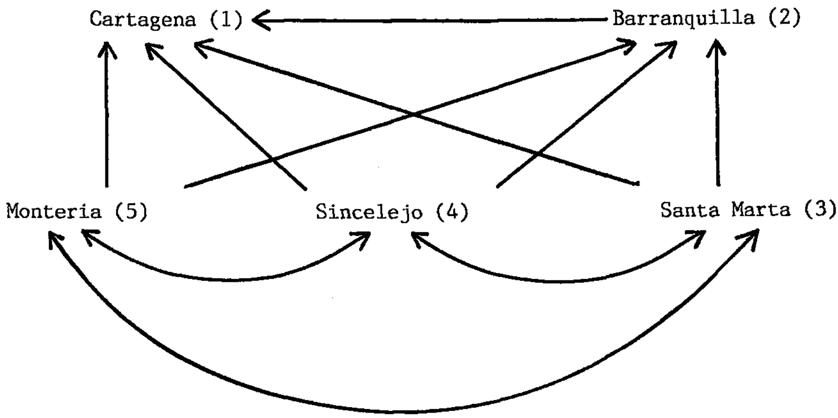
Resulting path coefficients are presented in Table 5.6. The influence of the Monteria area on the price formation in the major urban centers is practically zero, and its effect on prices in Cartagena even seem to be slightly negative. The influence of the Magdalena area (where Santa Marta is located) on prices in the consumption centers is clear. However, the Sucre area (where Sincelejo is located) has the most influence on price formation in the two large cities.

The most striking result is the negative path coefficient from Barranquilla to Cartagena. Although the observed correlation coefficient between the two areas is positive (0.475), this value is caused completely by the simultaneous influence of the producing areas on price formation in these towns. The direct influence of prices in Barranquilla on prices in Cartagena is calculated to be negative. Such evidence suggests that arbitrage between the markets is absent and that the hypothesis of a causal relationship between Barranquilla and Cartagena prices was wrong.

Estimation of path coefficients without the assumption of causality from Barranquilla to Cartagena (see Figure 5.3.B) produces slightly lower values for the remaining path coefficients. For Barranquilla, some 55% of the total retail price variance can be explained, and for Cartagena some 73%. These values appear reasonable if we consider that not all supply areas are included in the analysis. Price changes in two of the three production areas are transmitted to the consumption centers, but between consumption areas, price transmission is absent. Spatial integration in the cassava market does not appear to be strong.

Path diagrams for yam and plantain were designed and tested in a similar way. Correlation coefficients were used, and the resultant path diagrams are shown in Appendix 5. The area around Monteria is most important for explaining yam prices in

A: Influence of Barranquilla prices on Cartagena prices



B: No influence of Barranquilla prices on Cartagena prices

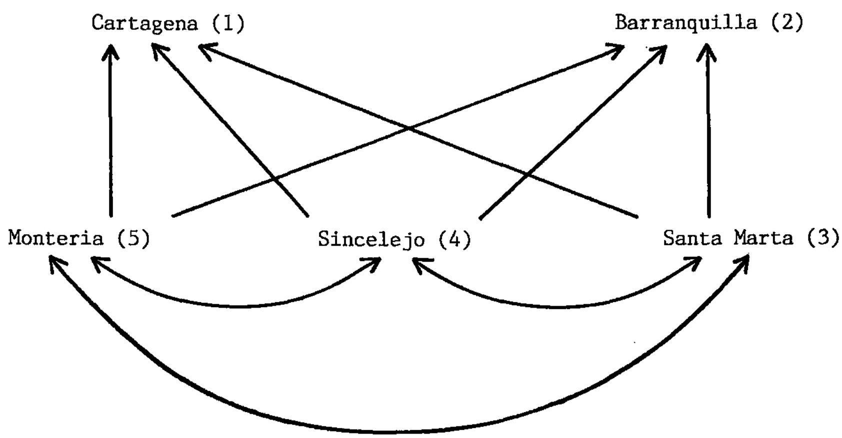


Figure 5.3 Path diagrams indicating causal effects on cassava prices between towns.

Note: Single arrows indicate causal effects; double arrows indicate correlationships.

Table 5.6. Path coefficients between cassava retail price series in five different towns in the Atlantic Coast region, 1970-1984. 3/

	Barranquilla	Sincelejo	Monteria	Santa Marta
Barranquilla		0.51	0.02	0.40
Cartagena	-0.26 1/	0.84 1/	-0.05 1/	0.42 1/
	- 2/	0.71 2/	-0.06 2/	0.32 2/

1/ Values assume the Cartagena price is dependent on the Barranquilla price.

2/ Values assume the Cartagena price is not dependent on the Barranquilla price.

3/ Sincelejo prices from 1979-1984.

consumption centers, while the influence of the Sincelejo area is weak. This is in accordance with the observed importance of different zones in the region's yam production. The market of Barranquilla appears to strongly influence prices in other consumption centers such as Cartagena and Santa Marta. Yam is a more storable product than cassava and the better market integration is related to this characteristic.

Market integration of plantain was again low. Plantain is mainly grown around Santa Marta, Cartagena, and Monteria. The influence of these areas on consumption areas could be distinguished, but between the consumption areas, no significant positive relationships could be found. As in the case of cassava, plantain is not stored in the marketing channel. Storage influences the degree of spatial market integration.

Correlation analysis

On the basis of the observed correlation coefficients (Appendix 5) some rough conclusions on market integration for potato and rice were drawn. All correlation coefficients were higher for potato than for cassava. Since the estimated trends and the expected prices were also more uniform for potato than for cassava, it would appear that potato markets are better integrated. For rice, correlation coefficients were higher than for cassava in eight out of ten possible cases. The average value of the rice correlation coefficients is 0.70, a low value in comparison with what Harriss (1979) reports for Africa. This might be because of the low variability in the rice prices or because of the specific influence of some minor rice production areas on the prices in the smaller towns. Nevertheless, trends of the rice price series were also observed to differ for each town. Rice market integration is not as strong as expected for an easily storable and easily transportable cereal.

5.5 Dried cassava processing and marketing

Cassava drying for animal feed is a relatively new activity in the region, started by the DRI (Integrated Rural Development) program to improve cassava's marketing possibilities. The dried cassava marketing channel is organized very differently from the fresh cassava marketing channel: farmers sell their cassava directly to a cassava drying association or cooperative. These associations or cooperatives consist of some 15 to 40 members who own a small solar drying plant, normally financed with soft government credit. These drying plants operate in the dry season, from November to March, when cassava supplies peak in many areas. The original idea was that the members would provide all the cassava to run their plant. In reality members provide about half of the prime material, while the rest is bought from non-members. When the cassava arrives at the plant it is weighed and chipped. The chips are spread on a concrete floor at a density of twelve kilograms per square meter and are dried within two days. For each 2.5 kilograms of fresh cassava, one kilogram of dried cassava is obtained. When the cassava is dry, it is stored in sisal sacks in the warehouse of the plant. When a quantity large enough to fill a truck has been prepared, a vehicle is rented by the suppliers or sent by the buyer and the product is shipped off. Most dried cassava has been sold to animal feed factories but an increasingly large portion is being supplied to integrated pig or chicken producers. At the buying point, cash or check payment is made for the dried cassava.

The cost structure for cassava drying

By the end of 1985 some 20 drying plants were functioning and another 20 plants were being constructed. The investment needed to start a modest drying plant is relatively small (see Table 5.7). The normal starting size for a drying plant is 500 square meters of drying floor. In the dry season of the region some sixty batches of six tons each of fresh cassava can be dried in such a plant. Investing in a 500 square meter plant requires about nine thousand US dollars. Almost 60% of this goes to the construction of the drying floor and the warehouse, while another 30% is needed to purchase a cassava chipper and the motor that drives it, and the last 10% to purchase additional equipment. To establish a plant of double capacity, an additional four thousand US dollars is required, mainly to increase the size of the drying floor. Working capital is also needed, and was estimated at five thousand dollars for a 500 square meter plant and eight thousand dollars for a 1000 square meter plant. Yearly depreciation is around 11% and yearly maintenance around 3% of the investment in infrastructure and equipment.

Operation costs for cassava drying, excluding interest and depreciation, are between 15 and 25 dollars per ton of dried cassava. Drying is rather labor-intensive, as about 20 man-hours are needed per ton. Most labor is spent in turning the chips on the floor for uniform drying. Since cassava drying takes place in the dry season, when little other employment is available, it is easy to obtain labor to run the plant. Over 70% of total operation costs are for unskilled and administrative labor.

Transporting dried cassava to buyers in the Atlantic Coast region costs 10 to 15 dollars per ton. Transport to other regions might cost up to $25 per ton. Cassava could be milled to ease

Table 5.7. Private economic parameters of a cassava drying plant of 500 m^2.

A:	INVESTMENTS (US $)	
	Drying floor + warehouse	± 5400
	Chipper + motor	± 1800
	Other equipment	± 900
	TOTAL	± 9000
B:	WORKING CAPITAL	± 5000 (US $)
C:	PROCESSING COSTS (US $/tons of dried cassava)	
	Operation costs	15-25
	Transport costs	10-25
	Interest costs	± 10
	TOTAL	35-55
D:	MISCELLANEOUS PARAMETERS	
	Production per year	144 tons
	Prime material needs	360 tons
	Profit/ton	19 US $
	Internal rate of return	30 %

Source: Janssen and Ospina, 1983.

transportation, but present production levels do not justify this investment.

A last important cost is for capital. Interest payments are about 10 US-dollars per ton of dried cassava.

Total processing costs are between 35 and 55 US dollars per ton of dried cassava. This value appears high but is partly caused by the overvaluation of the Colombian peso versus the dollar. In 1984, at an average purchasing price of 50 dollars per ton of fresh cassava and a sales price of 200 dollars per ton, the drying plants made a profit of 19 dollars per ton processed. The internal rate of return for cassava drying is above 30% in real terms. The profitability of the process is reflected in the expansion of the drying plants. As of 1985, all plants had doubled their capacity after the first year of operation. Some plants had already increased four-fold.

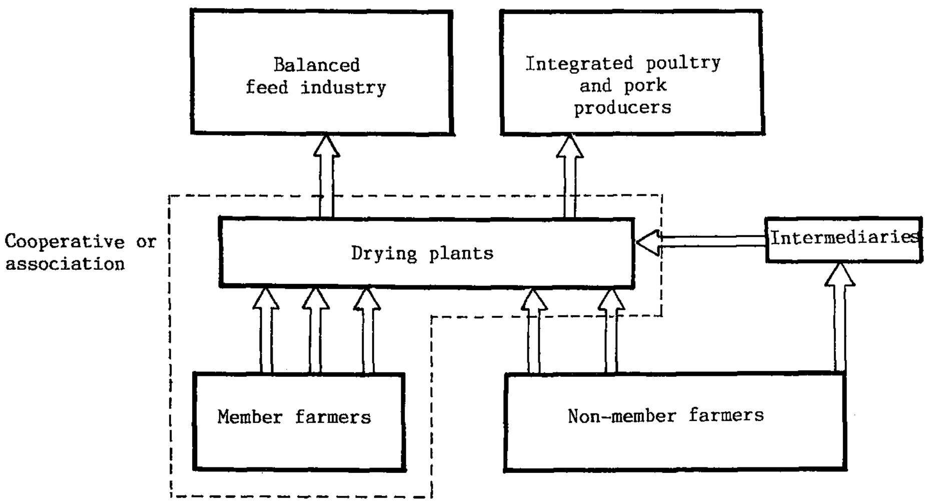
The structure and conduct of the dried cassava marketing channel

In the dried cassava marketing channel, the drying plant forms the assembly point for the supply of fresh cassava. On the average a drying plant has contacts with some 30 to 90 cassava producers, who transport their cassava to the plant after having made a sales arrangement. In certain areas of Cordoba some intermediaries are assembling cassava for the drying plants. The drying plant sells its produce to the sixty animal feed concentrate producers or to the estimated two hundred integrated pig or poultry producers in Colombia (see Figure 5.4). Commercial contacts exist with at least 15 buyers, and new contacts are quickly established.

Within the dried cassava market product differentiation is very limited. Quality characteristics are well-defined, and easy to comply with; up to the present no attempt has been made to change product appearance. Market information is relatively good for both sides of the marketing channel. Purchasers as well as suppliers know the expected production of cassava and other crops, before the drying season, and this helps to form the price.

The many potential purchasers for cassava guarantee an open and equitable price formation. The price of dried cassava is strongly intertwined with prices of other feedstuffs, such as sorghum and soybean. In feed mixing, one ton of dried cassava and 0.2 tons of soybean have about the same nutritional value as 1.2 tons of sorghum. This implies that the maximum price for one ton of cassava is about 1.2 times the price of sorghum per ton minus 0.2 times the price of soybean per ton. For 1985 this nutritional relationship would result in a price for dried cassava of between 80 and 85% of the sorghum price. Since in Colombia sorghum is worth 240 dollars per year this would indicate that dried cassava could be worth 200 dollars per ton.

Figure 5.4. Dried cassava processing and marketing channels in the Atlantic Coast region, 1985.



The national marketing board for grains, IDEMA, has considerable market control, since it sets domestic price floors for feed grains and has the monopoly on importation of grains. National balanced animal feed production has been growing very quickly in Colombia (at a rate of eight percent per year in the 1970's), and domestic feed grain production can not satisfy the growing demand. At present Colombia is deficient in feed grain production, floor prices are above world market level, and most animal feed producers are very interested in diversifying their raw material sources.

Since animal feed production is often limited by the lack of raw material, the sales perspectives for dried cassava are excellent. Dried cassava producers have organized themselves in a federation that determines what the price for dried cassava will be. Given the basic price set by the federation, contracts between purchasers and suppliers are made to deliver certain quantities of dried cassava through the drying period. If the supplier provides more, a bonus on the agreed price might become effective.

Entry into the market is without barriers for dried cassava purchasers, since there is no need for additional equipment to process dried cassava. Entry into the market for producers depends on obtaining the capital to establish a plant. For many small farmers this investment is considerable and they depend on the DRI-program for the needed credit. Farmers need to be trained to run a drying plant. Although other government institutions have expressed an interest in building drying plants, the DRI-program plays the major role in plant establishment. The capacity of the DRI-program to establish plants is limited by the availability of qualified manpower and credit resources. The limited capacity of the DRI-program constrains the entry into the market of dried cassava suppliers. A subjective estimation is that only thirty plants, with a total capacity of 5000 tons of dried cassava, could be built per year. However the stimulus to build plants will also be determined by the prices that occur in the market. If fresh cassava market prices have been high, the interest in drying plants will be low.

At the moment dried cassava is a sellers' market and buyers have to do their best to obtain the product. The efforts of the purchasers to obtain cassava did not lead to predatory tactics but to special sales arrangements, such as the advance of working capital and the supply of transport facilities or cassava planting material at reduced cost.

In the more balanced market of the future, product and promotion policies of the supplier will revolve around the price/ nutritional contents relationship. The animal feed industry is extremely price sensitive and its profits depend on cheap acquisition of raw material. Therefore, a probable change in product policy might be the introduction of pelletization to reduce transport costs to distant markets. Storage to provide dried cassava outside the drying season could be another future option to improve dried cassava marketing, as could be the development of swine production systems on the basis of self-produced dried cassava and complementary feedstuffs.

Nevertheless, in the near future most efforts will be directed towards increasing supply.

The opening of the dried cassava market has strongly decreased the sales risk for the small farmer by making a price floor for cassava. Many farmers near the plants sell for drying or for the fresh market, according to where the price is best. As was shown in Chapter 4, the improved market perspectives stimulate yield improvements and area expansion. In the secure dried cassava market the stimulus to produce large quantities at low costs is high.

5.6 Conclusions on cassava marketing

The fresh cassava marketing channel is directed towards the quick distribution of the product. Other functions such as grading and sorting or spatial arbitrage are absent. The quick distribution system operates at a high cost. It is a labor-intensive marketing channel, in which any trader can only handle limited volumes at a time. Additionally, the fear of being left with deteriorated cassava diminishes marketed volumes and causes the consumer price to increase above the equilibrium level given the cost structure of the market. Deterioration costs comprise 14% of the total margin.

Fresh cassava prices show different seasonal patterns in different areas. Seasonality in cassava retail prices is low and only explains a limited part of the within-year price variance. Since the supply in the market depends on the quantities harvested and cannot be adjusted from stocks, the marketing channel does not absorb price fluctuations at farm level, but reinforces them.

The fresh cassava marketing channel provides the product at a higher price to the poor than to the rich. The price difference with regard to the degree of urbanization is striking: in the large towns cassava is 50% more expensive than in the small towns!

Market transparency for cassava and some other crops such as rice and plantain, is very low. Prices in different urban centers show little relationship with each other and tend to change in different ways. This indicates that there is considerable room for improving market information and communication.

Fresh cassava marketing margins are extremely high, often more than 200% of the farm price, but do not leave high profits with the cassava traders. Most of the marketing margin stays with the retailer, who buys and sells very reduced quantities (some 60 kg) per day. The market structure for cassava consists of many small and competing traders. Nevertheless, the best word to describe the market structure would be atomistic: the market allows competition, but does not appear to be efficient. The unstable price formation and the large margins prohibit a dynamic role of the crop in the development of the Atlantic Coast region.

The perishability of the product forms a major obstacle to improved marketing. Improved storage could remove the upwards pressure on the prices and increase the volumes handled per trader. This could make a significant contribution to the decrease of the fresh cassava marketing margin, and improve price formation and market efficiency. In turn this will strengthen the role of the crop as a human nutrition calorie source in the urban areas.

Dried cassava is a product with a completely different nature and its marketing differs accordingly. Prices per season are assured through contracts between plants and purchasers. The product is traded directly from the associative or cooperative drying plants to the animal feed producer. In the animal feed raw material market, prices depend strongly on nutritional contents. Consequently the price for dried cassava is to a large extent determined by the price for feedstuffs such as sorghum and soybean. At the domestic price level for feedstuffs, cassava drying is a very attractive activity.

The interest for buying dried cassava is high. At the end of 1985, with some twenty small-scale drying plants working, the market was definitely a sellers' market. Construction of new cassava drying plants is greatly dependent on credit and technical assistance of the DRI-program. The growth of the industry is steady, but constrained by the capacity of the DRI-program to establish new plants.

Few product developments are appearing in the dried cassava market. Neither long-term storage nor pelletization has been tried yet at drying plant level. However, the dried cassava market does have a more progressive character than the fresh cassava market. Producers as well as purchasers are aware of the importance of increased, low cost cassava production and do their best to obtain this. The availability of a new market outlet has greatly increased the farmers' enthusiasm for cassava as a source of income. Development of the dried cassava market will create rural employment and contribute to balanced development of the region.

Chapter 6: CASSAVA CONSUMPTION IN THE ATLANTIC COAST REGION

6.1 Cassava consumption patterns

Cassava is a traditional food crop in the Atlantic Coast region, along with plantains and yams; most of the local residents following the example of their ancestors have eaten it daily since birth. The role of these traditional food crops, however, has diminished due to two developments. First, the urbanization process (more than 60% of the population now lives in towns) has changed eating habits drastically, which is exemplified by enormous increases in urban rice consumption. Second, the improvement of the national and regional infrastructure has facilitated low-cost importation of products grown outside the region, such as potato. Although the overall quantity of starchy product consumption has likely not changed due to the development process, the relative importance of each starch in the Colombian diet has changed. Cassava consumption should be studied together with consumption of other starchy products, given the developments towards urbanization and improved infrastructure.

Until recently, most cassava in this region has been used fresh for human consumption. While most consumed cassava is still eaten in its fresh form (cooked or fried) some processed forms are being eaten as well, such as bollo de yuca, a doughy noodle product, and enyucado, a sweetened pastry product. Another very important cassava product is animal feed, made from chipped and dried cassava.

This chapter will analyze cassava consumption in relation with consumption of other starchy staples, within the framework of urbanization and infrastructure changes. This analysis has two basic purposes. First, the potential role of cassava in consumption patterns and the resulting benefits to consumers will be analyzed, as will the present role of cassava in the human diet and the regional constraints to further consumption; also, the potential of dried cassava for animal feed will be investigated. Second, the analysis will indicate the income potential of the different market opportunities for the cassava producer. This analysis will expedite predictions as to the impact of possible market improvement strategies.

Urban migration and improved infrastructure have diminished the importance of cassava in the diet, because consumption decreases when consumers move from a rural to an urban environment. It also decreases over time when other, new products become available in the market. Cassava consumption should therefore be studied in different geographical strata and in different periods. In line with tradition the analysis should also consider the importance of per capita income. Ideally, cross-section and time-series data should be combined in this study, but if time series are not available, other methods for obtaining a historic perspective on cassava consumption should be evaluated.

To obtain historic perspectives on consumption of dried cassava is impossible, because the product is new. However, the analysis should consider the historic development of products for which dried cassava would substitute (mainly sorghum) and integrate this knowledge with estimates of currently existing dried cassava demand.

6.2 Fresh cassava consumption

Table 6.1 shows the per capita consumption of different crops in different urbanization strata. Cassava producers are also the largest consumers, eating almost half a kilogram per day. Consumption falls strongly in the more urbanized environments, to some 30 kilograms per head per year in the metropolitan area. Yam consumption shows a similar but less marked tendency. For plantain only a slight tendency towards decreasing consumption in urban areas can be noticed. Rice is consumed equally in the different areas. Consumption of the imported potato decreases in the more rural environments, due to transportation constraints. Cassava has the highest per capita consumption among producers and rural purchasers, but the lowest consumption among metropolitan purchasers. The marketing problems, which cause unfavorable retail prices in the urban areas, are responsible for lowering the quantity of fresh cassava consumed.

Table 6.1. Average consumption of some starchy food crops in the Atlantic Coast region of Colombia, by degree of urbanization, 1983, (kg/head/year).

	Rice	Potato	Cassava	Plantain	Yam	Number of observations
Metropolitan urban area	69.4	36.6	30.5	64.4	30.5	80
Intermediate urban areas	71.4	35.0	53.5	76.6	30.8	80
Rural areas	66.9	24.2	82.9	67.8	41.9	160
Producers	68.7	8.9	170.4	79.0	85.7	160

Source: Cassava consumption surveys among purchasers and producers, 1983 (Table 3.1).

The income effect on cassava consumption can be appreciated in Table 6.2. For cassava purchasers, consumption is similar in different income classes. Rice consumption is also hardly dependent on income, whereas potato, plantain, and yam consumption increase with income. These data do not support the often made suggestion that cassava is an inferior product, but would suggest that its relative importance for the poor is higher than for the rich.

Direct cassava price elasticities were calculated in simple linear regressions of consumption on prices. The results show that the poor are most sensitive to cassava price changes. Decreasing consumer prices would have most impact on the poor and would have an egalitarian distributive effect.

The amount of fresh cassava consumed by producers is positively related to farm size, which was used as an approximation of income. Different consumption levels are partly explained by the ability to harvest cassava throughout the year from the farmer's own land. Large farmers are able to harvest cassava during 85% of the year; middle-sized farmers during 80%; and small farmers

Table 6.2. Average consumption of some starchy food crops in the Atlantic Coast region of Colombia, by income or farm size, 1983 (kg/capita).

A: Consumption by purchasers by income group.

	Rice	Potato	Cassava	Plantain	Yam	Estimated cassava price elasticities	Number of observations
High income (IPC > 840)	67.7	40.5	54.3	86.7	42.3	-0.62 (1.68)	78
Intermediate income (840 ≥ IPC > 554)	70.5	25.8	54.3	76.5	40.2	-0.65 (3.65)	80
Low income (554 ≥ IPC > 336)	62.6	35.0	59.5	61.0	34.4	-0.80 (4.86)	80
Very low income (IPC ≤ 336)	72.0	22.7	54.5	59.9	31.2	-0.96 (2.56)	79

Note: For the elasticity-estimations, t-values in parentheses.
IPC = Yearly income in US-$ per capita.

B: Consumption by producers by farm size.

	Rice	Potato	Cassava	Plantain	Yam	Number of observations
Large farms (X ≥ 8 ha)	67.0	9.3	182.3	111.0	131.8	54
Middle sized farms (8 ha > X ≥ 2 ha)	77.3	9.3	168.7	80.3	72.9	54
Small farms (X < 2 ha)	61.1	7.8	155.8	40.7	41.6	53

Note: X = farm size
Source: Cassava consumption survey among purchasers and producers, 1983. (Table 3.1).

during 72% of the year. For yam and plantain, consumption increases more strongly with farm size, and rice and potato consumption are equal in different farm sizes. Cassava consumption does not decrease with growing farm size, but its nutritional contribution is more important for the small than for the large farmer.

Producers and rural purchasers consume similar amounts of cassava at breakfast and lunch (Table 6.3). Most cassava consumed at

Table 6.3. Distribution of cassava consumption over the different meals, by urbanization stratum, 1983.

	Metropolitan urban areas	Intermediate urban areas	Rural areas	Producers
% of cassava consumed at breakfast	30.0	53.5	50.2	42.3
Most important form of preparation	boiled	boiled	boiled	boiled
% of cassava consumed at lunch	69.0	43.6	39.7	49.1
Most important form of preparation	in soup	in soup	in soup	in soup
% of cassava consumed at dinner	1.0	3.0	10.0	8.6
Most important form of preparation	boiled/ fried	boiled/ fried	boiled/ fried	boiled/ fried
Number of meals per week with cassava	4.9	6.3	8.3	11.0
Average portion of cassava served per person (grams)	118	158	191	313
Number of observations	80	80	160	160

Source: Cassava consumption survey among purchasers and producers, 1983 (Table 3.1).

breakfast is boiled, while at lunchtime it is put in soup. Cassava is not important in the evening meal, except for the smallest producers. In the metropolitan areas, the importance of cassava as a part of the breakfast decreases and as part of the lunch increases. The ready availability of bread in the urban areas, makes it a more convenient breakfast food than cassava.

The number of meals with cassava is considerably higher and the portions per meal larger among producers and rural purchasers than among urban purchasers. In the rural areas cassava is eaten more than once a day. The average cassava portion among farm families is three times larger than per urban family. This large amount among producers, however, might be partly wasted and afterwards fed to the animals. This is less true for the small than for the large producers, as small farmers eat cassava more frequently, but in smaller portions than large farmers. In the same pattern, the urban poor eat cassava more often but in smaller portions than the urban rich, underlining the importance of cassava's role in the poor man's diet.

Trends in cassava consumption could not be studied by means of time series, so a procedure was developed to estimate consumption in recent history. The same questions that were asked in the consumption survey to estimate present consumption were repeated pertaining to consumption levels of three years before [1].

Cassava consumption appears to have decreased over the last three years (Table 6.4). In the metropolitan areas, cassava consumption fell by 45%, and in the smaller urban centers, consumption decreased by 10%. For the rural cassava purchasers a reduction of 22% was measured, while at the producers' level consumption dropped by 9%. The values obtained where checked against data on quantities bought. The reductions in quantities bought were very similar. The decrease in cassava consumption cannot be explained by migration tendencies, as 80% of the people interviewed were living in the same house and, of the people who had moved, the majority still lived in the same municipality. Plantain was most often mentioned as the starch that had replaced cassava, followed by rice, potato and bread. The price differences observed in the DANE price series for 1980 and 1983

Table 6.4. Changes in cassava consumption between 1980 and 1983, by urbanization stratum.

	1980 cassava consumption per capita (kg)	1983 cassava consumption per capita (kg)	% difference	% difference according to purchasing data	Number of observations
Metropolitan urban areas	56.3	30.5	-45.8	-41	80
Intermediate urban areas	59.7	53.5	-10.4	-8	80
Rural areas	107.0	82.9	-22.5	-21	160
Producers	186.9	170.4	- 8.8	n.a.	160

n.a. = not applicable

Source: Cassava consumption survey among purchasers and producers, 1983 (Table 3.1).

(cassava +11%, plantain -35%) explain the consumption decrease found in medium-sized towns. The bigger decreases in metropolitan consumption cannot be explained on the basis of the price development (cassava -2%, plantain -23%), nor does it appear feasible that the consumption decrease was completely caused by price changes in the rural areas.

Marketing problems might have been causing the decrease in cassava consumption in the larger metropolitan areas. In the rural areas and among producers, not the marketing problems of cassava, but the improved marketing of other products such as potato, rice, and bread might have contributed to the fall in cassava consumption. This decline implies a large reduction in the income potential of the crop for the many small farmers who grow it. If this hastens rural-urban migration, then the impact on balanced development of the region is very negative.

Other forms of cassava consumption

In comparison with consumption of fresh cassava, consumption of products such as bollo de yuca and enyucado is low. For bollo de yuca an average consumption of almost four kilograms in fresh cassava equivalents was measured (Table 6.5). For other processed cassava products another four kilograms of fresh cassava equivalents per person were consumed. Consumption of processed cassava products is highest in the metropolitan area, reflecting not only the importance of processing in urban areas, but also a shift, caused by urbanization, to more convenient foods. Bollo de yuca consumption also decreased, due to its laborious processing methods. In the medium-sized urban centers bollo de yuca consumption increased, but from a very low start value.

Table 6.5. Consumption of processed cassava products and total human consumption of cassava in fresh root equivalents, 1983.

	Metropolitan urban areas	Intermediate urban areas	Rural areas	Producers
Consumption of bollo de yuca, fresh root equivalents (kg/head)	5.9	1.0	3.9	12.7
% Change between 1980 and 1983 in consumption of bollo de yuca	-73	+40	-64	-43
Consumption of other processed cassava products, fresh root equivalents (kg/head)	4.6	2.7	3.9	0.9
Total cassava consumption in fresh root equivalents (kg/head)	41	57.2	90.7	184.0

Source: Cassava consumption survey among purchasers and producers, 1983 (Table 3.1).

Total consumption of cassava in fresh root equivalents is given in Table 6.5. Processed cassava consumption is highest, but total consumption of all cassava lowest, for metropolitan purchasers. The figures on cassava consumption are above the 55 kilogram average consumption calculated by Sanint et.al. (1984), but are consistent with the data on aggregate cassava production. The importance of cassava for human consumption, then, is highest among producers and in the rural areas, where cassava still has an important function as a semi-subsistence crop.

6.3 Fresh cassava purchasing habits

Cassava purchasing is constrained by the bad storage quality of the product. As shown in Table 6.6, the average quantity bought is necessarily small, especially in the urban areas, whereas other products are always bought in bigger quantities than cassava. The shopping frequency for cassava is very high, close to twenty times per month in each of the distinguished environments. The poor tend to shop more frequently than the rich. The frequency of purchases, however, does not prevent a considerable part of the cassava from deteriorating before actual consumption. Deterioration is highest in the metropolitan areas.

Fresh cassava is often bought in retail outlets, close to the house. Urban shoppers most often buy their cassava in a neigborhood shop, seconded by street hawkers and supermarkets. In the intermediate urban areas, the neigborhood shop is again most important, but the hawker's importance has increased. Hawkers are often small farmers selling directly to the consumer. It is easier for these hawkers to gain entry to smaller towns and villages than to large towns. They are most important in the rural areas, where more than a third of the consumers purchases cassava from them. Although cassava in the marketplace is on the average 20% cheaper than in other outlets, distance to the market often makes this outlet inconvenient for shoppers, especially in metroplitan areas. In the other environments marketplaces are more important, but still only a maximum of 30% of the people interviewed buys cassava in the marketplace. Although cassava tends to be cheaper in the marketplace, and

Table 6.6. Fresh cassava and other starchy products: purchasing habits in the Atlantic Coast region of Colombia, 1983.

	Metropolitan urban areas	Intermediate urban areas	Rural areas
Purchasing quantity (kg):			
Cassava	0.86	1.85	1.74
Potato	2.01	2.41	1.57
Plantain	3.2	5.43	4.3
Yam	1.49	3.76	6.29
Rice	5.92	9.11	5.59
Cassava purchasing location (%):			
Market place	12.3	27.5	21.3
Neighborhood shop	43.2	36.3	20.6
Street	19.7	26.3	36.2
Supermarket	19.7	2.5	-
Other	5.1	7.4	21.9
Reason for buying cassava in a certain outlet (%):			
Close	60	48	59
Buy everything there	17	17	12
Cheap	-	-	14
Type of cassava purchased determined by (%):			
Availability	73	40	52
Quality	26	49	35
Most important cassava quality characteristics mentioned (%):			
- High starch content	24	38	42
- Slowly deteriorating	48	35	52
- Taste	48	34	30
Estimate of % cassava deterioration before consumption	15	5	5
Sample size	80	80	160

Source: Cassava consumption surveys, 1983 (Table 3.1).

of higher quality than that found in neighborhood shops, the low popularity of the marketplace stresses the importance of purchasing convenience versus price in the choice of a cassava retail outlet.

Questions on why people preferred a certain cassava retail outlet showed that the most important reason was proximity, followed by one-stop-shopping quality (all necessary purchasing could be done in one shop). Price was a factor only in the rural areas. Purchasing convenience has never been recognized clearly in developing countries but plays an important role in retail outlet choice.

The type of cassava bought is determined by what is available. Since most retail outlets have only one type available, the purchaser has to take that one. The decision to buy in a convenient place overrides the desire to select a certain type of cassava. Quality more often determines the choice in the rural areas where better stocked, and more important central marketplaces exist.

Appreciation of specific varieties is absent. Most people cannot distinguish between varieties, except for skin color. The quality judgment is mainly determined by the starch content, the speed of deterioration and taste: starch content should be high, deterioration slow, and taste sweet.

The purchasing convenience of cassava is very low. Price, quality and freshness are sacrificed for closeness of the retail outlet. Increasing cassava storage ability would reduce the pay-off between purchasing convenience on the one hand, and price, quality, and freshness on the other. It would enable the consumer to purchase larger quantities at once and diminish the need to buy high-priced or low-quality cassava in retail outlets that have the advantage of proximity. The price and quality advantage would stimulate cassava consumption or make room in the budget for other expenses.

6.4 Consumers' attitudes towards cassava

As discussed in Chapter 3, in the low-involvement decision-making process (Engel and Blackwell, 1982), attitudes that are formed on the basis of experience with the product influence future consumption, making it essential to understand these attitudes. Attitude measurement, however, is a complex and expensive process even in developed countries where the average consumer has a reasonably high educational standard; also, attitude itself is a concept with many different definitions (Lilien and Kotler, 1983). Three requirements could be formulated for an appropriate method of measuring attitudes. First, the measurement method has to be appropriate for the educational level of the people interviewed. Traditional measurement methods for market research in developed countries, such as the Likert scale or the semantic differential, are too complex to be applied to illiterate or semi-literate people. Second, the method should be applicable for a reasonably large number of people at a low cost, in order to obtain significant conclusions. Third, attitudes towards products similar to cassava should be measured, in order to clarify specific aspects of attitudes towards cassava itself.

Measuring consumers' attitudes towards cassava

The three requirements formulated above could not be satisfied by any one existing measurement method. Finally a method was developed that is related to Lawrence's Consumer Preference Profile (1968), and was widely tested by Foxall (1980 and 1981). In the Consumer Preference Profile, the interviewed persons are confronted with two products (labeled A and B) and are asked whether they agree with a number of statements for A, for B, for A and B, for neither, or, that they do not know.

This method was adapted in the following way: people were confronted with five products--cassava, rice, plantain, potato, and yam--, were read test statements and, (instead of the answers possible in the Consumers Preference Profile) asked to name the products they felt agreed with the statements. The essence of the method lies in the comparison of the percentage of people that agree on certain statements for the different products. By comparing the percentages of agreement for different crops, one can determine where the score of cassava is significantly different from the score of other products.

Each person in the total sample (360 purchasing consumers and 180 cassava producers) was presented with seventeen selected statements. To facilitate the answers, flash cards with the name plus a picture of the product were shown to the respondent. The large number of interviews that can be executed with this technique makes it easy to compare scores on a regional or income basis. In the Atlantic Coast region consumers were stratified according to income and degree of urbanization.

The statements concerned relative prices, storage ability, quality, nutritional value, waste in preparation, ease of preparation, taste, importance in the diet, shopping habits and recent shifts in consumption (Table 6.7). Statements were selected to cover most consumption decision criteria, but with emphasis on purchasing convenience, since this was identified as a determining factor for cassava consumption. The score of each product on each statement was determined by the ratio of housewives agreeing to a certain statement (Table 6.7).

In comparison with most attitude measurement scales, the method used does not allow the intensity of agreement with the statements to be measured. The respondent was asked only for a positive (yes) or negative (no) response. Since the method does not weigh the importance of different statements, it does not allow for the estimation of a final overall attitude per consumer per crop; however, it has an advantage over traditional attitude measurement in that the comparison of five products can be done in a minimum of time and that the comparison per statement indicates specific areas of attention for improving cassava marketing. Tull and Hawkins (1984) mention the importance of simulating in the interviewing technique the common multi-alternative situation in the marketplace. The method used fulfills this criterion.

Statistical analysis of the data obtained is straightforward. Since the approval by any respondent of any product on any statement is assumed to be independent from approval of other statements or products, the sum of the scores per product per statement can be seen as the sum of selections from a binomial probability distribution, repeated as many times as the number of questionnaires applied. The expected variance of this sum is equal to:

$$\frac{n^2}{n - 1} * p * (1-p)$$

where n = number of observations
p = ratio of respondents agreeing to the observation

Consequently, significantly different intervals can be determined by approximation through the normal distribution as follows:

$P_0 - P_1$ = significant with a probability "X" if

$$P_0 - P_1 \geqslant t_n * \sqrt{\frac{n^2 * P_0 * (1-P_0) + n^2 * P_1 \ (1-P_1)}{(n-1) \cdot n^2}}$$

where t_n = t-value of significance with probability "X" and n degrees of freedom
P_0 and P_1 = ratios of agreements for the crops compared in the analyzed statement.

With 160 observations the minimum significant difference with 95% probability would be 0.092.

Results of the attitude measurement procedure

Table 6.7 shows the scores on the applied statements. The price for cassava was considered to be attractive for more than half of the rural, but less than a quarter of the urban consumers (statement 1). Prices for plantain were regarded as better, but prices for yam and rice, worse. The potato price was considered better in the urban area. Rice and potato prices were considered most stable (2). Cassava and plantain prices were considered equally unstable, which, given the low seasonal price variation for cassava, suggests large random price variation. Prices of

Table 6.7. Percentage of respondents in different urbanization strata agreeing to attitude statements for different products.

	RICE			POTATO			CASSAVA			PLANTAIN			YAM		
	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers
(1) At the moment this product has an attractive price	15.5	18.6	0.6	50.3	36.0	21.7	24.8	62.1	77.0	87.6	78.8	77.0	11.8	29.2	21.1
(2) This product has a constant price	41.6	29.6	26.7	36.6	25.3	12.4	11.2	14.2	18.6	10.6	10.5	8.7	3.8	5.6	8.7
(3) The price of this product increased gradually in the last years	31.1	19.1	13.0	39.1	27.1	21.1	16.8	32.1	27.3	32.9	29.0	9.9	12.4	18.5	16.8
(4) This product cannot be kept well	0.6	0.0	0.6	23.8	14.8	13.7	96.9	92.0	95.0	11.9	12.3	9.3	10.6	13.0	13.7
(5) This product is bought on the day of consumption	47.8	73.5.	n.a.	57.1	60.5	n.a.	83.2	91.8	n.a.	51.5	74.1	n.a.	55.9	67.3	n.a.
(6) To buy this product is always risky for quality reasons	3.1	2.5	n.a.	17.4	9.3	n.a.	80.7	71.0	n.a.	2.5	4.3	n.a.	26.7	26.5	n.a.
(7) The quality of this product varies strongly	8.7	18.6	24.9	27.3	13.0	13.7	87.6	87.6	67.1	5.0	6.2	3.1	29.8	35.4	29.2
(8) This product is easy to prepare	65.8	65.2	65.2	65.8	64.0	55.3	73.3	81.4	87.6	53.4	68.3	64.6	48.4	61.5	64.0
(9) Of this product a lot is wasted in the preparation	0.0	0.0	0.0	35.6	24.7	20.5	56.3	41.3	44.1	3.8	1.9	0.6	47.5	49.4	60.9

n.a.= Not available
Note: Percentages are based on 160 observations in each urbanization stratum.
Source : Cassava consumption surveys among purchasers and producers 1983 (Table 3.1).

Continuation

Table 6.7. Percentage of respondents in different urbanization strata agreeing to attitude statements for different products.

	RICE			POTATO			CASSAVA			PLANTAIN			YAM		
	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers	Urban consumers	Rural consumers	Producers
(10) This product is always available	88.2	93.8	91.9	70.8	77.6	45.9	60.9	74.5	81.4	69.6	85.1	76.4	48.4	64.6	56.5
(11) When you were young you ate more of this product	37.3	42.9	42.2	48.7	29.8	21.1	63.9	71.4	71.0	69.6	62.1	68.9	52.5	60.9	65.2
(12) In the last years the consumption of this product decreased	13.6	13.0	7.5	20.7	15.5	17.4	63.6	38.5	27.3	11.7	15.5	6.8	48.1	32.3	23.6
(13) In the last years the consumption of this product increased	45.3	27.8	22.4	38.4	26.5	11.8	13.2	10.5	17.4	56.6	29.0	18.6	12.0	14.8	16.1
(14) This product is very nutritious	15.6	7.5	11.8	55.0	37.8	33.5	20.6	22.4	24.8	90.0	93.8	93.2	18.7	12.4	13.0
(15) This product is very tasty	56.5	53.4	60.2	77.0	55.3	51.5	70.2	64.0	67.7	85.7	80.1	77.6	58.4	59.6	62.1
(16) This product is indispensable in your daily meals	77.0	82.1	80.1	64.6	42.0	26.7	48.4	75.3	94.4	82.6	85.2	81.4	40.4	48.8	57.1
(17) If you could spend more money in food you would buy more of this product	29.1	31.7	52.8	51.3	34.2	43.5	35.4	37.3	27.3	68.4	64.6	57.1	27.8	29.8	31.6

n.a.= Not available
Note: Percentages are based on 160 observations in each urbanization stratum.
Source : Cassava consumption surveys among purchasers and producers, 1983 (Table 3.1).

potato, rice and plantain in the urban environments and of cassava in the rural environments were considered to have increased (3), which implies that their competitiveness might have fallen.

Cassava's storage quality is perceived as bad by more than 90% of the interviewed persons in every environment (4). Many people, therefore, agreed that cassava has to be eaten on the day of purchase (5). The high values for the other crops on this statement are caused by the budget constraints that urge many people to shop on a daily basis. Cassava's quality is perceived as variable by many persons, with a high possibility of buying bad quality cassava existing (6, 7). Most persons consider cassava easy to prepare (8), but say that a lot of the product is wasted (9). The ease of preparation is countered by shopping inconvenience and by the high waste percentage. These last factors might have a strong negative influence on actual consumption.

Purchasers rate cassava availability less favorably than potato, rice and plantain (10), whereas producers rate only rice as being more available than cassava. Although cassava is produced in the region, its availability is below that of imported rice and potato, suggesting that cassava marketing is not very effective.

Many people said consumption of cassava had fallen. The long-term tendency is illustrated by statement 11. Only for plantain did more urban respondents agree that they ate more of it when they were young. The short-term tendencies are shown by statements 12 and 13. For cassava, many more people agree that consumption has fallen than it has increased, showing that cassava has a traditional but decreasing role in the diet of the Coastal people.

Cassava's nutritional value is rated below plantain and potato, but above rice and yam (14). Its protein deficiency is not considered a drawback to its consumption. These perceptions differ markedly from the judgment based on nutritional contents, which would rate rice higher. An explanation for the difference might be that people do not rely on these traditional starchy crops for protein intake. In large parts of Latin America, calorie deficiencies are more important than protein deficiencies and the nutritional perception might be mainly based on the caloric content of the crops. Cassava's taste is well appreciated (15). In the urban areas plantain and potato find some higher appreciation but in the rural areas only plantain scores higher. For almost all producers interviewed (but for less than half the urban purchasers) cassava is an essential part of the diet (16). Cassava means more for rural than for urban consumers. Other products do not decrease similarly in meaning.

Finally, product appreciation was tested by asking which products would be bought more often if the food budget were larger (17): plantain is the most appreciated product, with cassava coming right after plantain in the rural areas and in the third place in the urban areas. Cassava had the lowest score among producers, which reflects only that they do not ever buy cassava, since they grow it.

The attitude towards cassava is positive as far as taste and ease of preparation are concerned, and its low nutritional value does not constrain consumption. Cassava is generally considered to have variable quality, to need great purchasing effort, and to be difficult to store. These factors might have caused the observed fall in consumption. The negative aspects of the attitude towards cassava are felt more in the urban areas than in the rural areas, and, cassava is considered to be more of an intrinsic part of the diet in rural areas than it is in urban areas where products like rice, plantain and potato are more important.

6.5 A model to explain cassava consumption on the basis of measured consumers' appreciation

Once attitudes to different products have been measured, their influence on consumption patterns must be investigated. In the analysis of cassava consumption this has special relevance with regard to understanding the consequences of the unfavorable scores that cassava received concerning product quality, purchasing risk, shopping effort and storage ability. In case the negative appreciation for these characteristics diminished consumption, then amelioration of these characteristics could improve market perspectives. To explain the effect of these and other characteristics, consumption and appreciation of cassava has been compared with rice, yam, plantain and potato, the other starchy staples in the diet.

Other product properties than price are rarely taken into account in explanations of consumption patterns. The hedonic price method, which estimates the value of a product on the basis of its specific features, is one of the methods which tries to do so. Hall (1971) describes how this method was used to determine the value of cars on the basis of variables such as fuel use, manufacturer, and the presence of power brakes. The problem of the hedonic price method is that it explains the price (one of the properties of a product) on the basis of other properties, while the question of how the interaction of price and other properties influences the consumption of the product is not answered. It appears more sensible to explain consumption on the basis of price and appreciation of other properties, rather than only on other properties.

To facilitate consumption comparison between crops, comparable units should be used. Since the crops included in the analysis mainly provide energy to the consumer, consumption can feasibly be expressed in calories. To explain differences in consumption levels, the model should consider two sets of determining factors. First, the appreciation of distinct properties of the crops under consideration, with a well-recognized factor in this set being the relative price. Other important properties, as shown above, are taste, ease of preparation, year-round availability, price, and stability of quality. Second, the socio-economic characteristics of the consumers, with income per head and degree of urbanization being two of the most important characteristics in this set. Other factors, which are not included in the present analysis because they appear to be of minor importance, are household size and racial/regional origin.

If socio-economic characteristics of consumers plus appreciation of product characteristics determine consumption, then the following model can be formulated to explain differences in consumption levels between crops among various consumer groups:

$$C_{ij} = \text{function } (I_j, U_j, P_{ij}, A_{ij}, B_{ij} \ldots)$$

where C_{ij} = Consumption level per head of crop i by consumer group j, expressed in calories

I_j = Expenditures per head in consumer group j

U_j = Urbanization degree of consumer-group j.

P_{ij} = Price per calorie of crop i for consumer group j

A_{ij}, B_{ij}.........= Appreciation of other characteristics of crop i, that influence consumption in consumer group j.

This model resembles the Lancaster model, in which the utility derived from a certain product is an additive function of the characteristics of the product (Ratchford, 1975). The products included in the analysis are assumed to be different combinations of the same characteristics. The score per product on the different characteristics is measured and used to explain actual consumption. Since consumption of the different products is measured in the same unit (calories), the effect of the different characteristics on consumption can be estimated in one model which covers all the products included. In this model consumption per product in calories depends on the scores per product of the characteristics included.

An estimation procedure to explain cassava consumption

For rice, plantain, cassava, yam and potato, consumption levels and prices were obtained from the consumers survey among purchasers, and afterwards converted into caloric values (for caloric values of different products, see Instituto Nacional de Nutricion, 1967 or Platt, 1977). Income information was also obtained in the consumers survey, while for the appreciation of other product characteristics, data from the different attitude statements were used. Producers were excluded from the analysis because incomes or price paid could often not be obtained. These procedures are summarized in Figure 6.1.

The socio-economic characterization of consumers was made according to the degree of urbanization and the expenditure level. Four degrees of urbanization were distinguished: metropolitan areas (Barranquilla and Cartagena), intermediate-sized urban areas (Sincelejo and Monteria), regional centers with some 30,000 inhabitants, and villages with some 5,000 inhabitants. Within each urbanization stratum 80 interviews were held, stratified over four income groups. In this way sixteen different consumer groups were identified, each one containing about twenty observations. For each substratum, average consumption, prices paid, and scores on the attitude statements were determined.

After eliminating some statements that did not have a direct correlation to appreciation of specific product characteristics (1, 11, 12, 13, 17) the scores per crop and consumer group on the other statements were treated in a factor analysis with the varimax procedure to clarify the underlying patterns of the answers (Child, 1970). This analysis showed that four factors were able to explain 77% of the communality of the original matrix with statement scores. The loadings of the original statements on these factors are shown in Table 6.8. After careful analysis, these four factors were defined as the following product properties:

(1) Buying inconvenience, strongly associated with statements 1 to 5 in Table 6.8.
(2) Intrinsic value, associated with statements 6 and 7.
(3) In-shop availability, associated with statements 8 and 9.
(4) Short-term price appreciation, associated with statement 10.

In the next step, factor scores for each combination of crop and consumer group were obtained. Average values of factor scores per crop are presented in Table 6.9, showing clearly that cassava has an outstanding, positive value on "buying inconvenience," while its appreciation for "intrinsic value" and "in-shop availability" is average. The "buying inconvenience" of rice is low, while its "availability" is high. Potato is the product with the highest

Figure 6.1. A procedure to estimate influence of crop properties on crop consumption.

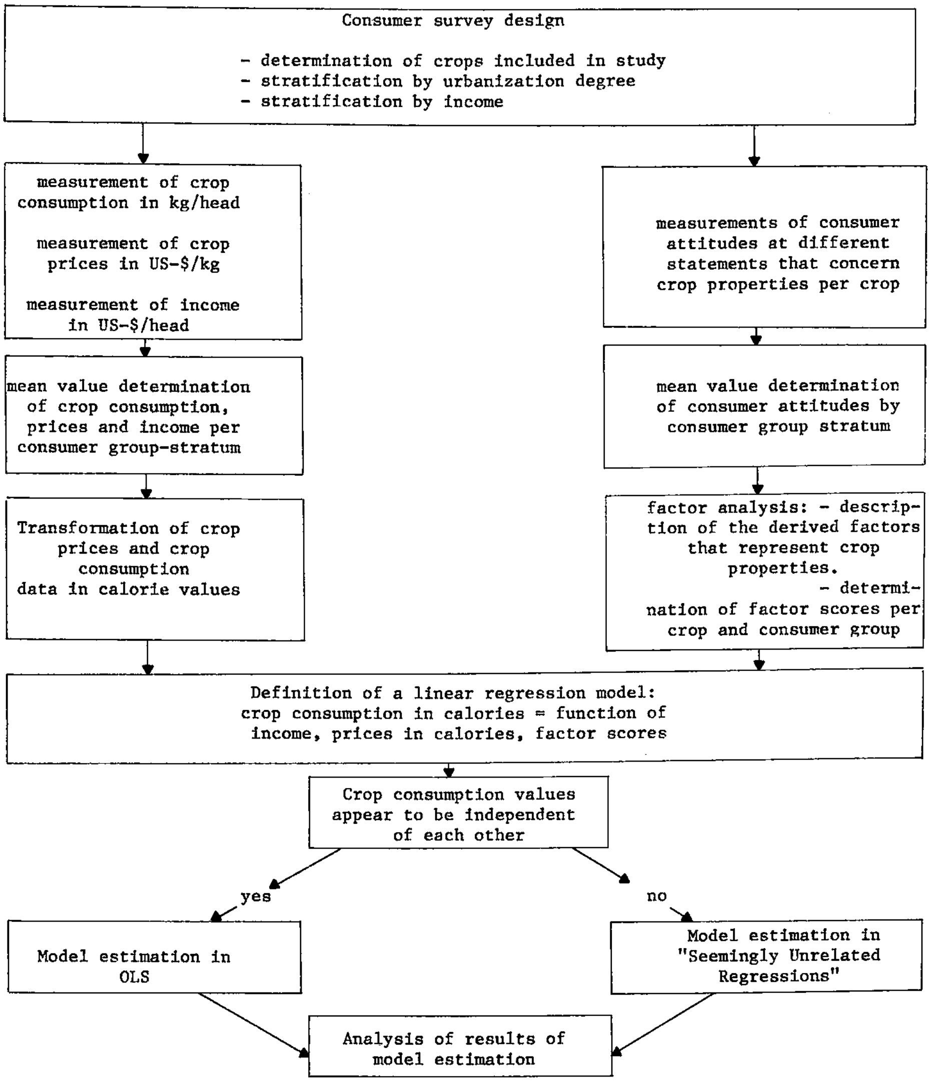


Table 6.8. Factor loadings of various attitude statements.

Statement	Factor 1	Factor 2	Factor 3	Factor 4
1. To buy this product is always risky for quality reasons	0.96	-0.08	-0.05	0.04
2. This product cannot be kept well	0.89	-0.01	-0.02	-0.14
3. Of this product a lot is wasted in the preparation	0.74	0.08	-0.17	0.47
4. The quality of this product varies strongly	0.94	-0.14	0.00	0.03
5. This product is bought on the day of consumption	0.59	-0.07	0.07	-0.11
6. This product is very tasty	0.10	0.88	0.19	0.10
7. This product is very nutritious	-0.28	0.87	-0.04	-0.09
8. This product is always available	-0.17	0.06	0.86	-0.14
9. This product is easy to prepare	0.44	0.32	0.69	-0.04
10. The price of this product has risen slowly in the last few years	-0.21	0.11	0.03	0.89
11. This product has a constant price	-0.29	-0.35	0.56	0.27
12. This product is indispensable in your daily meals	-0.22	0.26	0.51	-0.59
Communality estimation	3.97	1.86	1.85	1.51

"short-run price appreciation" score, indicating that recently its price has risen.

The model described above can now be formulated as a linear regression model in which the calorie-consumption levels of the different crops in each consumer group depend on expenditures per head, price per calorie, and the scores of the crops on the factors. Urbanization was entered through the estimation per urbanization stratum of price effect, income effect, and the "buying-inconvenience" effect.

Table 6.9. Factor scores per crop, average values of total sample.

Crop	Factor 1 "buying inconvenience"	Factor 2 "intrinsic value"	Factor 3 "in shop availability"	Factor 4 "short term price-appreciation"
Rice	-0.77	-1.00	0.85	-0.64
Potatoes	-0.35	0.08	0.00	1.20
Cassava	1.75	-0.18	0.05	0.42
Plantain	-0.69	1.42	-0.26	-0.75
Yam	0.06	-0.32	-0.89	0.64

The actual estimation of the model is complicated by the fact that consumption levels of different crops are measured in the same consumer groups. In this case it is not sure whether the error terms of the estimations are independent from each other. This brings back the issue of substitution or complementarity of the products analyzed, as it could be reasoned that since these are similar products, if consumers like one product, they also like the others. It could also be reasoned that if these products all provide calories, they will substitute each other. The surveyed crops together comprise around 30 to 50% of total calorie consumption and the correlation between consumption of any two crops had a negative sign in only one case. Substitution therefore does not appear strong. To solve the problem of dependency between consumption for different crops, be it positive or negative, the model can be estimated as a system of "Seemingly Unrelated Regressions" (Zellner, 1962 or Kmenta, 1971). This method first estimates the covariance between error terms in an Ordinary Least Squares (OLS) model, and afterwards transforms the system to take into account the estimated covariance. The effectiveness of "Seemingly Unrelated Regressions" depends on the significance of the estimated covariances between error terms.

Model results: analysis and discussion

Preliminary specifications of the regression model showed a negative relationship between the "intrinsic value" characteristic and consumption. This was caused by the fact that crops which are consumed in large quantities were consistently poorly appreciated for taste and nutritiousness. The levels of consumption of these crops might have caused a saturation feeling, in which case the causal relation would be inversed; consumption no longer depends on the appreciation of its intrinsic value, but the appreciation is determined by the high consumption levels. In that case the "intrinsic-value" characteristic has to be eliminated from the regression. Since this variable was almost ortogonal to the other variables included in the analysis, this hardly changed their regression coefficients (see Appendix 6 for correlation coefficients between variables).

Inspection of the covariance matrix of error terms showed that only three out of ten were significantly different from zero, two with a negative value (substitution) and one with a positive value (complementarity). The most significant correlation coefficient had a value of 0.4, while the average correlation of error terms was only 7%. It was decided that evidence of correlation between error terms was too weak to apply "Seemingly Unrelated Regressions" and that OLS-estimates were the best estimation alternatives.

The regression coefficients of the model and the derived elasticities are shown in Table 6.10. The R-square value of the model (0.69) and the F-value (10.34) indicate that the model is reasonably able to estimate average consumption patterns of the different consumer groups. The data show that consumption of the crops studied is not highly dependent on income. In big towns, where prices are higher than in other areas, consumption of the calorie sources included in the analysis rises slightly with income. In the other environments, consumption falls slightly when income rises. The tendencies are weak and do not allow a significant conclusion to be formulated on the relationship between income and consumption of the crops studied.

Table 6.10. Estimation results of the model to explain consumption of cassava and other starchy crops.

	Income per head (Co US-$/month)	Price US-$ calories)	Factor 1 (buying in-convenience)a	Factor 3 (availa-bility)	Factor 4 (price assessment)	Derived income elas-ticity	Derived price elasticity	Impact on cassava consumption of improvement in shopping convenience (kg/year)
Total Sample:	-	-	-	38192 (4.10)	-26710 (2.38)	-	-	-
Urbanization strata								
large towns	60 (0.27)	-221876500 (1.54)	-26544 (2.50)	-	-	0.04	-0.69	+15.6
intermediate towns	-320 (1.03)	-304472300 (2.21)	-26937 (2.28)	-	-	-0.17	-0.66	+10.9
large villages	-383 (1.00)	-3345119 (1.92)	-18556 (1.54)	-	-	-0.17	-0.62	+8.8
small villages	-267 (0.67)	-281295100 (2.21)	+8701 (0.59)	-	-	-0.13	0.70	-4.4

t-values are put in parenthesis $R^2 = 0.69$ $F^{79}_{12} = 10.34$

a To understand the impact of the factors included, one should consider the factors-scores mentioned in Table 6.9 The impact of the factor "buying inconvenience" is 26000 calories (17 kg of cassava) for each point of difference. In urban areas cassava scores for this factor are on the average 1.7 points higher than for other crops, which would decrease its consumption by about 30 kg/head/year. Halving this difference would then increase cassava consumption by about 15 kg/head/year in urban areas.

b To estimate the impact of improvement of buying convenience it was supposed that the difference of cassava's score on inconvenience with the next most inconvenient crop in a certain stratum would be halved.

The relationship between consumption and price per calorie on the other hand is reasonably strong. Three of the four estimated price coefficients were significant with 95% reliability. The fourth one, for metropolitan consumers, is only significant with 90% reliability. The lower reliability of the metropolitan coefficient is probably caused by the more uniform prices in this environment. An average calorie-price elasticity of -0.65 is estimated, indicating that consumers respond sensitively to price changes. This stresses the validity of strategies directed toward decreasing acquisition costs of food crops as a means to improve nutritional status. The calorie-price elasticities are highest in the large towns (because food prices are high and force people to be more price-conscious) and in the small villages (where prices are relatively high while incomes are low).

Availability is strongly and positively related to consumption, as expected. The well-appreciated availability of rice (see Table 6.9) seems to have a positive impact on its consumption of 12 kg/capita/year. Yam and plantain consumption are limited because the crops lack availability.

The negative sign of the "short-term price appreciation" is also as expected. When consumers thought that the price of a crop had risen, consumption dropped. Potato and yam were supposed to have experienced unfavorable price developments and their consumption consequently decreased.

The "buying inconvenience" factor has special relevance for cassava, which scored very highly on it. Cassava consumption is significantly reduced because of its "buying inconvenience." The impact of the "buying inconvenience" factor on consumption is similar in large and intermediate towns. Regression coefficients have 98% probability of significance. Since the value for "buying convenience" is lower in the intermediate than in the metropolitan towns, the "buying inconvenience" factor causes most reduction of cassava consumption in the metropolitan areas. In the large villages the effect of "buying inconvenience" is more modest than in the urban areas. Also the significance of the coefficient (93%) is less. In the small villages, the relationship between "buying inconvenience" and consumption is positive, implying that the more inconvenient a product, the more it is consumed. The estimate for the small villages is not significant and probably implies that "buying inconvenience" does not influence consumption in this environment.

The effect of cassava's "buying inconvenience" has been estimated by reducing cassava's score on this factor in comparison with the next highest score of any crop (For example, in Table 6.9 cassava has a score of 1.75 and yam of 0.06. The cassava score is reduced to 0.90). Since "buying inconvenience" was higher in the large towns, the effect would have been biggest here, around 16 kg/head per year decrease in consumption. In intermediate towns and large villages the effect would have been 11 and 9 kg/head per year.

The answers to the statements that composed the "buying inconvenience" factor suggest that it is strongly related with cassava's postharvest deterioration and storage problem. Effective control of this adverse quality factor would convert the crop into a much more attractive product for urban consumers. Adequate fresh cassava storage would allow cassava to maintain or increase its role as a staple calorie source even with rapid urbanization occurring.

6.6 Dried cassava consumption

Dried cassava is used as a calorie source in compound animal feed. Production of dried cassava in the region only began in 1981, as a pilot project; by 1985 some 3000 tons of dried cassava were being produced. The demand of the animal feed industry greatly exceeds present production, and competition within the industry to acquire dried cassava is strong. To measure the demand for dried cassava a questionnaire plus a sample of dried cassava was mailed to all Colombian animal feed factories and to half the population of integrated (i.e. producing their own compound feed) pig and poultry producers. It was decided to mail the questionnaires, since this would enable the factory decision-makers to determine the extent of their interest in dried cassava by consultation with other information sources within or outside of their management teams.

This method provided a better imitation of the decision-making process than a personal interview with the purchasing manager (Sheth, 1973). Because of the interest industries have in dried cassava, motivation for replying (see Tull and Hawkins, 1984) was expected to be high. Over 70% of the industrial force returned the completed questionnaire.

The animal feed industry

Production of animal feed in Colombia has been growing rapidly in the past 15 years. Between 1970 and 1981, animal feed production grew at a rate of 8.6% per year. Its growth has been fueled by increasing per capita incomes and the related rise in demand for animal products. Although beef is the traditional meat of Colombia, its production did not increase quickly enough (Hertford and Nores, 1982) to meet the demand. The poultry sector reacted most swiftly. Based on the introduction of improved layers and broilers and modern husbandry techniques, egg and poultry meat production experienced a very rapid growth, and 75% of all compound feed production goes to poultry (Table 6.11). More recently pork production in Colombia has started to grow rapidly, due to improved management and hygiene. Intensive dairy production close to urban areas is a last source of growing animal feed demand.

Close to one and a half million tons of balanced feed was produced in 1984. Production is spread over some 50 animal feed producers and some 150 integrated pig and poultry producers. The estimation is that 150,000 tons is produced by integrated pig and poultry producers and the rest by the compound feed industry. Three companies (Solla, Purina, and Finca) control 45% of feed production. Figure 6.2 shows that the distribution of animal feed production in Colombia is concentrated around Bogota, Medellin and Cali, with some secondary demand centers in the Atlantic Coast region and around Bucaramanga.

The rapid growth of animal feed production has led to an even more rapid growth of demand for specific animal feed raw material. In the early years, the animal feed industry relied greatly on by-products of other agroindustrial processes, such as

Table 6.11 Animal feed production in Colombia, 1984.

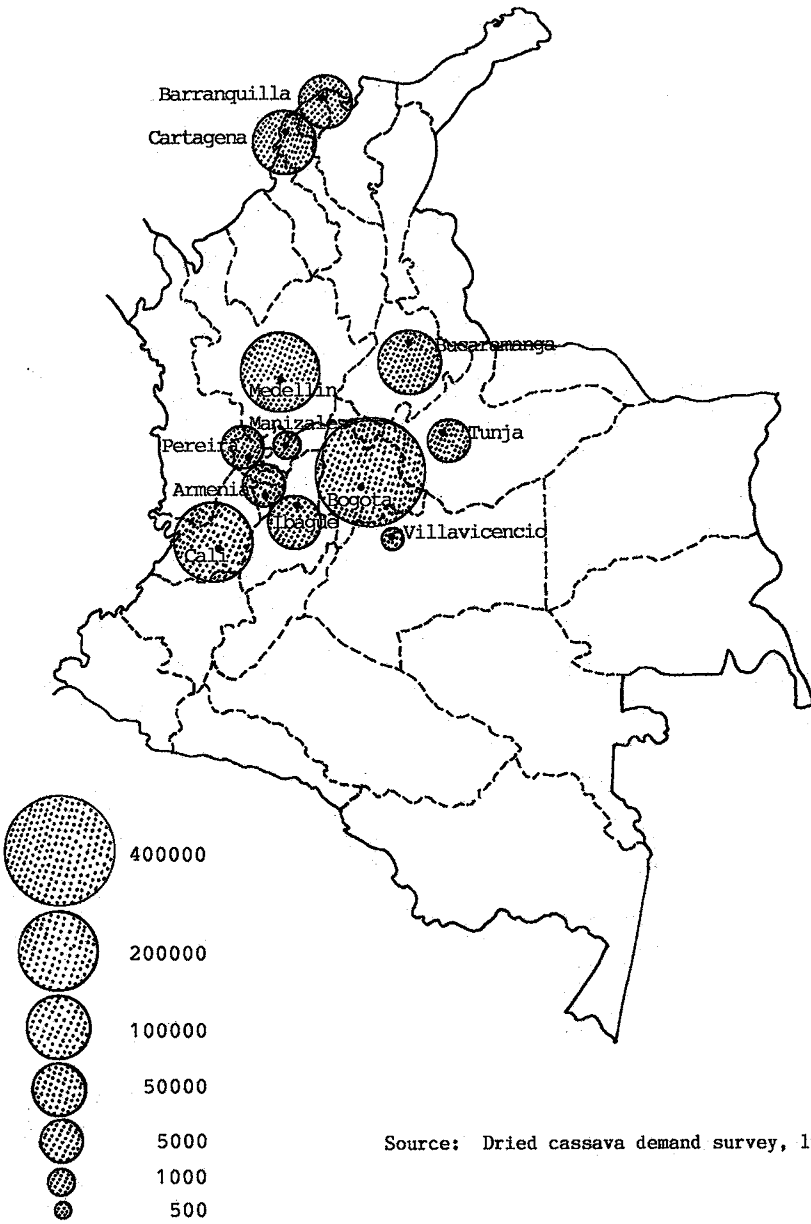
	Production (000 tons)	% of total production
Animal feed for:		
Layer-hens	790.7	51.5
Broilers	372.6	24.3
Pigs	219.7	14.3
Cattle	130.3	8.5
Others	22.1	1.4
Total	1,535.6	100.0

Source : FEDERAL: Estadisticas Basicas de la Agroindustria de Alimentos Balanceados para animales. Bogotá, 1984.

rice meal, cotton by-products, and molasses (Figure 6.3). Since the growth rate of by-product availability is far below the one of animal feed production, a demand gap was created which stimulated production of crops such as sorghum and soybean. At present these two products absorb almost 60% of total spendings in raw material of the industry (Table 6.12).

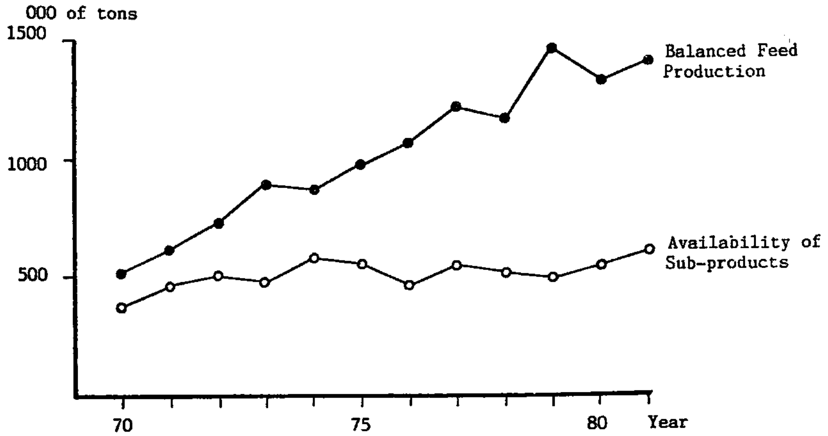
In the animal feed industry, raw material makes up 80% of total costs (FEDERAL, 1984). Animal feed producers are very sensitive to relative prices of different raw materials. Dried cassava is used in animal feed to replace sorghum. According to the linear programming models used to determine the composition of balanced feed, dried cassava has a value that is between 80 and 85% of the sorghum price, depending on price and availability of protein sources and other nutrients. In Colombia soybean meal is the most important protein source. Based on a simple method developed by Newby (1982), who states that the price of a product can be calculated by considering its protein and its calorie contents, a first approximation for the value of dried cassava would be:

Figure 6.2 Localization of balanced animal feed production in Colombia, 1984, tons.



Source: Dried cassava demand survey, 1985

Figure 6.3 National balanced animal feed production, and availability of sub-products used in the animal feed industry 1970-1981.



Growth Rates:

Balanced feed production	:	8.6%
Availability of by products	:	2.3%
Difference	:	17.5%

Source: FEDERAL: Estadisticas Basicas de la Agroindustria de Alimentos Balanceados para Animales, Bogota, 1984.

$P_{ys} = 1.2 * P_{sr} - 0.2 * P_{sy}$

where P_{ys} = Price of dried cassava per ton

P_{sr} = Price of sorghum per ton

P_{sy} = Price of soybean meal per ton

This formula reflects the fact that 1.2 tons of sorghum is roughly equivalent to 1.0 ton of dried cassava and 0.2 ton of soybean. Using this formula to calculate the value of dried cassava, a similar price to the one from the linear programming models results.

The growth of the Colombian animal feed industry has been restricted by lack of raw material, making animal feed producers willing to pay a premium price for feedstuffs. The value of a raw material also depends on the balanced feed formula used. The value of a certain product should not be seen as a rigid number, but as an indication of the price level where demand will settle.

Table 6.12 Prime material purchases by the Colombian animal feed industry, 1984.

Product	Volume (%)	Expenditures (%)	Estimated expenditure (US$ x 10^6)
Sorghum	51	42	190
Maize	2	1	6
Soya meal	11	17	76
Cotton meal	4	4	18
Fish meal	4	7	32
Rice meal	8	6	27
TOTAL	80	78	349

Total expenditures in prime material : ± 447 million US-dollars

Source: Dried cassava demand survey, 1985

Demand for dried cassava in Colombia

The mailed survey was used to estimate national demand for dried cassava at three different price levels and at the assumption of six months per year or year-round availability. Estimates are shown in Table 6.13. At a price level of 175 US dollars per ton (73% of the sorghum price) demand for cassava would be 140,000 tons if available for six months and 210,000 tons if available the whole year through. At 194 US dollars per ton demand would be 35% lower and at 217 US dollars per ton it would be 60% lower. Demand is strongly price-elastic. From the half yearly data, a (arc-)price elasticity of demand at factory level of -4.18 can be calculated. The resulting (arc-)price elasticity of demand at farm level would be -3.18. The elastic dried cassava demand could contribute to more stable on-farm cassava prices.

At present, natural drying systems (through which dried cassava can be supplied in the first six months of the year) are adequate for supplying the industry. Estimated demand is 30 times bigger than actual production. In case the half yearly demand were

Table 6.13 Dried cassava demand in Colombia, 1984.

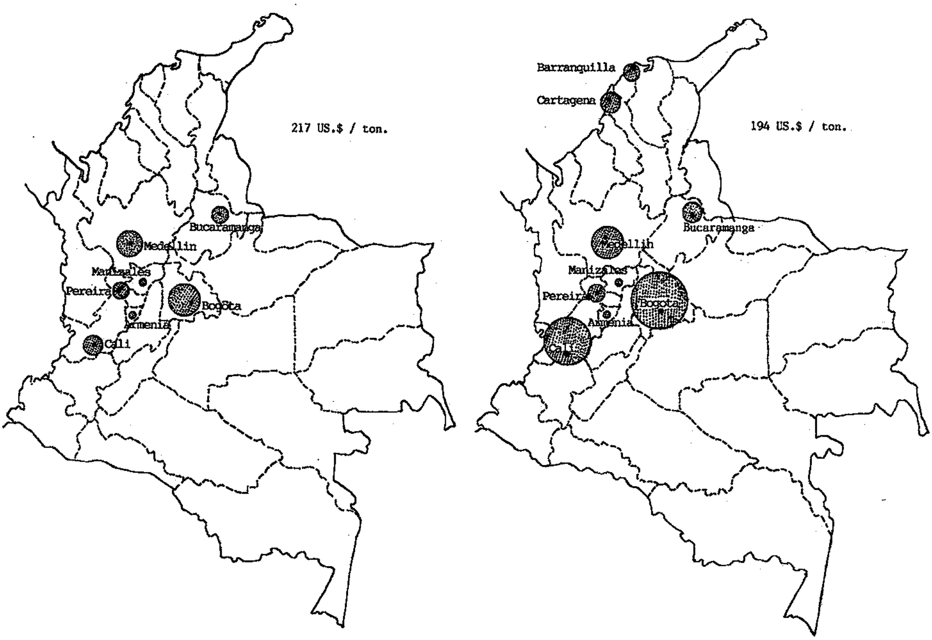
	Available during six months per year		
US-$/ton	175	194	217
Dried cassava demand (tons)	140,000	87,000	51,000
	Available during the whole year		
US-$/ton	175	194	217
Dried cassava demand (tons)	210,000	144,000	80,000

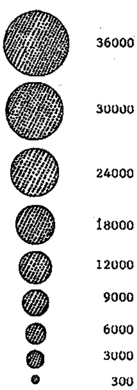
Source: Dried cassava demand survey, 1985 (Table 3.1).

saturated, storage of dried cassava through the rest of the year is probably more effective than artificial drying, which turns out to be rather expensive (Lema and Mendez, 1984).

Localization of dried cassava demand at different price levels can be seen in Figure 6.4. Most dried cassava demand is located in the center of the country, especially at higher price levels. Even at the highest price level, however, some 15,000 tons of dried cassava would be in demand in the easily accessible Medellin and Bucaramanga markets. At the intermediate price level, 27,000 tons, and at the lowest price level, 33,000 tons would be demanded in easily accessible markets. The large demand in remote areas indicates that reducing transport cost is vital for further development of the drying industry.

Most dried cassava would be used in layer-hen rations, followed by pig rations. Table 6.14 shows that its inclusion in pig and cattle rations would be overproportional, while its inclusion in broilers and layers rations would be less than proportional. Since production of cattle and pig rations has lately been growing faster than production of poultry rations, future demand for dried cassava might grow quicker than total demand of the animal feed industry.





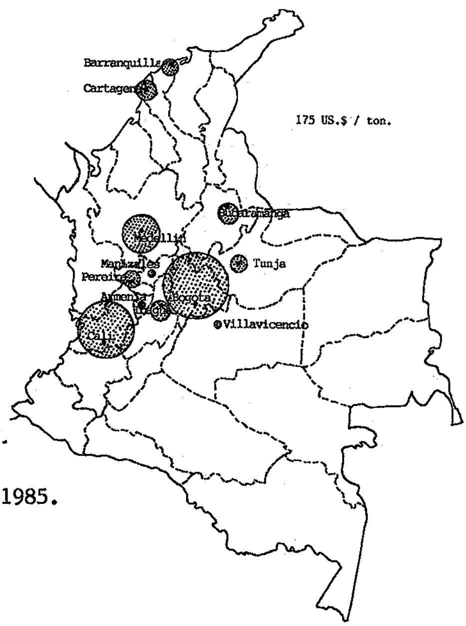


Figure 6.4. Dried cassava demand localization in Colombia at different price levels, 1985, tons.

Source: Dried cassava demand survey, 1985.

Table 6.14. Dried cassava demand in Colombia, by production line, 1984.

Production	% of total dried cassava demand	% of total animal feed production
Layer-hens	41	52
Broilers	19	24
Pigs	26	14
Cattle	13	9
Other	1	1
TOTAL (000 tons)	140	1,536

Source: Dried cassava demand survey, 1985 (Table 3.1).

The animal feed producers were asked if they had preference for a specific product appearance or packaging. There was a 20% greater demand for pelletized cassava because of its better flow characteristics. At present, with sufficient market opportunities nearby, pelletization is not necessary, although it will become increasingly attractive for decreasing transport costs to remote markets and for increasing demand. Dried cassava in bags was preferred over bulk, because only 20 % of the storage capacity listed in the questionnaires was in the forms of silos while the rest was in warehouses. Storage capacity of the industry amounted to 29% of the annual production, or roughly three months of production.

The quality exigencies formulated by the animal feed industry can be reasonably satisfied. Table 6.15 compares quality exigencies by the industry with presently delivered quality. Metabolizable calories and protein content are higher than the norm values, while fiber, ash, and cyanide contents are lower than the norm values. Only the humidity value would not match the wishes of the industry. The value put up by the industry might be influenced by

Table 6.15. Quality exigencies by potential dried cassava purchasers, 1985.

	Quality exigencies	Actual quality characteristics
Metabolizable calories (cal)	3378	3400
Protein (%)	3.07	3.1
Fibers (%)	4.00	3.4
Ashes (%)	3.25	2.0
Cyanide (ppm)	62	56
Humidity (%)	11.8	12.6

Source: Dried cassava demand survey, 1985 (Table 3.1).

their experience with grains, which can be dried to a lower humidity level than cassava.

Only five percent of the responding plants would have to purchase additional equipment to begin including dried cassava in their feed mixes. For the other companies present equipment is sufficient for processing.

Some additional advantages and disadvantages of dried cassava were mentioned in the respondents' questionnaire comments: disadvantages were the extra care needed to avoid cyanide problems, the limited amounts to be included in high protein mixtures, and the fact that the product comes available at the same moment as the second semester sorghum harvest; advantages include decreased dependence on imported cereals, dried cassava's ease of storage, and the low financial costs in the use of the product since it could be supplied during a six-month continuous period.

If the dried cassava industry maintains its 8% growth rate, demand for dried cassava could be around 200,000 tons by 1990. At the same time, animal feed producers would become more familiarized with the product and might want to use more than was expressed in this study. A demand of 200,000 tons of dried cassava implies a demand of 500,000 tons of fresh cassava, almost equal to the total production of the Atlantic Coast region at present. The demand for animal feed opens up great possibilities for expanding the role of cassava cultivation in the region.

6.7 Conclusions on cassava consumption in the Atlantic Coast region

Fresh cassava consumption levels in the Atlantic Coast region are mainly determined by urbanization. Consumption falls strongly from the rural, producing areas (annual consumption of 80 kg/head for purchasers) to the large urban areas (annual consumption of 30 kg/head for purchasers). The importance of the urban markets on price formation is less than would be expected on the basis of population.

The simple use of income elasticities hides significant information about the development of food patterns. Instead of the actual increase of the food budget, other tendencies that occur at the same moment might be responsible for these changes. This study found the improved marketing for non-native products (rice, potato), as caused by improved road infrastructure, to be an important mechanism for explaining cassava consumption decreases in the rural areas. The trend towards more convenient foods, as caused by urbanization, is an important factor behind cassava consumption decreases in the urban areas and also explains the greater importance of processed cassava products in these areas. Identification of these tendencies is essential for appropriate food consumption analysis and policy conclusions.

Cassava consumption does not depend on income, although the observed price elasticities were highest for the poor. Consumption levels for purchasing consumers were almost equal in all income strata. Since consumption of other staples increases with income, cassava has relatively more importance for the poor than for the rich. Among producers, fresh cassava is eaten less on the small farm (annual consumption of 155 kg/head) than on the large farm (182 kg/head), but small farmers eat it more frequently and obtain a larger share of their staple calories from cassava. Increasing the availability of cassava would be of more benefit to poor than to rich consumers.

Fresh cassava purchasing habits are influenced by its bad storage qualities, making the average quantity purchased considerably smaller than for other products. Consequently the shopping effort for cassava is high. Cassava is often purchased in retail outlets close to the house, even although these outlets are rather expensive. Reducing the purchasing effort appears to be an important path to increasing cassava consumption.

In comparison with crops such as rice, plantain, potato, and yam, the appreciation for cassava's taste, ease of preparation, and nutritional value is good. However, the attitude regarding its quality, purchasing effort, storage, and waste are bad, especially in the urban environment. Consumers in the urban areas consider the crop less indispensable than consumers in rural areas. A factor analysis showed that cassava had a marked score on an attitude complex that could be described as "buying inconvenience." Reduction of cassava's score on this factor could increase its consumption by nine kilos in the larger villages and by sixteen kilos in the metropolitan area. Since the "buying inconvenience" factor is related with its bad storage quality, effective storage improvement could have a positive effect on cassava consumption.

Dried cassava consumption is small at present, basically because of limited processing capacity. However the demand for dried cassava is large and very price-elastic. If the animal feed industry maintains its historic growth rate, demand for dried cassava could equal 200,000 tons by 1990. Dried cassava could replace imported sorghum and would reduce the dependency of Colombia on imports. Dried cassava would find its highest use in pig and cattle rations, two of the fastest growing animal feeds. Most dried cassava demand is concentrated in the center of the country, but there is sufficient demand in areas close to the region to guarantee successful further development of the drying industry. Pelletization might become useful in the near future, to decrease transport costs and to improve product flow.

Improvement of fresh cassava improvement through storage technology as well as development of dried cassava consumption for animal feed are feasible strategies for increasing the role of cassava in the Atlantic Coast region. The two strategies would have different beneficiaries. Fresh cassava storage technology would increase the convenience of the crop and would have most impact on consumption levels in the urban areas, especially among the poor, who are most dependent on fresh cassava. This would allow modest market expansion and therefore modest small farmer income increases. Dried cassava demand would almost double cassava production. Dried cassava would benefit the animal feed industry, which is in constant need of raw material, and would greatly increase income perspectives for the small farmer by opening up a market with large and rapid growth potential.

1) These questions treated the quantity of cassava prepared per meal, the numbers of meals with cassava, and the number of persons for whom the meals were prepared. The three year time span was chosen because a major public disaster (the collapse of the Sincelejo bullring in which 200 people died) clearly recalled by most people took place three years ago. When possible, the moment was also refreshed by referring to the age of the youngest child. Consumption habits change slowly and infrequently in the Atlantic Coast region, so it was hoped that the obtained data would be reasonably reliable.

Chapter 7: A MODEL OF THE CASSAVA MARKET SYSTEM IN THE ATLANTIC COAST REGION

7.1 Model structure and characteristics

A simulation model was constructed to forecast the future development of cassava production, marketing, and consumption, which might result from drying industry growth or fresh cassava storage improvements. This simulation model integrates the knowledge on production, marketing, and consumption in order to investigate what the effect of changes in one part of the marketing channel would imply for the other parts. In this chapter the general characteristics of this model will be exposed; the model equations will be discussed; and the model will be applied to simulate possible developments in the cassava system.

The simulation model has a recursive nature. Prices that are formed in one year determine the supply in the next year. This supply in turn determines prices in the next year (Figure 7.1). The model has a ten year time horizon, which appears to be a reasonable compromise between the time needed to introduce changes in the market system and the reliability of forecasting. The sensititivity of the results obtained is measured by varying critical model parameters. This helps to analyze different events that might occur (e.g. ex-ante evaluation of different market development alternatives), as well as to analyze the robustness of the model.

Cassava yields have a stochastic nature in the model, because of the unpredictable effects of climatic conditions. Since cassava yields are stochastic many other variables become stochastic as well. The stochastic nature of yields and its effect on price formation complicates the prediction of year-to-year changes. The stochastic specification of the model does not improve short-term forecasts, but recognizes that short-term forecasting is only possible with large error margins. Additionally, it reflects that

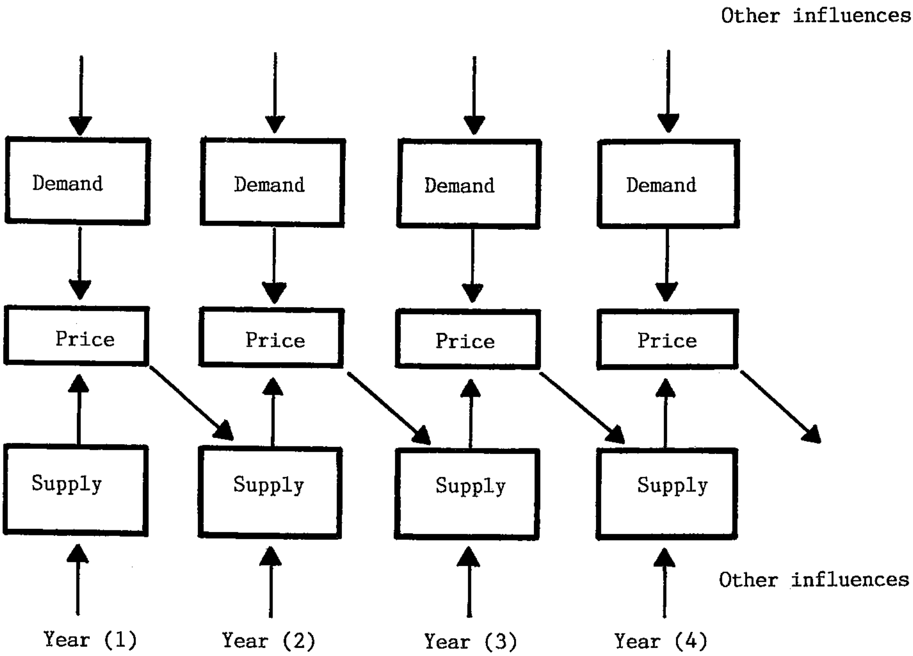


Figure 7.1. The recursive nature of the cassava system simulation model

the expected conduct of a stochastic system is not equal to the conduct of a similar, deterministic system (Dent and Blackie, 1979).

To obtain reliable forecasts on the expected development of the cassava system, 25 runs for each simulated situation were executed (Dent and Blackie, 1979). The data from these runs were averaged to obtain means and standard deviations of model variables. Since the repeated execution of the model is relatively costly in terms of computer time, certain developments were evaluated with deterministic runs.

The simulation model has a partial equilibrium nature. It considers how the development of the overall economy influences the cassava market system, but does not calculate the effect of changes in the cassava market system on the overall economy. The *ceteris paribus* assumptions made, underscore the need to make careful interpretation of model results within the context of the predicted economic development. The <u>ceteris paribus</u> nature stresses the importance of adequate forecasts of overall economic development to obtain reliable predictions. The model, however, still maintains part of its value by comparing the effects of alternative market improvement strategies, even if future developments are not correctly forecast.

The simulation model is mainly specified in linear equations, estimated on the basis of the production, marketing, and consumption analyses of the previous chapters. The linear specifications follow from the linear relationships estimated before, facilitating the transformation from the structural form (the model equations) to the reduced form (the computer algorithm). Within the intra- and extrapolation used, linear specifications do not affect the robustness of the forecasts. The computer model used to estimate the developments in the cassava system is presented in Appendix 7. Here the structure of the model, in which six components can be distinguished, will be discussed (Figure 7.2).

The first component is the consumption component (Equations 1-8). Seven consumption segments are distinguished: the demand for cassava in metropolitan areas; urban areas; rural areas; among producers; for processing in starch or snacks; for the animal feed industry; and for on-farm animal feeding or processing. The model concentrates on fresh cassava and dried cassava demand development. Demand for processing into snack foods or starch is included in a less comprehensive way. Demand for on-farm swine feeding and for on-farm processing is considered to be a lump sum, equal in every year.

The second component is production (9-19). Three production segments are distinguished: small farmers; middle sized farmers; and large farmers. Cassava production is determined by area planted and yields. Since yields are stochastic (to simulate weather influences), total production is also stochastic. Production depends on prices realized in preceding years according to a distributed lag structure.

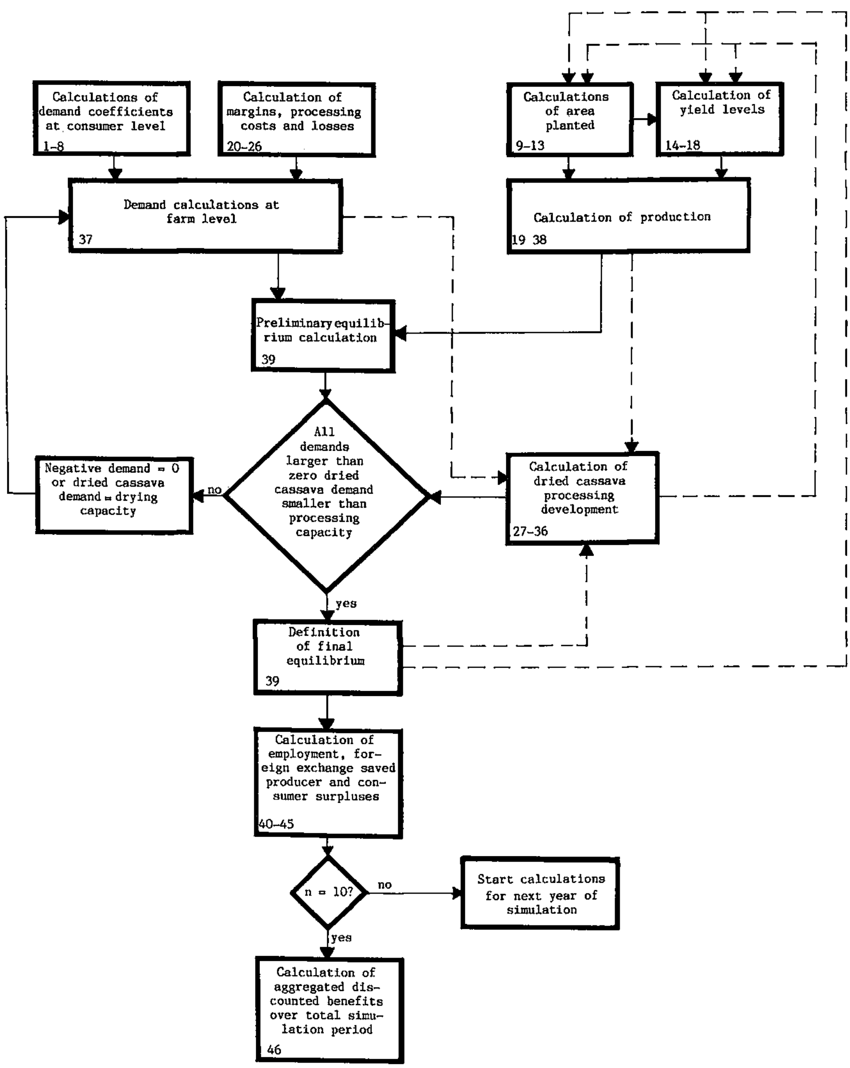


Figure 7.2. A schematic representation of the Atlantic Coast cassava system simulation model.

Notes:
- Closed lines indicate the effect within one year of simulation, interrupted lines indicate the effect from one year to the other.
- Influence of exogenous variables has been omitted from the diagram.
- Numbers in left lower corner of each block indicate equation numbers in text.

The third component is the marketing component (20-26). Marketing margins and losses in the marketing channel are specified for the various consumption zones. A processing cost function for cassava drying is specified.

The fourth component is the cassava drying capacity development (27-36). This development depends on the consumption of dried cassava in the year before, as calculated in the equilibrium conditions. If the drying capacity was a constraint to consumption, the interest in building new plants to enlarge the market is large. If capacity was underutilized, the interest in expansion will be low. Development also depends on production. If farmers notice they can produce at a low price, they will be more likely to produce extra cassava and sell it in the dried cassava market. If production costs hardly cover the price paid in the market they will not be interested in expanding production. Finally, development of the processing capacity depends on the potential demand for animal feed expressed in the previous year. If this demand was far above capacity, the stimulus to expand processing capacity will be great. In turn, the cassava drying capacity determines how much dried cassava can be consumed, and consequently, how many farmers will find their market perspectives improved and will respond by expanding their production.

After the model has calculated the parameters of the first four components, the fifth component defines equilibrium price and quantities of cassava consumed per market segment (37-39). After a preliminary calculation of equilibrium price and quantities, these are checked for feasibility. If any demand is negative or exceeds processing capacity, it is constrained and the equilibrium is recalculated until a feasible solution is found. The equilibrium price that is found is fed back to the production component to determine supply for the next year.

The sixth component measures potential benefits of different cassava market development strategies (40-46). Employment in production, processing and marketing (in rural as well as urban areas) is calculated. Savings in foreign exchange by substituting dried cassava for sorghum are measured. Benefits for consumers and producers are estimated by the shift in consumers' or producers' surplus. This is done for every single year of simulation. As long as the last year of simulation (year 10) has not been executed, the program will run the next year of simulation after execution of the benefit component. If year 10 has been simulated, aggregated discounted benefits over the total period are calculated to obtain the present net value of benefits.

7.2 Specification of model components

The consumption component

Fresh cassava and dried cassava consumption equations were estimated on the basis of the consumption questionnaires, while cassava demand for processing into starch and snackfood is based on rough estimations of consumption in 1983. The consumption equations are as follows:

Fresh cassava consumption:

$$QF_{ij} = (A_i - b_i*P_{ij} + c_{ij}*d_i^{\,j}*I_i) *e_i^{\,j}*f_i^{\,j}*g_i^{\,j-t} \quad (1)$$

Cassava consumption for starch and other processed products:

$$Q_{5j} = (90000 - 833(P_{4j} - 8)) * d_3^{\,j} \quad (2)$$

Dried cassava consumption:

$$PSOR_j = PSOR * h^j * k^{j-t_1} \quad (3)$$

$$PSOY_j = PSOY * 1^j * m^{j-t_2} \quad (4)$$

$$PSHA_j = 1.2*PSOR_j + 0.2*PSOY_j \quad (5)$$

$$QYS_j = (61675 - 1387(PYS_j - PSHA_j))*(1 + 2(d_1 - 1)) \quad (6)$$

$$Q_{6j} = 2.5 * QYS_j \quad (7)$$

Cassava demand for on-farm feeding and processing:

$Q_{7j} = 63000$ (8)

in which,

QF_{ij} = Fresh cassava consumption in consumption stratum i in year j (tons/year)
A_i = Intercept of fresh cassava consumption equation in stratum i
b_i = Price coefficient of demand in stratum i
P_i = Price for fresh cassava in stratum i (US$/ton)
c_i = Income coefficient of cassava consumption in stratum i
d_i = Unity + income growth rate per year per head in stratum i
I_i = Initial income per head in stratum i (US$/year)
e_i = Unity + population growth rate per year in stratum i
f_i = Unity + present demand change per year in stratum i
g_i = Unity + consumption change per year if cassava storage is successfully introduced
t = Year of introduction of cassava storage technology
Q_{5j} = Cassava demand for starch and snack food production
$PSOR_j$ = Domestic sorghum price in year j (US$/ton)
$PSOY_j$ = Domestic soybean meal price in year j (US$/ton)
$PSHA_j$ = Shadow price of cassava in year j (US$/ton)
QYS_j = Demand for dried cassava in year j (tons)
PYS_j = Dried cassava price in year j (US$/tons)
Q_{6j} = Demand for cassava as animal feed in fresh cassava equivalents
Q_{7j} = Cassava demand for on-farm feeding and processing
h = Unity + growth rate of domestic sorghum price until year t_1
t_1 = Year in which sorghum price trend changes
k = Unity + growth rate of domestic sorghum price after year t_1
l = Unity + growth rate of domestic soybean meal price until year t_2
t_2 = Year in which soybean meal price trend changes
m = Unity + growth rate of domestic soybean meal price after year t_2

In the present specification quantities consumed depend on price. However, given the recursive nature of the simulation model, first the actual quantity is defined and the price is calculated afterwards. If the price depends on the quantity, the procedure to estimate their relationship should put the price as the dependent variable. Outcome of this analysis would not necessarily be similar to the case where the quantity is the dependent variable. Since the probable difference falls within the error margins of the model, the estimation procedure (in which quantity depends on price) has been maintained.

Ad 1) Aggregate fresh cassava consumption depends on price, the income per capita level, and the population size. The term f is below one and indicates that at present, cassava demand is falling. If fresh cassava storage is introduced this decrease would be counteracted by an increase equal to the term g. Fresh cassava demand per head would increase for three years and afterwards stay constant. Three years after introduction of storage technology, $f_i^{j} * g_i^{j-t}$ will be fixed at its last value. Cassava storage technology only has an effect in the first three years, which reflects the quick impact it is expected to have on cassava consumption. The assumption that cassava consumption per capita will stay constant after introduction of storage technology, is a rather optimistic one. One of the sensitivity analyses applied, will be to estimate what happens if fresh cassava demand does develop less favorably.

The parameter estimates of fresh cassava consumption are shown in Table 7.1. Price elasticities of -0.5 for producers and rural consumers, -0.68 for intermediate urban, and -0.75 for metropolitan consumers are assumed. The price elasticity for producers reflects the attraction of selling versus consuming in years with high prices. The income effect for cassava was estimated slightly positive, equal to an income elasticity of 0.03. Measured incomes were highest in the intermediate urban areas, but are growing most quickly in the large metropolitan centers. The metropolitan area has a population of 1.6 million people, the intermediate urban area 0.57 million and the rural areas 1.73 million inhabitants, with 0.9 million people producing their own cassava (Hulsbosch, 1981 and DRI, 1983). Population growth rates were

Table 7.1. Value of parameters in the cassava demand equations.

Model parameters	Metropolitan area	Intermediate urban area	Rural area	Producers
i (stratum)	1	2	3	4
A (intercept)	83960	50301	210810	225432
b (price coefficient)	92.6	85.3	305.1	985.5
c (income coefficient)	0.024	0.012	0.078	0.128
d (1.0 + income growth rate)	1.03	1.02	1.02	1.01
I (income/head)	600	768	552	360
e (1.0 + population growth rate)	1.039	1.045	1.019	1.0
f (1.0 + present demand change)	0.96	0.98	0.97	0.99
g (1.0 + demand change after storage introduction)	1.10	1.06	1.05	1.00
P (price)	395	243	235	80

obtained from Hulsbosch (1981), while the figures for the fall and possible revival of cassava consumption were obtained from the analysis of the consumption survey, described in Chapter 6.

Ad 2) Cassava consumption for starch and snack foods equals some 30,000 tons and has a price elasticity of -2.0. The elasticity of -2.0 is based on the assumption that the demand in this segment is more elastic than for fresh cassava but less elastic than for animal feed. Model results are not very sensitive for the value of this parameter. The growth of cassava demand in this segment is considered to be slightly below overall income growth and was put equal to the growth of rural income. The starch and snack food producers can buy cassava at a discount price, because they offer a certain market security to the farmer and do not require the same commercialization costs as in the fresh market. The discount of eight dollars is half the value of the discount that can be paid by the cassava drying plants, which offer better sales conditions.

Ad 3-7) Dried cassava demand depends on income growth per capita, and on the difference between its market price and its shadow price. This shadow price is derived from the sorghum and soybean meal price using Newby's formula (1982). Prices for sorghum and soybean meal are determined in equations 3 and 4. These prices are sensitive to political decisions. The trend of these prices can be changed at any moment t_1 or t_2 according to best expectations. The price parameter was estimated assuming that 70% of the total dried cassava demand in Colombia would be supplied from the Atlantic Coast region. Although cassava drying could also develop in other areas of the country the potential of the other zones is much lower than the potential in the Atlantic Coast region (CEGA, 1985). The expected growth of dried cassava demand of 6% per year is a conservative estimate, given the 8.6% feed production growth experienced in the 1970's. Equation 7 converts dried cassava demand to its fresh cassava equivalents.

Ad 8) Cassava for on-farm feeding and for on-farm processing is fixed at 63,000 tons (consisting of non-commercial roots). This is equal to 600 kg. per farm per year.

The production component

Cassava production was estimated by comparing statistics from the Ministry of Agriculture, data from the reconnaissance survey, the production and farm marketing survey, the market risk survey, and data on aggregate consumption. The official data tend to overestimate yearly cassava production; instead of the 690,000 tons estimated a production of some 560,000 tons is more likely. Of this amount some 72,000 tons would be lost because of deterioration or root diseases. Official figures quoting yields of nine tons per hectare are probably exagerating by two tons. Data on land distribution indicate that some 32% of all cassava is produced by farms smaller than five hectares, 30% by farms between five and ten hectares, and 38% by farms with more than ten hectares of land.

Yields and areas planted depend on cassava prices, as observed in Chapter 4. The reaction to prices is considered to be of a distributed lag nature, with farmers reacting on the basis of prices observed in the years before. Since cassava prices are very unstable, the influence of the last observed price on the planting decisions will be limited, implying a rather big lag. The research into cassava production did not permit an estimation of the lag size, and a value of 0.75 has been assumed. This is a high value but is in accordance with the supply estimation survey of Askary and Cummings (1976).

The following equations to estimate area planted remain:

$$A_{nj} = C_n(1 + r_n*S_j) + 0.75*A_{nj-1} + o_n*P_{4j-1}*(1 + r_n*S_j) \quad (9)$$

$$AF_{nj} = C_n + 0.75\ AF_{nj-1} + o_n*P_{4j-1} \quad (10)$$

$$A^n{}_{nj} = AF_{nj}*(1-S_j) \quad (11)$$

$$A^a{}_{nj} = A_{nj} - A^n{}_{nj} \quad (12)$$

$$AREA_j = A_{1j} + A_{2j} + A_{3j} \quad (13)$$

The following equations explain the yield levels:

$$Y_{nj} = CY_n(1 + ry_n*S_j) + 0.75*FY_{nj-1} + oy_n*P_{4j-1}*(1 + ry_n*S_j) \quad (14)$$

$$YF_{nj} = CY_n + 0.75*YF_{nj-1} + oy_n*P_{4j-1} \quad (15)$$

$$Y^a{}_{nj} = \frac{(Y_{nj} - YF_{nj}*(1-S_j))}{S_j} \quad (16)$$

$$FY_{nj} = \frac{(Y^a{}_{nj}*A^a{}_{nj} + YF_{nj}*A^n{}_{nj})}{A_{nj}} \quad (17)$$

$$YR_{nj} = FY_{nj}*N(1,\ 0.13) \quad (18)$$

The following equation explains the production level:

$$QP_{nj} = A_{nj}*YR_{nj} \quad (19)$$

in which,

A_{nj} = Area planted by farms of size group n in year j (ha)
C_{nj} = Estimated intercept of the area equations
o_n = Short-term price coefficient of group n
P_{4j-1} = Farm gate price, lagged one year
r_n = Increase in price responsiveness due to market stabilization, caused by the presence of a cassava drying plant
S_j = Percentage of the Atlantic Coast region with drying plants and therefore with stabilized market perspectives
AF_{nj} = Area planted if no market stabilization would occur
$A^n{}_{nj}$ = Area planted at farms in zones without drying plants
$A^a{}_{nj}$ = Area planted at farms in regions with drying plants
$AREA_j$ = Total area planted in year j
Y_{nj} = Planned yield in farm group n before correction for the change occurring in the area planted
CY_n = Intercept of the yield equation
ry_n = Increase in the yield-price responsiveness because of market stabilization
oy_n = Price coefficient of group n
YF_{nj} = Planned yield in farm group n on farms in zones without drying plants
$Y^a{}_{nj}$ = Planned yield in farm group n on farms in zones with drying plants
FY_{nj} = Average planned yield of farm group n after correction for the increase in area planted by farms in zones covered by drying plants
YR_{nj} = Realized yield
$N(1, 0.13)$ = Normal distribution generator with mean 1 and standard deviation 0.13 to simulate the weather effect
QP_{nj} = Total production by farm group n in year j

Ad 9-13) The area planted depends on the historic price of cassava and the area planted in the year before. Market stabilization by cassava drying plants would increase the reponsiveness to prices through the factor r_n. This factor is weighed with the percentage of the region where market stabilization has occurred through the factor S_j. The distributed lag structure slows down the effect of market stabilization on the area planted. Additionally the area planted is separated into the area of farms in zones with drying plants and areas without drying plants, for correct weighing with yields (10-12)[1].

Ad 14-17) As in the case of area planted, yields depend on the price, the yield in the year before, and the presence of drying plants. Yield figures are corrected for the fact that farmers in zones with drying plants not only plant a larger area, but also produce higher yields[2]. The expected yield in each year is given by FY_{nj} in equation 17.

Ad 18) Realized yields are rarely the same as expected yields since the weather has an unpredictable influence on them. To include this the expected yield is multiplied with a normal distribution with a mean of 1.0 and coefficient of variation of 0.13. The yield variability introduced would explain all price variability in on-farm and retail prices. Supply changes are considered to be the only source of price variability. If area, yields, demand, and supply coefficients are known, then yield variability can be derived from farm gate price variability (Appendix 8). The coefficient of variation of 0.13 for aggregated yields is considerably below the value of 0.33, found for the yield fluctuations of the individual farmer. This indicates that yield fluctuations of individual farmers are evened out to a large extent.

Ad 19) In this equation production per farm group is calculated by multiplying yields with areas.

Coefficients of the production equations are shown in Table 7.2. Following the results of the quadratic programming model in Chapter 4, large farms are supposed to react more swiftly to price changes (by area planted) than are small farms. It is also assumed that the large farm will most strongly increase area

Table 7.2. Value of parameters in the cassava production equations.

Model parameters	Small farms	Intermediate sized farms	Large farms
n (farm type)	1	2	3
C (area intercept)	3932	2108	1345
o (short term area coefficient)	21.1	39.5	66.7
r (increase in area response)	0.06	0.2	0.25
Cy (yield intercept)	0.7	0.875	1.4
oy (short term yield coefficient)	0.1325	0.1094	0.0438
ry (increase in yield-response)	0.10	0.20	0.25

planted as a consequence of market stabilization. Changes in yields as a consequence of changes in price are strongest in the small farm, that has no option to increase area planted. The small farm will increase yields less than the large farm as a consequence of improved cassava marketing, since sales problems are smaller for the small farm anyway.

The marketing and processing component

Fresh cassava marketing functions have been estimated through the cassava market agent questionnaires and by the interpretation of the fresh cassava retail price series. Dried cassava processing costs were estimated through the feasibility study on cassava drying. Marketing functions calculate the cost of marketing to different consumer groups and the quantities of cassava lost because of deterioration. Because fresh cassava cannot be stored it is assumed that traders increase margins when supply is low and prices high and that they decrease margins when supply is high and prices low. This assumption would give a logical explanation for the fact that price instability at retail level is considerably higher than at farm level (Chapter 5.3) and is in accordance with other findings (Serba, 1984), relating to margin behavior for vegetables. Marketing margins and dried cassava processing costs are broken down into labor costs, interest costs, deterioration costs, transport costs, and other costs. The equations are as follows:

For dried cassava processing:

$$PYS_j = 2.5(P_{4j}-16) + 32.5*R_j + 4.5*L_j + TY_i + OC_i \quad (20)$$

For fresh cassava marketing:

$$P_{ij} = P_{4j} + ((0.375*R_j + 0.125*L_j)*P_{4j} + t_i*L_n + u_i*D_{ij} + TY_i + OC_i + TRT_j))*(1.1 + v_i*D_{ij}) \quad (21)$$

$$Q_{ij} = QF_{ij}*(1 + D_{ij}) \quad (22)$$

where:

$$D_{ij} = D_i/(j - t) \qquad \text{if } t < j \leqslant t + 3 \quad (23)$$

$$TRT_j = (j-t)*10 \qquad \text{if } t < j < t + 3 \quad (24)$$

$$D_{ij} = D_i \quad \text{and } TRT_j = 0 \qquad \text{if } t \geqslant j \quad (25)$$

$$D_{ij} = D_i/3 \quad \text{and } TRT_j = 20 \qquad \text{if } j \geqslant t + 3 \quad (26)$$

in which,

PYS_j = Price of dried cassava in year j
P_{ij} = Price of fresh cassava in consumer group i in year j
QF_{ij} = Fresh cassava consumption in consumption stratum i in year j
Q_{ij} = Fresh cassava supplied to consumer stratum i in year j at farm level
PYS_j = Price of dried cassava in year j
R_j = Nominal interest rate in year j (0.40 at the start)
L_j = Day labor wage in year j (4 US dollars per day)
TY_i = Transport cost per ton for demand segment i
OC_i = Other costs for demand segment i
P_{ij} = Fresh cassava price in stratum i in year j

D_i = Percentage losses in the marketing channel

t_i = Factor that represents the amount of contracted labor per ton of fresh cassava marketed

u_i = Value of losses in the marketing channel

TRT_j = Expected cost of storage treatment

v_i = Mark-up because of risk faced in cassava marketing

t = Year of successful introduction of a cassava storage method

Ad 20) The price of dried cassava depends on the cost of raw material and the costs of processing. Two and a half tons of fresh cassava are needed to produce one ton of dried cassava. At a sixteen dollar discount per ton, farmers are as interested in selling to the fresh as to the dried cassava market (Chapter 4.3). Processing costs consist of labor, transport, capital, and other costs and would amount to 50 US dollars per ton.

Ad 21) Fresh cassava marketing costs are composed of labor, deterioration, transport, and other costs which were identified as the major cost groups in Chapter 5. Part of the costs depend on the farm gate price and allow for a rising margin with a rising farm gate price. The fixed costs of the traders are interest on working capital and remuneration of self-labor. If volumes are low and prices high, the high price for their services will compensate for low volume. Contracted labor, deterioration losses, transport costs, and other costs are calculated per ton traded. If there is little supply, the value of deteriorated cassava rises but the chance of deterioration diminishes since it is easier to sell. The two effects are supposed to cancel out. The traders charge a margin over their cost to remunerate their entrepreneurship and risk-taking. This is estimated at 10% (e.g. Harrison, 1974). There is also a mark-up for working with a highly perishable crop. This mark-up expresses the underutilization of resources in the cassava marketing channel caused by the perishability of the product.

Ad 22) The deterioration losses in the marketing channel are included by correcting consumption at the consumer level (QF_{ij}) for the losses in the marketing channel (D_{ij}). The volume measured in Q_{ij} is the volume which is shipped off to a certain market, not the volume which is consumed.

Ad 23-26) Storage technology could decrease the losses in the marketing channel and therefore improve the utilization of resources. The cost of applying a storage method is expressed in the factor TRT, which according to preliminary studies (Janssen and Wheatley, 1985) would be some 20 US dollars per ton. The better utilization of resources is entered through the reduction of the mark-up. Storage technology is introduced in two years but the margin decrease takes three years.

Marketing margin and processing coefficients are shown in Table 7.3. The presented values would, after substitution in equation 21 and averaging for the different geographical areas, deliver the marketing costs that were described in Chapter 5.2. Costs of deterioration are largest in the metropolitan area, because the amount that deteriorates (D) and the value of the deteriorated cassava (U) are highest. Transport costs (T) for dried cassava are favorable in comparison with those for fresh cassava since full truckloads can be transported at a time. The mark-up for

Table 7.3. Value of parameters in the cassava marketing equations

Model parameters	Metropolitan area	Intermediate urban area	Rural area	Dried cassava marketing
i (stratum)	1	2	3	5
R (interest rate)	0.4	0.4	0.4	0.4
L (day wage)	4	4	4	4
D (amount of cassava lost)	0.13	0.05	0.05	-
TY (transport costs/ton)	40	21	15	12
OC (other costs)	60	39	39	5
t (amount of contracted labor)	0.0054	0.005	0.005	-
u (value of losses per ton)	320	200	200	-
v (mark-up)	3	2	2	-

underutilization (V) is higher in the metropolitan than in the other areas. The values used appropriately explain the cost differences in fresh cassava marketing for different consumer groups.

The development of the drying industry

The development of the cassava drying industry determines the degree of market stabilization and subsequent increases in area planted and yield. Lilien and Kotler (1983) quote some models that may represent such development. In most of these models the exogenous stimulus for development is constant. The development of cassava drying depends critically on the rest of the cassava system. This means that the stimulus for development is not exogenous, but should be explained within the model. Therefore its development was modeled in the following way:

$$QYS_j \leqslant CP_j \qquad (27)$$

$$POT_j = [61675(1 + 2(d_i-1)) - 1387(1 + (cd - 1))* (32.5*R_j + 4.5*L_j + TYS_j + OC_6 - PSHA_j) - QYS_j] / [(1 + 2(d_1-1))* 13873*2.5] \qquad (28)$$

$$AY_j = PROD_j/AREA_j \qquad (29)$$

$$COST_j = AY_j*2.5*L_j + 254.5 \qquad (30)$$

$$COTON_j = COST_j/AY_j \qquad (31)$$

$$STIM_j = \frac{(POT_j - COTON_j - 5)}{18.54} \qquad (32)$$

$$DCP_j = CI* STIM_j + CI*(1 - gp)*STIM_j + CP_j*gp*STIM_j - (CP_j - QYS_j) \qquad (33)$$

$$CP_j = CP_{j-1} + DCP_{j-1} \qquad (34)$$

$$S_j = \frac{CP_{j-1}*0.89}{70253} \qquad (35)$$

if $DCP_j < 0$, then $DCP_j = 0$ (36)

in which,

CP_j = Drying capacity in dried cassava equivalents in year j
QYS_j = Realized dried cassava demand in year j
POT_j = Potential price in fresh cassava equivalents that could be paid by the drying industry
AY_j = Average cassava yield in year j
$COST_j$ = Production costs of cassava per hectare
L_j = Labor costs per man-day
$COTON_j$ = Production costs of cassava per ton
$STIM_j$ = Factor that expresses the attractiveness of the dried cassava market
DCP_j = Growth of the dried cassava processing capacity in year j
CI = Capacity of government institutions to build drying plants
gp = Growth rate of existing drying plants
S_j = Part of the region with drying plants

Ad 27-28) To determine the interest in building dried cassava plants, the maximum cassava price that the drying industry can pay is determined. First it must be determined if realized dried cassava demand is equal to, or smaller than, the processing capacity (27). Then the maximum price can be calculated (28), by substituting the processing function into the dried cassava demand function and solving this for a given processing capacity (QYS_j). If the demand for dried cassava is not restricted by the processing capacity, the equilibrium price of the model will be produced.

Ad 29-32) The highest possible price that the drying industry can pay is related to the cost of production, which depends on the yield level. First, the yield level determines the harvesting costs ($AY_j*2.5*L_j$ in equation 29), a large part of total costs per hectare (30). Second, the yield level determines over how many tons the costs per hectare can be split (31). Equation 32 subtracts production costs from the highest possible price. The difference is diminished by 5 US dollars, the minimum profit per ton of cassava that farmers will accept. In year one the resulting difference would have a value of 27.81. This value is divided by 18.54 to obtain a value of STIM of 1.5. STIM indicates the attractiveness of expanding the drying industry. If STIM is higher than one, then the development of the drying industry will take place at full possible speed. If the difference between the potential price and the production costs is limited, STIM will be lower than one and the growth of the drying industry will slow down.

Ad 33-34) The growth of the drying industry depends on STIM, the institutional capacity to build cassava drying plants (CI) (see Chapter 5.5), the growth rate of the industry (gp), and the potentially existing overcapacity ($CP_j - QYS_j$). If STIM is higher than one, the institutions construct a drying capacity of CI. The capacity constructed in the year before will double in size and the older plants will grow with the term gp. Since the capacity constructed in the year before forms part of CP, the doubling of its capacity has to be reduced with the natural growth taken into account in CP*gp*STIM. To do this CI*(1-gp)*STIM is included instead of CI*STIM. Finally, equation 34 states that the capacity to dry cassava equals last years' capacity plus last years' growth.

The growth equation of the drying industry has some attractive features: profits influence growths; the growth curve will have an S-shape (see Figure 7.3), because growth depends on existing capacity, but will be stabilized if overcapacity exists; and the growth path relates the capacity of the drying industry with the part of the region with improved market perspectives (35). It appears that a drying plant needs an area that produces 2.5 times more cassava than it actually processes to assure supply. Given yield levels of seven tons per hectare and a conversion of fresh into dried cassava of 2.5, the area of influence of the existing drying capacity can be described as: CP*2.5*2.5/7 = CP*0.89. This area is related to the initial total area planted with cassava to calculate the coverage of the drying industry.

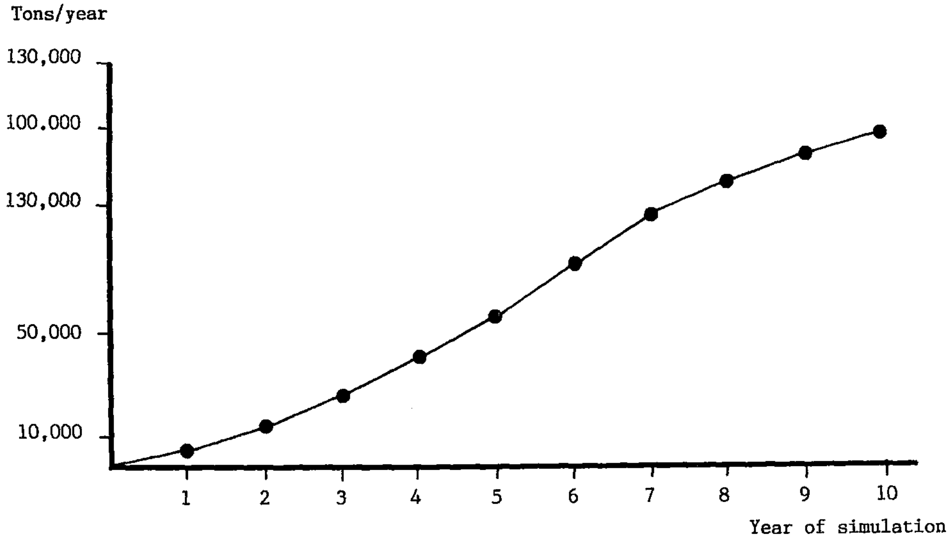


Figure 7.3 Development of dried cassava processing capacity during simulation period.

Note: Represented situation corresponds with situation B in Table 7.5

The equilibrium component

$$CONS_j = Q_{1j} + Q_{2j} + Q_{3j} + Q_{4j} + Q_{5j} + Q_{6j} + Q_{7j} \quad (37)$$

$$PROD_j = QP_{1j} + QP_{2j} + QP_{3j} \quad (38)$$

$$CONS_j = PROD_j \quad (39)$$

In which

Q_{ij} = Cassava consumption in stratum i in year j
QP_{nj} = Cassava production by farmers' group n in year j
$CONS_j$ = Total cassava consumption in year j
$PROD_j$ = Total cassava production in year j

The equilibrium component defines total consumption (37) and total production (38) and states that the two have to be equal (39).

The benefits component

The model calculates three classes of social benefits as the consequence of changes in the cassava system: foreign exchange, employment, and increases in the producer and consumer surplus. The equations for foreign exchange and employment are as follows:

$$PSI_j = PSI*(1 + si)^j \quad (40)$$

$$PSIY_j = PSIY*(1 + siy)^j \quad (41)$$

$$AD_j = QYS_j*(1.2*PSI_j - 0.2*PSIY_j) \quad (42)$$

$$MOU_j = (0.31*Q_{1j}*(P_{1j} - P_{4j}) + 0.24*Q_{2j}*(P_{2j} - P_{4j}) + 0.24*Q_{3j}*(P_{3j} - P_{4j}) + Q_{5j})/ 260 \quad (43)$$

$$MOR_j = (AREA_j*(55 + AY_j*2.5) + QYS_j*2.55 + 0.07*Q_{1j}*(P_{1j} - P_{4j}) + 0.14*Q_{2j}*(P_{2j} - P_{4j}) + 0.14*Q_{3j}*(P_{3j} - P_{4j})) /260 \quad (44)$$

$$MO_j = MOU_j + MOR_j \quad (45)$$

in which,

PSI_j = World market sorghum price, CIF in Colombia (140 US dollars/ton in year 1)
$PSYI_j$ = World market soybean meal price, CIF in Colombia (250 US dollars/ton in year 1)
si = Expected growth rate of the world market sorghum price
syi = Expected growth rate of the world market soybean meal price
AD_j = Foreign exchange saved in year j
QYS_j = Realized dried cassava demand

MOU_j = Urban employment in man-years in year j
MOR_j = Rural employment in man-years in year j
MO_j = Total employment in man-years in year j
Q_{ij} = Cassava consumption in fresh equivalents by stratum i in year j
P_{ij} = Cassava price in stratum i in year j
$AREA_j$ = Area planted with cassava in year j
AY_j = Average yield per hectare in year j

Ad 42) The calculation of foreign exchange saved is based on the substitution of 1.2 tons of sorghum for 1.0 ton of cassava and 0.2 tons of soybean meal (see Chapter 6.6).

Ad 43-45) Cassava production, processing and marketing create employment. Employment in cassava marketing is related to the size of the marketing margin. Marketing employment is split into a rural and an urban segment. For employment in cassava processing (drying and other forms), it has been assumed that processing one ton of fresh cassava takes one man-day. Agricultural employment depends on the area planted and the yield levels.

Equations for consumer and producer surplus are not presented here. These equations are the integrals of the original supply and demand equations. They measure the difference between the gross payment received or paid and cost of production or willingness to pay, as expressed through supply and demand functions (see Curry, Murphy and Schmidt, 1971 or Willig, 1976). The yearly consumer and producer surpluses are discounted and aggregated to obtain net present value of social benefits. These values have been grouped for different fresh cassava purchasing groups, for producers and on-farm consumers and for different industrial destinations, to obtain net present values of benefits to consumers, producers, and industry. The absolute value of these figures is less relevant than the difference between alternative situations, and only the differences will be reported.

7.3 Verification and validation

Verification and validation are concerned with testing the applicability of the model. While verification concerns the testing of the model against design criteria, validation tries to check the model against the reality it should represent (Dent and Blackie, 1979).

Verification stresses the internal consistency of the model and the appropriate use of mathematical formulas. Verification is often a long struggle to eliminate "bugs" present in preliminary specifications. This struggle can be minimized by building the model in small interlinked modules (Anderson, 1974).

For validation, few formal criteria are agreed upon. Anderson (1974) describes a heated exchange in the American Economic Review on criteria for validation. Some scholars state that the ability to imitate reality should be the main criteria (positivism); others think that the model should correctly reflect theoretical assumptions (rationalism); and still others state that these theoretical assumptions should be independently verified (empiricism). Bagozzi (1979), in his discussion of construct validity, proposes six criteria for validation, which will be discussed here for the cassava model:

1) Theoretical meaningfulness. This criterion is similar to the rationalistic one above. The theoretical meaningfulness of the model is good. Signs of coefficients are consistent with the theory, and the terms included in the equations correspond to standard economics. The linear specifications used are theoretically correct if extrapolation is limited.

2) Observational meaningfulness. This criterion requires that the theoretical variables specified in the model correspond correctly with their operationalizations. This appears similar to the empiricistic criterion. Correct measurement is essential to satisfy this criteria. The analyses in Chapters 4 to 6 were conducted with the explicit purpose of measuring in detail the theoretical variables and expressing this in model operationalizations.

3) Internal consistency of operationalizations. Model outcomes should be clearly and unambiguously interpretable. In some models it is not always clear what it means when a specific model outcome is higher than another outcome. In the present model the correspondence rules between theoretical variables and their operationalizations are very clear and changes in the outcomes of the model can be interpreted easily.

4) Convergent validity, and 5) Discriminant validity. If similar events are measured in different ways (e.g. through this model and through another hypothetical model), the outcomes of the measurements should agree. If different events are measured with the same model, the outcomes should be clearly distinguishable. Convergent validity is hard to test since other models to express the cassava system have not been developed. Discriminant validity is good, as will be seen in the discussion of the different simulated situations.

6) Nomological validity. To which degree are predictions from the model confirmed? This criterion appears similar to the positivistic criterion, mentioned above, except that nomological validity requires theoretical accuracy. Nomological validity can only be assessed by comparing the model's predictions against the development of the system modeled. Historical data on the system have to be available. Models are often constructed, as in this case, when it is difficult to obtain historical data. In that situation nomological validation is very difficult. One way to test nomological validity would be to simulate the past, and although historic simulation has not been pursued with great precision, the developments of the cassava system from 1982 to 1986 could be reasonably explained and predicted by the model. Another way to test nomological validity is through subjective tests. Mitroff (1969) developed a Turing-type of test, in which a panel of experts is asked to comment on the reality of the data. This type of subjective testing was applied in this study, by discussing the potential development of the cassava market in the Atlantic Coast region with people who were familiar with the situation. The expectations of these persons were correctly fulfilled by the model.

Criteria 1, 2, 3 and 5 listed by Bagozzi are completely satisfied by the model. Criterion 4 is hard to satisfy since alternative models to compare performance are not available. Criterion 6 is adequately satisfied, given the objective for building the model and the difficulty in encountering historical data to compare model predictions.

7.4 Model results in alternative situations

The non-intervention situation

As can be seen in Table 7.4.A and in Figure 7.4, if the cassava system is not subject to any market improvement (situation A), production will stay close to present levels. Yields would slightly increase because of the effect of the drying capacity already established. The area planted would be stable and the on-farm price would slowly fall.

Fresh cassava consumption in different urbanization strata would fall, even while becoming cheaper (Table 7.4.B). In the metropolitan area annual consumption would decrease from 30 to 22 kg/head, in the intermediate urban area from 54 to 47 kg/head, and in the rural areas from 81 to 64 kg/head. Population growth does not compensate for the fall in per capita consumption levels. The low demand for fresh cassava would favor the drying industry, which would be able to use its fixed capacity of 5000 tons more efficiently. Yearly consumption of dried cassava would increase from 4089 to 4681 tons.

Employment in cassava production and marketing, in the rural as well as in the urban areas, would fall (Table 7.4.C). Foreign exchange savings achieved by replacing sorghum with dried cassava would be slightly less than one million US dollars per year. The net present value of the social benefits for the non-intervention situation is not reported, since this situation forms the basis for the calculation of the net benefits in the alternative situations: these benefits are calculated by subtracting consumer and producer surplus in the non-intervention situation from their values in the alternative situations.

Table 7.4.A. Simulation Results: production parameters, 1994, stochastic runs.

	Situation in 1985	A*	B*	C*	D*	B1*	D1*	B2*	D2*	B3*	D3*	B4*	D4*	C5*	D5*	C6*	D6*
Yields (ton/ha)																	
Small farms	6.81	6.98	7.73	7.44	7.97	8.50	8.74	7.40	7.64	7.89	8.08	7.81	8.04	7.29	7.89	7.48	8.00
Middle sized farms	6.83	7.10	8.29	7.49	8.48	8.51	8.72	7.34	7.54	8.49	8.66	8.37	8.55	7.36	8.43	7.52	8.51
Large farms	6.83	7.23	8.52	7.39	8.57	8.50	8.56	7.18	7.26	8.69	8.75	8.56	8.61	7.34	8.56	7.40	8.57
Areas (ha)																	
Small farms	22502	22344	23699	23076	24061	23583	23961	24059	24356	23983	24263	23821	24167	22832	23939	23134	24095
Middle sized farms	21142	20916	24708	22301	25395	24472	25206	25426	25919	25433	26009	24972	25639	21839	25182	22411	25459
Large farms	26801	26398	32496	28743	33722	32078	33384	33768	34672	33710	34726	32956	34142	27961	33336	28931	33837
Production, total (tons)	480878	496001	666137	551886	697094	682471	715812	607713	633339	698738	725381	678255	708471	532985	687453	556432	700037
Production, C.V.	0.13	0.13	0.13	0.13	0.13	0.14	0.13	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.12
Producers price	84.7	75.9	82.3	88.4	86.7	80.7	85.2	87.4	92.1	84.5	88.2	85.4	89.0	85.1	85.6	89.1	87.1
Producers price C.V.	0.27	0.29	0.17	0.24	0.14	0.19	0.16	0.12	0.10	0.10	0.09	0.18	0.15	0.25	0.15	0.23	0.14

* A = Present situation develops as expected without growing drying industry or fresh cassava storage.
B = Drying industry develops.
C = Fresh cassava storage is introduced.
D = Fresh cassava storage and drying industry develop together.

1 = Establishment of drying industry increases yields uniformly over the farm types with 25%.
2 = Establishment of drying industry does not increase yield levels at all.
3 = Drying industry grows at double the estimated rate.
4 = Dried cassava demand grows at double the estimated rate.
5 = In the case of fresh cassava storage, margins goes down, but demand does not increase but stabilizes.
6 = In the case of fresh cassava storage, margins do not decrease but demand does increase.

Table 7.4.B. Simulation Results: Consumption parameters, 1994: stochastic runs.

	Situation in 1985	A*	B*	C*	D*	B1*	D1*	B2*	D2*	B3*	D3*	B4*	D4*	C5*	D5*	C6*	D6*
Fresh cassava consumption (kg/head)																	
Metropolitan area	29.9	21.6	21.1	39.4	39.6	21.2	39.7	20.7	38.9	21.0	39.4	20.9	39.3	33.6	33.5	35.0	35.3
Intermediate urban area	53.5	46.5	45.0	57.7	58.2	45.4	58.7	43.9	56.6	44.5	57.8	44.3	57.5	52.3	52.2	58.5	59.1
Rural area	80.6	63.7	62.2	83.3	83.8	62.6	84.3	61.0	82.1	61.7	83.3	61.5	83.1	79.6	79.5	84.2	84.8
Producers	164.0	158.5	152.4	146.5	148.1	153.9	149.6	152.5	142.9	150.2	146.7	149.4	145.9	149.7	149.2	145.8	147.7
Fresh cassava prices (US $/ton)																	
Metropolitan area	404	387	399	349	346	396	343	409	355	404	348	406	350	343	344	413	409
C.V. Cassava price in metropolitan area	0.11	0.11	0.07	0.11	0.06	0.07	0.07	0.05	0.05	0.04	0.06	0.07	0.07	0.11	0.07	0.10	0.06
Intermediate urban area	252	236	247	264	260	244	258	256	270	251	246	253	265	258	259	259	256
Rural area	243	228	239	256	253	236	250	248	262	243	256	244	257	250	251	251	248
Dried cassava																	
Total consumption (tons)	4089	4681	80108	3494	59923	84880	65440	62667	41251	95797	73126	88593	67398	3768	66582	3468	58692
Price (US $/ton)	221	199	215	230	226	211	222	228	239	220	230	223	232	222	223	232	227
C.V. of total consumption	0.46	0.25	0.29	0.65	0.38	0.29	0.36	0.33	0.49	0.26	0.35	0.29	0.36	0.57	0.35	0.68	0.39
% utilization of drying capacity	0.82	0.94	0.74	0.70	0.66	0.75	0.68	0.67	0.54	0.64	0.56	0.77	0.69	0.77	0.68	0.66	0.65

Table 7.4.C. Simulation Results: Social benefit parameters, for 1994, or for total period: stochastic runs.

	Situation in 1985	A*	B*	C*	D*	B1*	D1*	B2*	D2*	B3*	D3*	B4*	D4*	C5*	D5*	C6*	D6*
1994 benefits																	
Rural employment (manyears)	21608	21541	27422	23740	28448	27530	28628	26936	27755	28597	29433	27927	28903	23010	28126	24004	28638
Urban employment (manyears)	4404	4365	4363	6278	6306	4366	6309	4348	6290	4363	6308	4349	6296	5629	5648	6490	6524
Foreign exchange saved (millions US $)	0.56	0.65	11.05	0.48	8.27	11.71	9.03	8.65	5.69	13.22	10.09	12.23	9.30	0.52	9.19	0.48	8.10
Total benefits																	
Increase in producers surplus for (million US $):																	
Small farms	n.a.	-	8.4	8.3	14.1	9.8	15.7	10.9	16.2	12.8	17.0	9.2	14.8	4.7	11.5	9.1	14.7
Middle sized farms	n.a.	-	11.8	8.1	17.7	11.3	17.3	12.4	17.8	18.1	22.7	12.8	18.6	4.6	15.1	9.0	18.4
Large farms	n.a.	-	17.1	10.3	24.6	15.2	22.7	16.1	22.7	26.1	31.9	18.4	25.8	5.8	21.3	11.3	25.4
Increase in consumers surplus for million (US $):																	
Metropolitan consumers	n.a.	-	-1.1	24.3	23.6	-0.9	24.0	-2.0	22.2	-1.7	23.3	-1.3	23.3	17.8	16.8	8.6	8.1
Intermediate urban consumers	n.a.	-	-0.9	2.4	2.0	-0.7	2.2	-1.6	+1.2	-1.3	1.7	-1.0	1.8	1.2	0.6	1.8	1.4
Rural consumers	n.a.	-	-3.5	13.4	11.7	-2.7	12.7	-6.2	8.7	-5.2	10.8	-4.0	11.1	11.1	8.6	10.1	8.6
Animal feed industry	n.a.	-	8.6	-0.4	5.2	9.7	6.1	5.4	2.7	10.3	6.7	8.5	5.2	-0.2	6.4	-0.4	4.8
Increase in benefits for (million US $):																	
Producers	n.a.	-	33.3	20.6	48.5	33.1	48.7	32.3	46.2	50.8	62.7	35.8	50.8	11.6	41.8	22.9	50.2
Consumers	n.a.	-	-5.7	40.0	37.2	-4.3	38.8	-9.9	32.0	-8.3	35.7	-6.5	36.2	29.9	25.9	20.4	17.9
Industry	n.a.	-	7.2	-1.9	2.8	8.5	4.0	3.1	-0.3	8.1	4.0	7.0	2.8	-1.2	4.5	-2.2	2.4
Total increase in benefits (million US $)	n.a.	-	34.8	58.7	88.5	37.4	91.5	25.5	77.9	50.6	102.4	36.3	89.8	40.3	72.1	41.1	70.5

* For explanatory notes on the different simulations reported, see Table 7.4.A.

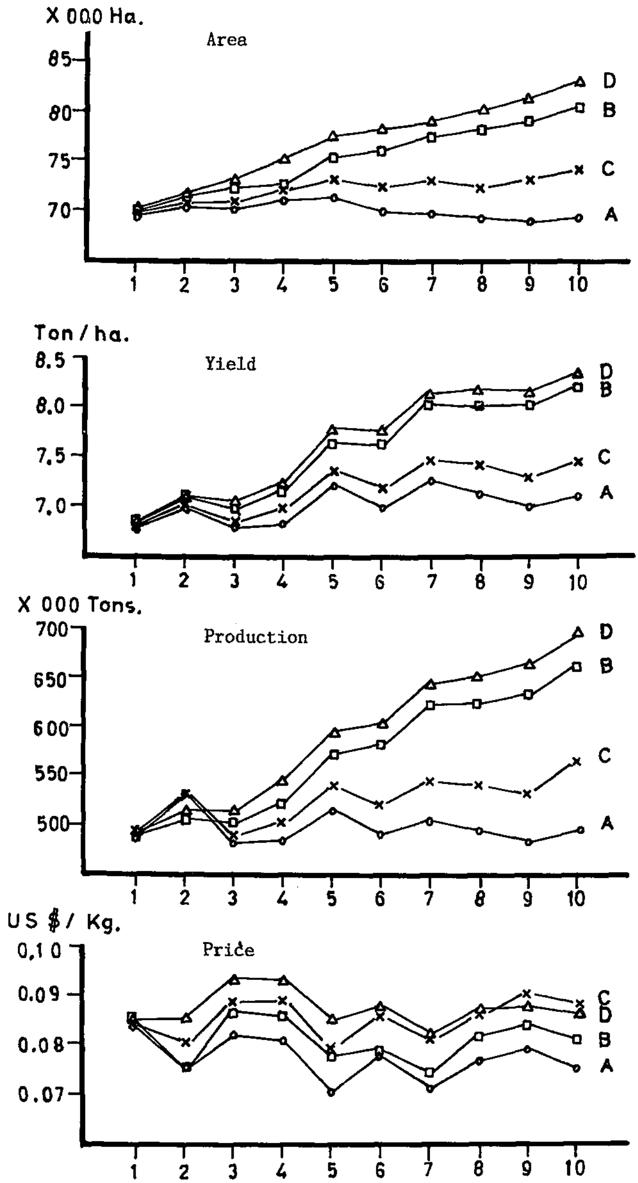


Figure 7.4. Area planted (ha), yields (ton/ha), production (tons) and farmers price (US$/kg) in the simulation period (stochastic runs):

Best expected development:

A = Non intervention situation
B = Drying industry develops
C = Storage is introduced
D = Storage and drying are introduced jointly

The effect of drying industry development

Drying industry development (situation B) would increase cassava production by some 40% over the ten years envisioned (Figure 7.4). Average yields would increase by 20% and area planted by some 15%. Yields and area increases are highest for the large farms. The on-farm price would first increase quickly but afterwards fall slowly. The price in the last year would be 8% higher than in the non-intervention situation. The farm price would be stabilized with its coefficient of variation falling from 0.29 to 0.17.

Demand competition for cassava by the different end-users would increase. Fresh cassava consumption would fall but fresh cassava prices would increase in comparison with the non-intervention situation (Table 7.4.B). Annual dried cassava consumption would be around 80,000 tons in the last year of simulation. The utilization of the drying capacity would be 74%, which indicates that it is strongly subject to unpredictable production changes.

In comparison with the non-intervention situation, rural employment would increase by some 27% (Table 7.4.C), a positive contribution towards relieving urban migration. Urban employment would not change. Savings in foreign exchange would be around 11 million dollars per year, a significant support to the balance of payments.

The largest producers would benefit most, by some 17 million US dollars. Discounted benefits for small farms would be some 8 million US dollars, and for intermediate farms, 12 million US dollars. Fresh cassava consumers would suffer from the increased price competition. The animal feed industry would receive net benefits of 9 million dollars over the ten year period.

Table 7.4.C summarizes the current net benefits for producers, consumers, industry, and total. The total net present value of the benefits of drying industry development over the ten years simulated would be some 35 million US dollars. Producer benefits are smaller than the aggregate change in producer surplus for small, intermediate and large farms, because the (negative) change in consumer surplus to on-farm consumers has been added.

Benefits for producers are positive, and for consumers, negative. Cassava drying stimulates rural development, at a slight cost to the urban people .

The effect of storage technology

Storage technology would increase the consumption of cassava among purchasers (Table 7.4.B, situation C). This is due to the price decrease (in the metropolitan area) and to the rising demand caused by extra convenience. Cassava production would increase by 11%, a smaller increase than in the case of dried cassava development (Table 7.4.A). A slightly positive area reaction takes place mainly among larger farmers who have greater options to increase the area planted. A slight yield increase would occur (especially in the small farms) in response to higher on-farm prices for cassava. The yield increase would be far less than in the case of drying development.

Rural employment would increase by 10% and urban employment by 44%. This increase, however, is smaller than the employment increase in cassava drying development. Foreign exchange saved by substituting dried cassava for grains appears to fall. If the increased cassava consumption substitutes for imported wheat, the foreign exchange effect might be more favorable. Net present benefits are more equally divided over different farm sizes but are always smaller than in case of cassava drying development. The metropolitan consumers would gain net present benefits of almost 24 million US dollars.

Total benefits are larger than for cassava drying development (59 versus 35 million US dollars), but are distributed in very different ways. Benefits to farmers would be smaller while those to consumers would be larger. Employment would grow more in the urban than in the rural areas.

The simultaneous introduction of drying and storage techniques

The two market development strategies can also be introduced simultaneously (situation D in Table 7.4 and Figure 7.4). In that situation, yields would increase by 23% and area planted by 18%. The on-farm price would first increase to over 94 US dollars per ton, afterwards fall for some years and then maintain an upward tendency. The on-farm price would be very stable as expressed in the coefficient of variation of 0.14. The market stabilization created by cassava drying plants would increase production so much that by the end of the period the on-farm price would be lower than if storage technology alone had been introduced. Fresh cassava consumption would rise to levels above those in the case of storage technology introduced alone.

Fresh cassava consumption would not suffer from simultaneous development with cassava drying, but dried cassava consumption would fall from 80,000 tons if developed alone, to 60,000 tons if developed jointly. The price for dried cassava would be 11 US dollars per ton higher and the utilization of the drying capacity 8% below the case of drying development alone.

The effect of simultaneous introduction on employment would be large. Rural employment would increase by 32% and urban employment by 43%. Foreign exchange saved by substitution of cassava for sorghum imports would be eight million US-dollars. Benefits of joint development for producers are considerable. Their net present value of benefits would be 15 million US-dollars higher than in the case of cassava drying development alone. For consumers, joint development would slightly depress their net present benefits in comparison with single storage introduction, because of the high fresh cassava price in the first years after simultaneous introduction of the two strategies. The severe price competition that would exist is most negative for the industry. Its net present value of benefits would be reduced from 7 million US dollars in case of drying development alone, to 3 million US dollars in case of simultaneous introduction. Total benefits of joint development would be around 88 million US dollars, only 5 million US dollars below the sum of the individual strategies.

<u>The effect of different yield increases</u>

Table 7.4 and Figure 7.5 situation B1 (drying industry develops alone) and D1 (drying industry and storage develop together) show the effect of equal yield increases of 25% in all farm sizes instead of the different effects per farm size. Yields in the small and intermediate farm would increase more quickly than yields in the large farm. The area planted would increase more slowly but total production would be higher, and on-farm prices lower, than in the original situation.

Cassava consumption would be up in all consumption strata: for fresh consumption the difference would be about one percent, but for dried cassava the increase would be some five to ten percent. The drying capacity of the industry would be more efficiently used.

Rural employment would be slightly higher, urban employment would stay the same, and foreign exchange saved would increase by 5 to 10 percent. Benefits would be more evenly distributed among farm types. The size of the total producers' surplus, however, would not increase. The increased yield in small and intermediate sized farms depresses prices more quickly and reduces the windfall profits that farmers make when demand increases more strongly than production. The benefits of increased yields affect the consumers, and especially the industry, in the form of lower prices. The total net present value of more rapid and uniform yield increases would be some 3 million US dollars.

Situations B2 and D2 in Table 7.4 and Figure 7.5 show the effect of zero yield level increases after market stabilization. Production would be down, yields lower, whereas area planted and on- farm price would be higher. Fresh consumption and industrial consumption would fall. Employment benefits and foreign exchange saved would be smaller. Net present benefits for small and intermediate producers would be higher than in any situation described before. For the large farm benefits would fall slightly. The windfall profit caused by the high cassava price cannot compensate for the more limited availability of cassava for on-farm consumption. Consequently the overall welfare of producers decreases. Cassava consumers (and most so the industry)

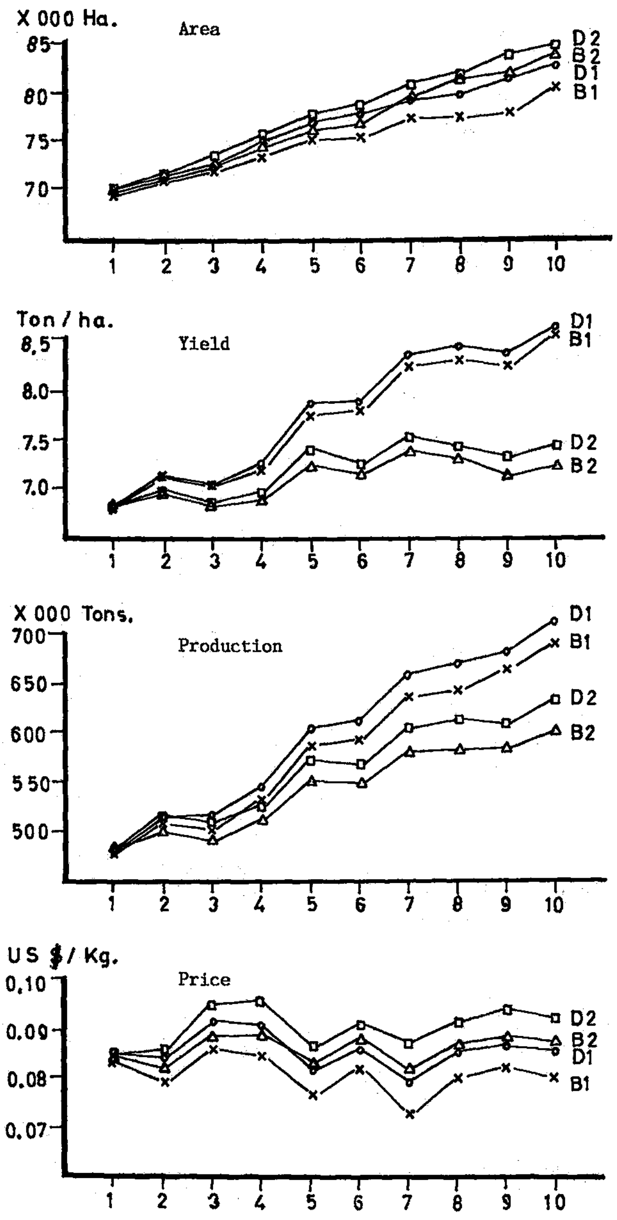


Figure 7.5. Area planted (ha), yields (ton/ha), production (tons) and farmers price (US$/kg) in the simulation period (stochastic runs)

Development with strong yield effect (1) and with no yield effect (2) of market stabilization

B = Drying industry develops
D = Storage and drying are introduced jointly

would be hurt by the absence of yield increases. The total benefits that will be lost if no yield increases occur have a net present value of some 10 million dollars.

These data suggest that yield increases have a positive impact on consumers but little impact on producers. This result is strongly influenced by the rapid demand growth and the subsequent windfall profits. In the last year of simulation the producers' surplus is biggest in case of the strong yield reaction. This implies that if a longer time span had been chosen the net present benefits for producers would have grown with increasing yields.

The effect of stronger development of the drying industry or of the dried cassava demand

The effects of more rapid growth of the drying industry or of the dried cassava demand are presented respectively as situations B3 and D3 and situations B4 and D4 in Table 7.4 and Figure 7.6. More rapid growth of the drying industry would positively influence yield levels and area planted. The extra processing capacity would allow dried cassava consumption to be higher than in the original situations but the utilization degree of the processing capacity would stay lower. Production growth is not able to satisfy completely the increased effective dried cassava demand and on-farm prices would be above those in the best expected situation.

Rural employment would grow extra by a thousand man-years while urban employment would stay the same. Savings in foreign exchange would also increase. For cassava producers the net present value of their benefits is 50% higher than in the best expected situation.

More rapid construction of drying plants is more effective in improving benefits to the producer than yield increasing technology which favors consumers over producers.

Growth of dried cassava demand at two times the expected rate would not have much impact on the development of the cassava

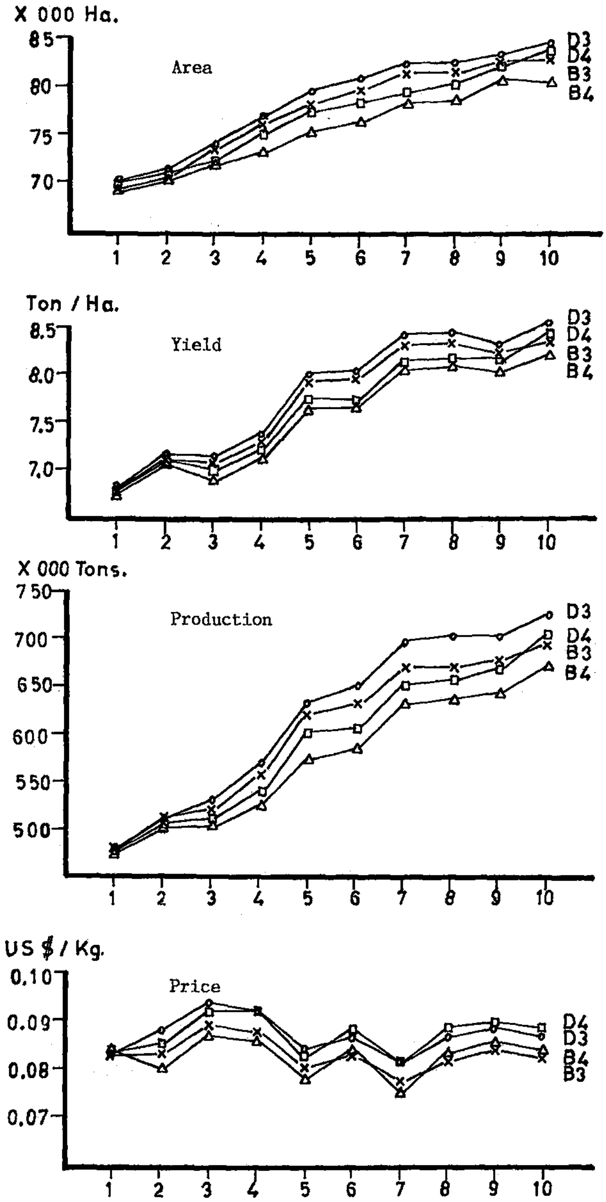


Figure 7.6. Area planted (ha), yields (ton/ha), production (tons) and farmers price (US$/kg)in the simulation period (stochastic runs)

Development with more rapid growth of drying industry (3) or of dried cassava demand (4)

B = Drying industry develops
D = Storage and drying are introduced jointly

system. The dried cassava industry would grow only slightly more quickly. Drying capacity would be used more efficiently. Farmers would receive some extra benefits as a consequence of the upward pressure on the prices. However, the presently assumed growth of dried cassava demand is more than satisfactory to enable balanced development of the dried cassava industry.

<u>The effect of margin decrease and demand stabilization after storage introduction</u>

If storage does not increase, but only stabilizes demand, annual fresh cassava consumption would be four to six kilos per head below the originally envisioned situation (see C5 and D5 in Table 7.4.B). On-farm consumption would be slightly higher. Farm prices would be lower and production would increase at a slower rate (see Figure 7.7). The drying industry could consume more cassava than in the original C or D situation.

Urban and rural employment would each fall by 600 to 700 man-years, but foreign exchange savings would increase. The net present value of the producers' benefits would only be half the original one. Consumers' benefits would decrease by 10 to 12 million US-dollars. Total benefits would be 16 to 18 million US-dollars below the ones originally found. The benefits of the storage strategy are very sensitive to the effect that it will have on fresh cassava demand.

<u>The effect of demand increase without margin decrease after storage introduction</u>

If the margins do not fall after introduction of storage (situations C6 and D6 in Table 7.4 and Figure 7.7), then consumption would fall in the metropolitan area, but increase in the intermediate urban area and the rural area. On-farm price and aggregate production would move up. The price increase that results, would depress dried cassava consumption.

Rural employment would be slightly above previously expected values. Urban employment would be higher as well, since the

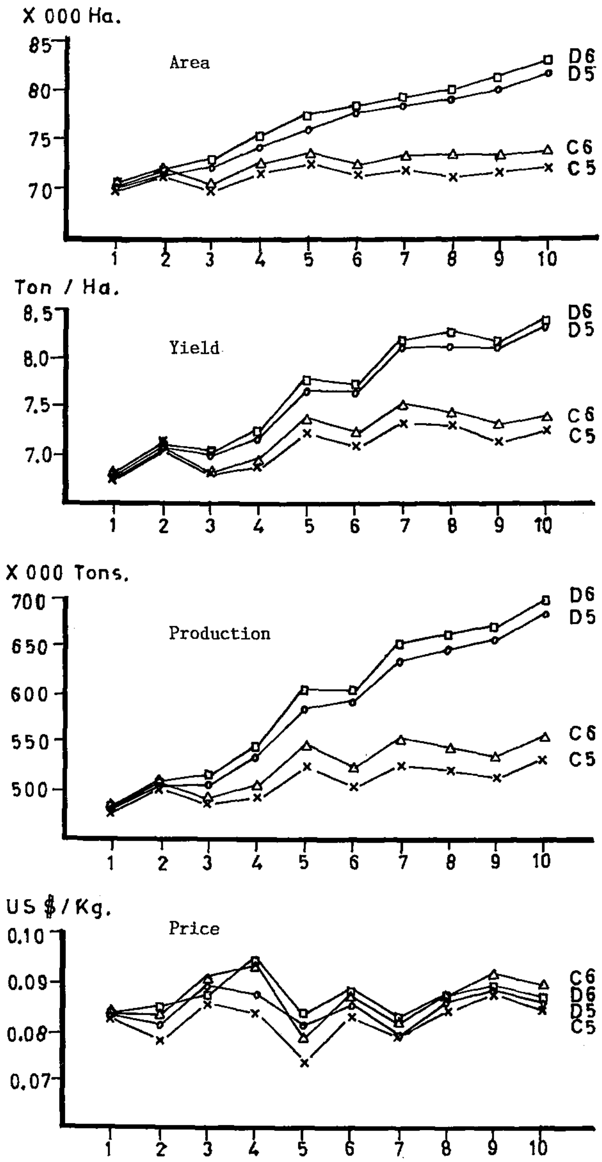


Figure 7.7. Area planted (ha), yields (ton/ha), production (tons) and farmers price (US$/kg) in the simulation period (stochastic runs)

Storage decreases margins but does not increase demand (5) or storage increase demand but does not decrease margins (6)

C = Storage is introduced
D = Storage and drying are introduced jointly

marketing channel would use the same amount of labor per ton traded. The producers' surplus would be bigger than in the original situation. For metropolitan consumers the benefits would be lower but for other consumers they would stay the same. This leads to the conclusion that metropolitan consumers benefit most from the margin decrease, while the other consumers benefit most from the increased convenience.

Total net present benefits in this situation would be 18 million US dollars below the original situation. This value is comparable to the case where it was assumed that the margin decreases but demand stabilizes. In the present case, however, benefits are distributed differently: if the margin decreases, benefits end up with consumers more than with producers; if demand increases, the producer gathers the major part of the benefits.

Deterministic model results

The sensitivity of the model to changes in some parameters of secondary importance has been tested by deterministic runs. Instead of 25 repetitions of the simulation, only one run has been made, without the normal distribution generator functioning. The outcomes of the deterministic models are similar to those obtained in the stochastic specification, for the situation without market improvement (A) and the situation when cassava storage is introduced (C), (see Table 7.5 and Figure 7.8). The expected development of the drying industry in case of stochastic yields (situation B or D) would be slower than in case of deterministic yields. The limited incentive for growth in years with bad harvests restrains the development pace of the drying industry. Benefits for producers and industries are reduced by the stochastic character of cassava production. Total net present benefits in the deterministic case are ten million US dollars higher than in the stochastic case.

If domestic sorghum and soybean prices decrease at a rate of 3% per year (situations B7 and D7 in Table 7.5 and Figure 7.9), the development of the cassava system hardly changes. Fresh cassava consumption would stay as it is, employment would decrease

Table 7.5. Simulation Results: Evaluation parameters: non-stochastic runs.

	Situation in 1985	A	B	C	D	B7*	D7*	A8*	D8*	A9*	D9*	A10*	D10*	A11*	D11*	A12*	D12*
Fresh cassava consumption (kg/head) metropolitan area	30.4	21.5	20.9	39.2	39.3	20.9	39.5	21.4	39.5	21.9	39.5	21.8	39.3	21.4	38.2	21.5	39.4
Intermediate Urban area	54.3	46.2	44.4	57.3	57.5	44.6	58.0	46.4	58.7	46.9	57.8	46.7	57.5	46.1	58.5	46.1	578
Price in metropolitan area (US$/ton)	395	389	406	351	350	404	347	386	340	381	347	387	350	389	350	390	348
Price in intermediate urban area (US$/ton)	243	238	253	266	265	251	262	235	256	231	262	235	265	238	265	239	263
Dried cassava consumption																	
Total Consumption (tons)	5000	5000	98406	5000	74900	95225	68748	5000	60428	5000	85438	5000	75554	5000	74398	5000	81130
Price (US$/ton)	209	202	222	234	232	220	228	197	219	192	228	198	232	201	232	203	229
Rural Employment	21776	21580	28882	23840	29637	28675	29236	21345	28501	21748	29312	21256	29476	21548	29640	21573	30166
Urban Employment	4447	4392	4364	6307	6310	4368	6316	4319	6244	3813	5449	4729	6876	4383	6252	4391	6314
Foreign exchange saved (US$/head)	0.69	0.69	13.58	0.69	10.34	12.64	9.13	0.69	8.34	0.69	11.80	0.69	10.43	0.69	10.27	0.69	11.12
Increase in benefits for: (million US $)																	
Producers	n.a.	-	49.1	21.4	61.3	47.5	57.6	-3.1	51.7	-6.8	56.5	-3.5	59.7	n.a. 1/	63.3	n.a. 1/	56
Consumers	n.a.	-	-9.1	39.5	34.2	-8.7	35.2	0.2	36.2	-6.4	23.2	-3.6	34.6	n.a.	43.3	n.a.	39.1
Industry	n.a.	-	5.5	-2.0	1.7	3.6	0.3	-0.2	2.4	0.8	3.2	0.4	2.0	n.a.	1.4	n.a.	4.9
Total increase in benefits	n.a.	-	45.4	58.9	97.1	42.4	93.2	-3.1	90.3	-12.4	82.9	-6.7	96.3	n.a.	108.0	n.a.	100

*7 = National sorghum and soya prices decrease at 3% per year.

8 = Income increase would be zero.

9 = Populations grow at half the expected rate.

10 = Population only grows in metropolitan areas, at 8% per year.

11 = Cassava demand is less elastic than expected (equal to 0.5 among purchasers and 0.25 among buyers).

12 = Distributed lag in farmers yield and area reaction would be 0.5 instead of 0.75.

1/ Since the change in the demand or supply slopes changes the absolute size of the surpluses, the values of the A situation cannot be compared reasonably with the original A situation.

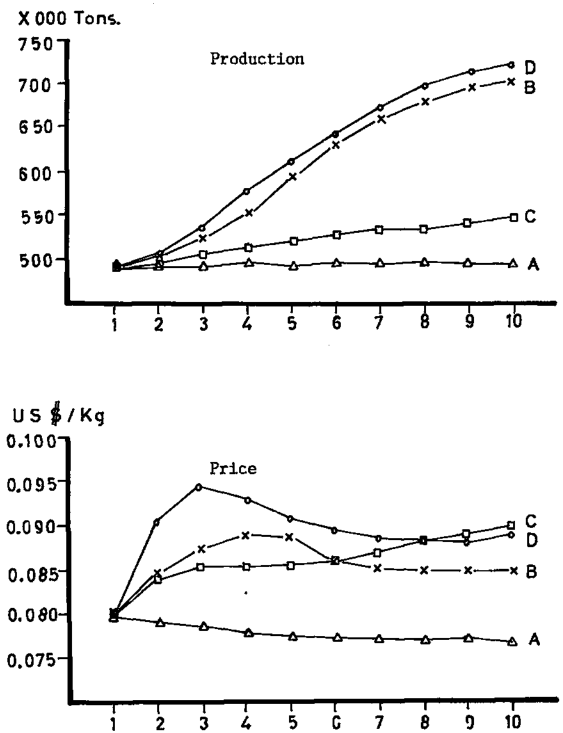


Figure 7.8. Production (tons) and farmers price (US$/kg) in the simulation period (deterministic runs):

Best expected development:

A = Non intervention situation
B = Drying industry develops
C = Storage is introduced
D = Storage and drying are introduced jointly

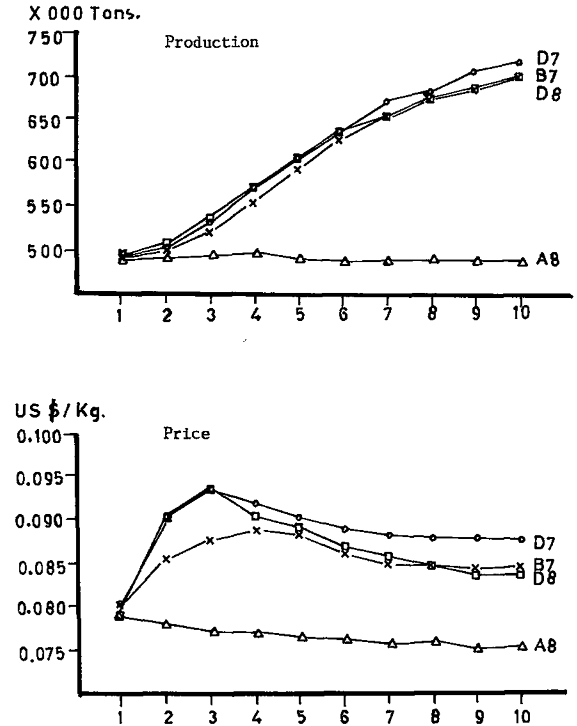


Figure 7.9. Production (tons) and farmers price (US$/kg) in the simulation period (deterministic runs):

Sorghum and soya prices fall with 3% per year (7) or income growth is 0% (8)

A = Non intervention situation
B = Drying industry develops
D = Storage and drying are introduced jointly

slightly and foreign exchange saved would fall by one million US dollars. Producers' benefits would fall by 1.5 million dollars.

The effect of zero income growth is evaluated in situation A8 and D8. In the case of non-intervention, this would only slightly restrain the development of the cassava market system. However, if the drying industry develops, the low income growth constrains dried cassava demand. This would allow fresh cassava consumption to rise, but would still depress the on-farm price and diminish net present benefits for farmers. Losses would be around 10 million US dollars.

If population growth was halved (situation A9 and D9 in Table 7.5 and Figure 7.10), aggregate demand for cassava would fall and the price would decrease. Per capita consumption levels would move slightly up, but employment and producers' benefits would be less than in the best expected situation. If the drying industry develops, it would benefit from the reduced growth of fresh cassava demand and reach a higher consumption level than before. This would reduce relative losses to the farmers and would allow the benefits to industries to increase 1.5 million dollars.

Concentration of the population growth in the metropolitan area (A10 and D10 in Table 7.5 and Figure 7.10) would reduce demand for fresh cassava. Prices, production and employment would fall. The industry could profit from the low cassava prices. If cassava storage were introduced, consumer benefits would be larger than normal because the metropolitan consumers benefit most from improved storage. Urban employment would reach a very high value. Total benefits would almost be equal to the original D-situation but would favor consumers slightly more than producers.

In the case of less elastic demand (elasticities in the urban and metropolitan area of -0.5 instead of -0.68 and -0.75), (situation A11 and D11 in Table 7.5 and Figure 7.11), fresh cassava consumption would fall more strongly in the non-intervention situation. If market improvement occurred, fresh cassava demand would shift slightly to the rural areas. The dried cassava industry would take its same course of development. The social benefits calculated for different consumer groups would grow as a consequence of the increased importance of cassava as

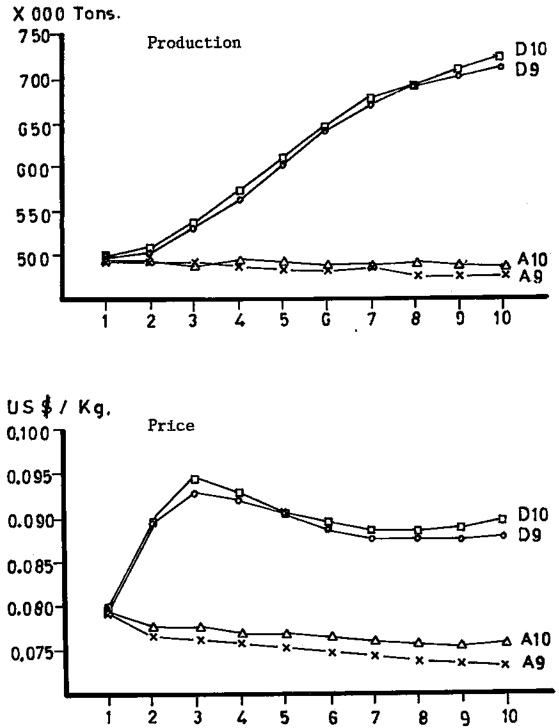


Figure 7.10. Production (tons) and farmers price (US$/kg) in the simulation period (deterministic runs):

Population growth is halved (9) or concentrated in metropolitan area (10)

A = Non intervention situation
D = Storage and drying are introduced jointly

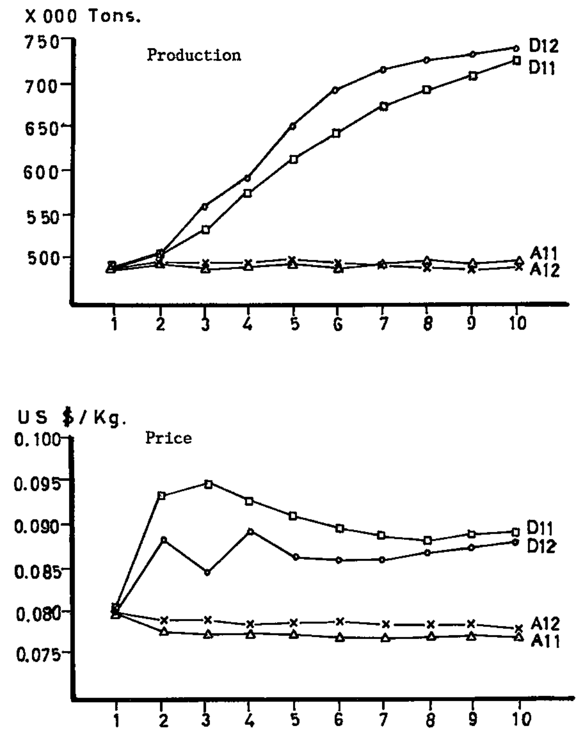


Figure 7.11. Production (tons) and farmers price (US$/kg) in the simulation period (deterministic runs):

Cassava demand is less elastic (11) or yield and area reaction have a smaller time lag (12)

A = Non intervention situation
D = Storage and drying are introduced jointly

expressed in the lower elasticities. Producers would also have extra benefits. If fresh cassava demand is less elastic than expected, benefits of market improvement are greater than originally expected.

The effect of a more rapid supply reaction to changing market conditions (a lag of 0.5 instead of 0.75) is shown in Table 7.5, situation 12 and Figure 7.11. Without intervention, the system would develop similarly to the original A-situation. Since farmers would react more rapidly to price changes, production would decrease more quickly in response to the falling price. In case of market improvement, the more rapid supply reaction would limit the price increase. Drying industry and employment would develop more quickly. Windfall benefits to farmers would be less and their total net present value of benefits would decrease. The net present value of benefits to consumers and the industry would increase. The total rise in the benefits would be some 3 million US dollars. If farmers react more rapidly to price changes than envisioned, the total benefits of market improvement have again been underestimated.

7.5 Conclusions on the future development of the cassava market system in the Atlantic Coast region

If the cassava market system in the Atlantic Coast region develops without any intervention, the income gaining and employment creating capacities of the system will slowly decline. The on-farm price of cassava will fall and the crop will not significantly contribute to rural development. Many small farmers will find it very hard to improve their living conditions. With this in mind, two strategies to develop cassava markets were evaluated.

1) The introduction of cassava drying which stabilizes prices and provides access to the quickly growing market for animal feed raw material. The price stabilization also creates a considerable supply shift.

2) The introduction of a storage method to overcome problems of fresh cassava deterioration. Storage would increase the

convenience aspects of cassava as a fresh food and would diminish marketing margins.

The simultaneous introduction of the two strategies was also considered.

The net present value of benefits for the storage method introduction is higher than for the drying industry development, (60 versus 35 million US-dollars). Storage mainly benefits metropolitan consumers. Producers' benefits only comprise a third of total benefits. The margin decrease determines benefits to the consumer and the demand increase decides the benefits to the producer. Industrial consumers lose through the increased competition for cassava. Storage introduction increases urban employment. It might have some effect on foreign exchange savings through substitution of wheat but the effect has not been estimated. Finally, the benefits of storage introduction are very dependent on the assumptions inherent in cassava demand development.

Cassava drying benefits all producers 70% more than storage development, and is inclined towards the large producer. The industry profits through the option to process and consume more cassava. Fresh cassava consumers are negatively affected. Rural employment in cassava production, marketing, and processing increases by 30%.

Cassava drying could save approximately 11 million US dollars per year by substituting cassava for sorghum. The growth of the cassava drying industry is hardly being harmed by a gradual price decrease of substituted animal feed raw materials. The drying industry stimulates yield increases and creates a demand for land to increase production. Increased yields cause about a third of the total benefits of drying industry development. However, these yield increases do not benefit the producer, who receives less windfall profits, but do benefit the consumer who faces a lower price. Fast and efficient development of the drying industry is more effective in helping the producer than is striving for greater yields. It raises prices for the fresh cassava consumer but brings considerable extra benefits to the producer.

Joint introduction of drying and storage initially sharpens price competition. Afterwards, production increases sufficiently for fresh cassava consumption levels to be be higher than if storage had been introduced alone. In the long run the impact of storage is enhanced by the development of the drying industry. Nevertheless, the industry suffers from simultaneous development, since it has to compete for its supply with the revived fresh cassava demand. For producers, however, joint development creates a strong and lasting demand for their cassava.

The farm-oriented benefits of cassava drying make it an excellent strategy to pursue in the interest of slowing urban migration and as a diving platform for other rural development efforts. Although storage also delivers sizeable benefits to the rural areas, its impact on migration and rural development is ambiguous since it also improves living conditions in the urban areas. Also, calculated benefits are very dependent on the assumed development of fresh cassava demand. Given these considerations, cassava drying appears preferable to storage introduction.

The simulation of the cassava market system in the Atlantic Coast region shows that market improvement could bring considerable benefits. Most of these benefits originate in the actual market improvement and not as a result of the simultaneously occurring yield increases. Market improvement is effective in increasing the income potential of small farmers and brings considerable benefits to the economy. The quantity of the benefits, however, should not be exaggerated. In the last year of the simulation the maximum increase in producer surplus was 18 million US dollars. This is some 20 US dollars per producers' family member per year, an income increase of 6% over present levels for the rural population. While market improvement can make a significant contribution towards increasing incomes for producers and the purchasing power of consumers, it is not enough, in and of itself, to make a major difference in the lives of the people of the Atlantic Coast region of Colombia. Market improvement is only a stepping stone for more extensive programs to improve urban and rural welfare.

Notes:

(1) For correct weighing of areas with yields the area planted has to be separated into area planted in regions without drying industry, and area with drying industry (Equations 10-12). Equation 10 calculates the area planted if no drying industry would have been built. By multiplying this with the percentage of the region without drying plants $(1-S_j)$, the area planted in farms outside the influence of the drying plants is found (11). This area is subtracted from the total area planted, to find the area planted in zones with drying plants (12).

(2) Yields have to be corrected for the fact that farmers in zones with drying plants not only produce higher yields but also plant a larger area (Equations 14-17). To weigh correctly, first the expected yield of farms in zones without drying plants is calculated in equation 15. The yield of the farms in zones with drying plants is calculated in equation 16 by subtracting the yield contribution by farmers in zones without plants from the average planned yield before correction and dividing with the percentage of the region with plants. Now the yield of the farms in zones with and without drying plants are multiplied with their respective area planted (16). After division with the total area planted this gives the final expected average yield. This last figure is fed back to equation 14 for the next years' calculation.

Chapter 8: ISSUES IN THE IMPLEMENTATION OF THE CASSAVA MARKET IMPROVEMENT STRATEGIES

8.1 Introduction

Cassava market improvement could effectively contribute to rural development. However, the theoretic effect any market improvement strategy might have, has to be studied along with the feasibility of its implementation. In this chapter some major issues for project implementation will be discussed.

One issue concerns the value of market improvement at international rather than domestic prices. This is especially relevant for project funding since potential lenders are very interested in the potential of the project at world market prices. While this is irrelevant for non-tradeable items like fresh cassava and other root crops which do not enter world markets, it is extremely relevant for dried cassava as animal feed. The world market for feed grains is widely developed and Colombia must determine whether producing dried cassava is a better use of resources than importing sorghum or producing feed grains within the country.

A second issue is the selection of appropriate regions for the proposed projects. Region selection depends strongly on the policy objectives the project wants to fulfill.

The market improvement strategies proposed depend on postharvest treatment. In the project definition it is critical to select appropriate postharvest technology. The type of technology chosen will greatly influence who the beneficiaries of the project will be.

A market introduction strategy and optimum conditions for market entry have to be defined. For dried cassava the market functions in a rational way, based on the nutritional value of the feedstuffs, whereas for storable fresh cassava, a specific introduction strategy to win over consumers will be necessary.

Yield improvements increase the benefits of the project and favor the consumer or industrial cassava user through decreasing prices. For market improvement programs, yield-increasing technology might not be essential, but would still be welcome if this could further decrease production costs. For fresh cassava storage, cassava quality might be an important factor in the success of the program.

A last issue in cassava market improvement programs is the institutional organization needed for efficient project implementation. The type of organizations that should participate, the credit and training programs needed, and the political support needed for the market improvement programs must all be considered.

8.2 The domestic resource costs of dried cassava production

In many countries, internal prices differ greatly from world market prices, because of specific tax and subsidy structures, or imperfections in land, labor, and capital markets. In this case internal prices are not appropriate for determining the international competitiveness of a certain activity. Domestic Resource Cost analysis (DRC) tries to correct deviations in domestic prices in order to arrive at an unbiased judgment on the international competitiveness of a certain activity.

For price corrections, two groups of items are distinguished. The first group is tradeable items. The international price is the best indicator of the value of these items. A problem in the use of world market prices is whether these prices will remain the same throughout the period of project analysis. Many world markets are flooded by surplus domestic production and subsequently prices are very unstable.

The second group is non-tradeables. These do not enter international trade and consequently their value is more difficult to estimate. Land, construction, and labor, more than material goods, comprise this group. Many non-tradeables can be separated into a tradeable and a non-tradeable component; for example, the construction materials for a building might be tradeable but the labor needed to build it is non-tradeable.

In the present study border prices for tradeable products have been calculated by correcting for the internal marketing margin. Border prices were then corrected for import duties, to arrive at international prices. The marketing margin itself was considered non-tradeable. Capital was treated as a tradeable item, because cassava market improvement programs might well be based on international funds. An interest rate of 11% was taken, as, at the time of analysis, this was equal to the Libor-rate plus the extra charge to Colombia. After a 4% correction for international inflation, an interest rate of 7% remained.

Most non-tradeable costs were corrected on the basis of a World Bank study by Schohl (1979), that analyzed price distortions within Colombia in an input-output table framework. Skilled labor was treated along the same lines, but unskilled labor was corrected on the basis of a case study in the Atlantic Coast (Hoogervorst, 1985), following the methodology of Squire and van der Tak (1975) for economic analysis of projects.

Cassava production costs were obtained from the production and farm marketing survey and are based on cassava-maize intercropping. Processing costs were obtained from a feasibility study on solar cassava drying (Janssen and Ospina, 1983). These costs are compared with sorghum production costs in the Atlantic Coast region, obtained from a case study by Borren (1983).

Dried cassava production and processing as well as sorghum production were analyzed as six-year projects. For items with a longer lifespan, the residual value of the investment was included as a benefit in the last year.

Project establishment involves institutional costs. In the case of sorghum production an extension cost of 12 dollars per hectare has been included, to be depreciated in 20 years. These extension costs are low and reflect the fact that sorghum growing is a widely-diffused, large-scale activity. For cassava, the institutional costs of establishing a plant are calculated at some 14,500 US dollars. This mainly reflects the costs of government organizations to train poorly qualified farmers in different aspects of plant operation.

The investments, production costs, incomes, and cash flow for sorghum (expressed in shadow prices) are presented in Appendix 9. For cassava, they are found in Appendix 10. A first conclusion is that sorghum production in the Atlantic Coast region receives considerable protection. The Effective Protection Coefficient for sorghum, which compares the value of output minus traded input at domestic prices with the same figure at international prices (CIMMYT, 1983) is around 1.5. Remuneration of production costs is 50% higher at domestic than at international prices.

To estimate the domestic resource costs or benefits of a certain project, several key-indicators can be used. One of the better known is the Domestic Resource Cost ratio (DRC-ratio), where the domestic costs of a certain activity are divided by the amount of foreign exchange saved (Pearson, Akranasee and Nelson, 1976). If the foreign exchange saved is multiplied by the (shadow) exchange rate, the DRC-ratio has to be below one for an activity to be profitable. Equally useful are the internal rate of return (IRR) or the Benefit-Cost ratio (B/C-ratio); Table 8.1 shows the values of these indicators for sorghum and dried cassava production.

Tables 8.1. Indicators of economic value of sorghum versus dried cassava in international prices, 1984.

	Sorghum production	Dried cassava production
DRC-ratio	1.26	0.72
IRR	-7.1%	43.8%
B/C-ratio	0.89	1.25

Dried cassava production is far more favorable for the country than sorghum production, as expressed by a DRC-ratio of 0.72 versus 1.26. For each dollar earned with dried cassava production only 72 cents have to be spent, whereas for sorghum production each dollar earned costs one dollar and 26 cents. Since the Colombian producer receives one and a half dollars for each dollar spent, sorghum production is still attractive at national prices.

Sorghum production in the Atlantic Coast region has a negative internal rate of return of around 7%, while dried cassava production has a positive one of about 43%. This last value appears very high, as it is partially caused by the low investments in comparison with the annual cash flow.

The B/C-ratios support the previous conclusions: for sorghum the B/C-ratio is 0.89 and for cassava 1.21. Dried cassava production is an attractive activity at international prices but for sorghum the benefits are not worth the costs.

This conclusion has been submitted to sensitivity analysis for the exchange rate, production levels per hectare, and world market prices for sorghum and soybean. Table 8.2 shows the impact of the exchange rate on the B/C-ratio of the two activities. If the Colombian peso appreciated 20% against the dollar, cassava

Table 8.2. The effect of changes in the exchange rate on the B/C-ratio for sorghum production and dried cassava production, 1984.

Exchange rate	Sorghum production	Dried cassava production
-20%	0.78	1.06
-10%	0.84	1.16
-	0.89	1.25
+10%	0.94	1.34
+20%	0.98	1.42

production would still be profitable. The exchange rate, however, has to fall by more than 20% for sorghum production to be profitable. Sorghum production is less sensitive than cassava to changes in the exchange rate, because 50% of the costs in sorghum production is tradeable, whereas only 30% of cassava production costs is tradeable.

Table 8.3 shows the effect of yields on the B/C-ratios. Sorghum yields have to increase by almost 20% to make sorghum attractive at international prices. Cassava yields could decrease to seven tons (-33%) and maize yields to 0.9 tons per hectare before cassava production for animal feed would be unattractive.

Table 8.3 The effect of yield increases on the B/C-ratio of sorghum production and dried cassava production, 1984.

Sorghum Production (monocrop)		Cassava Production	Maize yield = 800 kg/ha	Maize yield = 1000 kg/ha*	Maize yield = 1200 kg/ha
Sorghum yield (kg/ha)	B/C-ratio	Cassava yield (kg/ha)	B/C-ratio	B/C-ratio	B/C-ratio
2600	0.84	8000	1.07	1.13	1.19
2800*	0.89	9000	1.13	1.18	1.24
3000	0.94	10000*	1.18	1.23	1.28
3200	0.99	11000	1.23	1.28	1.33
3400	1.03	12000	1.27	1.32	1.37

* Most expected yield levels.

The effect of changing world market prices for sorghum and soybean meal is evaluated in Table 8.4. If the CIF sorghum price would move up to 180 US dollars/ton, sorghum production would be only just feasible. The probability of such a price change is limited. World market prices have been moving downwards more than upwards in the last decade and the trend appears to be continuing. Dried cassava production is still profitable at a CIF sorghum price of 140 US dollars per ton and a CIF soybean meal price of 270 dollars per ton. If the soybean meal price would

Table 8.4. The effect of world market price changes for sorghum and soya on the B/C-ratio of sorghum production and dried cassava production, 1984.

Sorghum Production		Dried cassava production		
Sorghum Price (US$/ton)		Soya meal price = 250 US$/ton	Soya meal price = 270 US$/ton	Soya meal price = 290 US$/ton
130	0.73	1.00	0.98	0.95
140	0.78	1.09	1.07	1.04
150	0.84	1.18	1.16	1.13
160	0.89	1.27	1.25	1.22
170	0.94	1.36	1.34	1.31
180	1.00	1.45	1.42	1.40

decrease at the same rate as the sorghum price, cassava production would stay attractive at even lower sorghum price levels.

For dried cassava production the utilization degree of the drying capacity might be another factor that influences its economic feasibility. Data presented suppose a utilization degree of 80%. If this utilization degree fell (as might happen according to the different scenarios for market improvement tested in Chapter 7), the feasibility of cassava drying will fall as well. A drop in the utilization degree to 60% would cause the B/C-ratio to drop to 1.20. This would still permit cassava drying at a satisfactory rate of return.

Under the present circumstances dried cassava production for animal feed is economically viable. On the other hand, sorghum production in the region is not attractive and maintains itself through the comfortable subsidies which it receives.

8.3 Region selection for the implementation of cassava market development programs

The location of market improvement programs forms an important factor in their possible success, and includes both region selection and site selection within the region. Recent anthropological research indicates that the beneficiaries of the programs live very close to where the program is being executed (CIAT, 1986).

This section only treats region selection since the selection criteria were more defined at the moment of writing than those for site selection. Two basic considerations interfere in region selection. The first is the appropriateness of the region for the planned program. The second is the impact of successful program implementation on the region.

For cassava drying, the potential of an area for increasing production in order to generate a surplus for processing is a chief determinant of the appropriateness of the region. Production potential is determined by a number of factors. A first one is the availability of land to expand cassava production. This would direct the program to those zones, where farm size would allow the expansion of cassava cultivation or where it is easy and secure to rent more land. A second factor is the labor availability for cassava production in critical times of the year, such as the land preparation and planting season. The ability to mechanize crop labor or to avoid land preparation (as in the case of zero tillage) plays an important role in defining this factor. Flat, mechanizable land should have preference over rolling hills, for ease of planting, and to minimize potential erosion. A third factor is the potential to increase yields in order to maximize benefits to the producer. The presence of good quality land and of a cropping system, in which cassava yields can be easily increased, is vital.

Successful entrance into the feedstuff market will be abetted if the access to the present market (i.e. for fresh cassava) is poor. In that case competition for cassava is limited and the drying industry can develop more quickly. This implies that perspectives are best in areas with limited access to the fresh cassava market, either because of remoteness or for quality reasons. Successful program implementation also depends on the appropriateness of the climate, which has to permit sun drying for enough of the year to allow efficient use of the drying capacity.

For cassava storage, the ability to support higher production is less important. More important is the production of high quality cassava, in order to assure access to the fresh market, and the continuous supply throughout the year. Fresh cassava storage programs should concentrate on zones with good fresh market access or zones that produce high quality cassava but cannot enter the market because of their remote location. Another condition is adequate access to the inputs needed to allow storage. Plastic bags to store cassava in an air-tight way, and the desired fungicide to prevent microbial deterioration should be readily and constantly available.

A last factor regarding the appropriateness of the region regards the presence of capable personnel to carry out the program. Regions with a strong institutional infrastructure, where cassava market programs could be incorporated in a larger development effort, should be preferred.

The impact considerations stress the importance of cassava market improvement in one zone versus another. Regions where cassava is a dominant crop and where few crop alternatives exist should have preference. Also, regions with high dependence on agricultural employment and few possibilities for off-farm employment should be considered with extra attention. Income levels of cassava producers form another indication of the impact that can be realized in a certain region.

For potential impact evaluation, a last criterion is the attention already received by the different regions. Projects should be preferably directed to zones that have so far been unattended, although this criterion might be inconsistent with the potential for successful program development as regards the capability of the existing institutions.

The actual choice of the region might be relatively straightforward: in the case of cassava drying in the Atlantic Coast, the southern part of the region was more appropriate for program implementation and would also benefit most from its impact. If appropriateness and impact criteria indicate different regions, then it is not easy to define which region to select. In that case the selection cannot be made on the basis of mere economic analysis but has to consider the political importance of appropriateness versus impact.

8.4 Postharvest technology choice

Postharvest technology selection depends on technical and socio-economic conditions of the market improvement program. In the case of cassava drying a number of technologies is available, from unmechanized sun drying to automized artificial drying systems. To determine the attractiveness of different technologies one should consider the following (see Moreno, Best and Janssen, 1985):

- The scale of the drying operation. Most cassava farmers produce small quantities of roots. The effort to coordinate this supply in large drying plants is awesome. Coordination problems appear to be responsible for the failure of many large-scale cassava processing projects. In large-scale operations, transport costs rise quickly. If the project is directed towards small cassava growers, small processing units are most effective.

- The needed quality of the end product. Artificial drying delivers a higher quality product but often at a higher price than solar drying. Is the extra quality worth the higher costs? For animal feed quality exigencies are fulfilled in the sun drying system and it is not relevant to apply more expensive drying methods.

- The type of raw material. Some cassava has a high cyanide content and needs a slow drying process to release this. In this case rapid artificial methods are less effective.

- The availability of public utilities and fuel. Where the availability of these items is minimal it is essential to select a drying method that does not greatly depend on them.

- The availability of labor and capital. Labor and capital intensiveness greatly determine the type of impact of the program. When employment in the region is scarce, labor-intensive technology has an advantage. It should be noted that in cassava drying, the bulk of employment creation comes from the expansion of cassava cultivation. Only one sixth of the total employment created is actually created in the plant. If labor-intensive technology with limited processing capacity would constrain the cassava area expansion, priority should be given to more mechanized forms of processing.

- The education level of future plant operators. Drying plants should employ people of the region. If the education level of these people is low, the technology applied should be simple.

Fresh cassava storage has to start with appropriate selection of roots. The roots have to be packed in plastic bags in the field to prevent physiological deterioration. The size of the plastic bag and the quantity packed per bag depend on consumer and trader preferences. One possibility would be to pack in large quantities in the field and to repack at retail level in order to allow the consumer to select his own purchase. The other possibility would be to pack in consumer portions at the moment of harvesting.

The roots must also be treated against microbial deterioration. Roots can be dipped in a fungicide solution, but this takes a lot of time, involves high fungicide use because of drip losses, and creates transport problems in getting the solution to the place of harvest. Another possibility would be to apply the fungicide solution in the bag with a back sprayer. Fungicide consumption and time needed would be reduced and the transport of the solution to the field would be simpler. The main problem is that the back sprayer might be used for other purposes such as herbicide application and that the fungicide solution might be contaminated with toxic elements. The acquisition of a special back sprayer for this purpose plus strong emphasis on health aspects in the extension of the method are essential.

The development of a simple quality control method for cassava storage is essential. Quality control should consider whether the treatment has been applied in the correct way, but also whether safety standards for human consumption are met. Preferably the assembly agent should have an easy method to check this. In case he has doubts about safety, he should have free access to a public laboratory for further analysis.

To avoid large scale losses in program implementation, the project should begin with a pilot program, to test the applied technology and to adapt this to the specific socio-economic and technical circumstances. If the technology is appropriately tested, replication of the program should succeed.

8.5 Market introduction and arrangements

The market for dried cassava exists in a small group of expert buyers who are well aware of the advantages and disadvantages of the product and who base purchase decisions on rational considerations regarding price and nutritional value. Dried cassava offered to this market under optimal conditions will not encounter any sales problems. It is critical, therefore, to define those conditions.

A first and dominating aspect is quality. Quality has to be constant to allow the animal feed industry to plan its feed mixes sufficiently in advance. Strict quality control at drying plant level is absolutely necessary.

A second aspect is supply. The animal feed industry will need to know the supply of dried cassava for its production planning. Prices for the product might be improved if supply contracts are made at the start of the drying season, when potential production can be estimated reliably.

Fresh cassava storage changes the characteristics of the product currently being sold. Questions regarding bag size, acceptability of a preservative, and quality appreciation after storage, have to be answered. The consumer has to be convinced of the quality and advantages of storable cassava. A consumer panel could answer the questions on the acceptability of the product and could begin to familiarize the general public with storable cassava.

Concurrently, cassava traders should be made aware of the potential for storage. They could participate in the consumer panels, but should also be made familiar with the packing method. Special attention should be given to the assembly agent, as he is the one who receives cassava from the farmer, and is most qualified to judge the quality of the treatment.

Fresh cassava is supplied to the cities from different areas throughout the year. Since cassava farmers do not sell the whole year round it is practically impossible to improve fresh cassava marketing from one production zone; the method must be introduced in each of the regions that supply cassava. The market agents (especially the assembly agent), are crucial to the rapid diffusion of fresh cassava.

After farmers, traders, and selected consumer groups have been introduced to the advantages of storable cassava, an information dissemination campaign should be launched at new audiences, while the product should simultaneously become available in a large number of outlets. The advertising and marketing strategy in this phase is similar to commercial methods for selling new products.

8.6 Improvement of cassava production

Production research for dried cassava market development should focus on dry matter yield. Root size or culinary qualities are not important, since the final product is chipped and only evaluated on its nutritional contents. Intercropped cassava yields should be judged on the profits of the total intercrop, not just the yield of the cassava. If the production of intercrops with less elastic demand would increase simultaneously with cassava production, the price for these products might fall. Production research should be directed towards cropping systems that are not subject to market constraints.

Production research should be linked with the pilot plant scheme for drying technology development. Production research should interact closely with the farmers involved in the program, to decrease institutional costs and improve its orientation. Production technology development in direct contact with farmers has been strongly developed over the last decade as a reaction to the problems in specifying research problems on experimental stations and is best known as "cropping systems research" (Zandstra et.al., 1981).

In the case of fresh cassava storage, successful introduction will be facilitated by high root quality. Production research should stress quality over yields. Consumers should be consulted for help in screening varieties with preferred culinary characteristics. This is especially relevant given the difficulty in defining physical parameters related to culinary quality.

With regard to spatial arrangements and intercropping patterns, not the total yield but the yield of commercially acceptable roots is important. This will result in relatively low planting densities to allow each plant to develop commercially acceptable roots.

8.7 Institutional arrangements for successful cassava market development

Farmer organization

Dried cassava processing and marketing requires investments that are too high for the individual small farmer. Plants should be organized around groups of farmers, who process their own cassava and run it with their own labor. Since the optimum size of a drying plant is quite small, its organization should not be very formal or costly. Cooperative farmers' groups have been attempted in the Atlantic Coast region of Colombia, but these cooperatives are overly constrained by government regulations which severely diminish plant profitability. A slightly less formal form (called association) would probably serve better.

The distribution of the benefits within the group should stimulate its coherency. Remuneration for labor and for cassava supplied should be attractive, but the plant should also try to capitalize part of the profits in order to maintain the loyalty of its plant members.

Dried cassava might also be produced by entrepreneurs, but this would provide less of a sales guarantee to the farmer, and less chance to employ his labor, than do associations. The value of enterpreneurial cassava drying for the farmer depends on the competition between different drying plants. If the farmer has the option to sell to a number of plants, then his negotiation position will be reasonable and his benefits acceptable.

Cassava drying could be used for the organization of landless people. The drying plant might provide these underprivileged people with employment, with profits from plant operation, and with improved access to the land rental market. The organization of landless people is risky since the plant would not have any supply security. On the other hand, the motivation of the landless is extremely high as they have nothing to lose, and the potential impact of these drying plants run by the very poor is equally high.

For fresh cassava storage, associations appear less feasible and less necessary. Investments to be made are small, which decreases the need as well as the potential to organize farmers. Also, an association working with fresh cassava cannot take complete charge of its own marketing. Urban fresh cassava is supplied from different areas at different times of the year, and a critical function of the market agents is to coordinate regional supply patterns and to control quality of cassava and treatment. It is difficult for a group of autonomous farmers to perform these functions during only a few months per year. A good working relationship between assembly agents and farmers appears more important for successful project development than does potential farmer organization.

Institutional support and organization

Institutional support for cassava drying programs must be directed towards appropriate financing of the plant, its working capital, and its cassava production, together with the establishment of appropriate savings possibilities.

Marketing know-how is also essential. Contacts with potential buyers have to be made, detailed knowledge on the product has to be extended, and purchasing conditions have to be checked. Marketing contacts should be passed rapidly to the drying plants themselves.

To run a drying plant, small farmers have to be acquainted with drying technology on the one hand, and administrative matters on the other, necessitating the development of training programs for the involved farmers.

Cassava drying will increase interest in cassava production. Agricultural backstopping should be available to enable increased cassava production.

A last issue is the organization of coherent farmer groups, which will require institutional expertise in social development processes.

Capital investment is less important for fresh cassava storage. Storable cassava, however desirable, will not dominate the market from the first day after introduction. Adoption by the consumer will take some time and losses may be experienced initially. There should be funds available to cover these losses.

Marketing knowledge is very critical, for both the marketing channel as well as the final consumer. Institutional relationships with marketing agents and understanding of the urban consumer should be optimal.

The technical knowledge on storage has to be diffused from the traders to the supplying farmers. Therefore traders should receive technical assistance on treatments and packing.

Within Colombia and many other countries, the expertise needed for the different aspects of a market improvement program is not present in one single instititution, but must be gathered piecemeal from several. If institutions already collaborate (e.g. the Integrated Rural Development program of the Atlantic Coast region), then the market improvement project can benefit from the existing institutional context. If this is not the case an ad-hoc relationship between different institutions might be the easiest form of coordination.

Training and extension

Once postharvest and production technology have been defined, they should be implemented in a quick and cost effective way. Two levels of training are envisioned.

The first is at the institutional level, where officials of the institutions involved should be trained in correct and proper application of the technology. Initially technology transfer to the institutions is meant to increase the speed of diffusion. Afterwards it is meant to facilitate effective trouble-shooting and consultation.

The second level is the training of farmers and, in case of cassava storage, traders. Training at this level should be coordinated with institutional training and start slightly later. Trained officials should begin to teach immediately and training contents should be revised according to the issues that arise in the courses. Training and extension will benefit from having had a pilot program, which (optimally) pinpointed specific training needs in an early phase of the project.

Instruction of farmers and traders can be shifted rapidly from the institutions to already experienced farmers and traders. On the basis of their own findings, they can transfer the essential knowledge to others. Early established drying plants or treatment operations (e.g. the pilot program) can be used as demonstration units. In this way the burden on the more qualified and expensive officials and the dependence of the program on institutional support can be reduced.

Political Support

Political support can be distinguished at program and at policy level. The main issue at program level is to guarantee sufficient resources and collaboration.

Political support at policy level is concerned with the economic circumstances of the proposed program. Policies regarding input and output prices determine these circumstances to a large extent. In some countries fertilizers and chemical inputs are subsidized, which favors high input over low input crops. In other countries, grain prices are subsidized to control the cost of caloric staples and animal proteins, or are maintained above world market prices to stimulate domestic production. Credit policy has significant impact on development programs. Land reform or reallocation is another way to change production and income capacity of agriculture.

The macro-economic conditions for dried cassava production in the Atlantic Coast region are favorable. The sorghum price is maintained above world market levels. Fertilizers are taxed, a policy which favors low input agriculture, such as cassava cultivation. Credit and land reform policies are less favorable. Credit procedures are bureaucratic and appear to be designed to delay its granting. Although small farm credit is subsidized, its availability is limited and does not allow rapid expansion of production. Credit for drying plant construction has been rationed by the DRI-program and is subject to the political interests of the DRI-officers. The land reform process is at a standstill and constrains income potential for the very poor. Since cassava drying appears feasible from a domestic resource point of view, from a foreign exchange point of view, and from an employment, income, and income distribution point of view, it would seem adviseable to eliminate credit constraints and stimulate land reform. One hundred thousand tons of dried cassava processing capacity could be established with 3 million dollars of seed money.

For fresh cassava, government intervention is virtually non-existent. Price formation for roots and tubers is left to a free, but unorganized and unclear market system. The government policy with regards to cereals affects the attractiveness of fresh cassava. Both wheat and rice prices are maintained above world market levels. Price competition is favorable for fresh cassava.

If the policy environment for cassava market improvement is unfavorable, it would not be wise to try to change the general outline of the agricultural policy, as the policy was designed to fit the objectives of many interest groups and political currents. If these strategies were redesigned, it is probable that some groups would be hurt and would take a position against the proposed programs. If policy changes are desirable it would be better to concentrate on obtaining specific arrangements for cassava rather than to attempt to restructure all of agricultural policy.

Chapter 9: SUMMARY AND CONCLUSIONS

9.1 Market impact on cassava's role in the Atlantic Coast region of Colombia

Market perspectives for small farm crops are often poor. Small farmers put great emphasis on home consumption in their production plans and tend to sell their surplus only after family food needs have been satisfied. Small farmers, therefore, are often involved with traditional food crops which are easily produced in their specific environment. Traditional food products, however, do not always face a growing demand in developing societies in the throes of urbanization. Urban environments demand that marketing feasibility as well as production feasibility define the appropriateness of a food crop.

The market situation for small farmers in the Atlantic Coast region is illustrative. Cassava, yam, and plantain are among their major products, and have always been central to the rural diet, yet demand for these products is stable or decreasing. Food demand is measured in the urban environments where the traditional calorie staples of the region are being supplanted by rice or bread. The bulky, perishable, and laborious traditional food crops maintain their role in on-farm consumption, where marketing characteristics are irrelevant, but sales to consumers plummet with urbanization. Small farmers face bad sales perspectives and are sometimes forced to plough under a crop without harvesting--consequently, their income perspectives are depressing as well.

Market perspectives are better for large farmers, since production of subsistence crops plays only a minor role on large farms as the farm plan is geared to commercial crops. In the Atlantic Coast region the large farm concentrates on cattle, cotton, and sorghum. Meat and textile demand rises in a developing economy, as does feed grain demand, and prices for cotton and sorghum are supported by government or semi-government agencies above world market levels. The rising demand and the stable price perspectives further prosperity on the large farm.

While this limited group of large farmers is being supported, the small farmer majority is left to struggle against the market tide. This situation is not favorable for balanced agricultural development.

A thorough understanding of the specific characteristics of cassava is essential for understanding the role it plays in the region, yet its bulky nature and high rate of deterioration have kept it out of the mainstream of market analysis, which is usually directed towards the less-perishable, high value grains.

At present, most cassava in the region is boiled and afterwards used for human consumption. This appears to be the most appropriate use of the crop for rural areas, given the ability to store cassava in the ground and the unimportance of marketing. The fresh cassava demand, however, is negatively affected by urbanization. Urban consumption levels are far below rural ones and appear to be falling, which has led to the suggestion that cassava is an inferior good. Nevertheless, cross-sectional data indicate that the decrease in cassava consumption is not related to income. Moreover, the answers to a number of attitude statements showed that cassava is as much appreciated as rice and potato, two crops with growing consumption levels in the region. There appear to be three better reasons for explaining declines in cassava consumption levels: cassava is an inconvenient product to buy and to store, and thus does not fit into the purchasing habits of urban consumers; high marketing costs make the product expensive; and, the increased availability of other products in many parts of the study region (rice, potatoes, bread) has redefined cassava's role in the urban diet.

Investigations into the factors influencing fresh cassava consumption reveal the narrowness of a term like inferiority. Consumption of a food crop is determined by a myriad of factors including income, urbanization, availability, convenience, and acquisition costs. Inferiority labeling is based only on income, with the influence of other factors like urbanization or availability being assigned to the income factor. Marketing can contribute to improved positioning of a product on several consumption-influencing factors. Since the future of fresh cassava is not so much determined by its production, as by its marketing, market programs can play a critical role in improving demand perspectives and income potential of the crop.

In the existing situation, the falling fresh cassava consumption levels will slowly diminish its income potential for the producer, suggesting that one of the economic cornerstones for small farmers will erode. The unfavorable market perspectives for cassava limit the region's rural and small farm development potential which, in turn, might stimulate rural-urban migration and increasingly burden the weak and overdrawn urban economy.

Cassava marketing also reflects the character of the product. To avoid perishability problems, cassava is traded extremely rapidly, reaching the final consumer 30 to 35 hours after harvest. Perishability prohibits assembly, so the marketing channel is directed towards rapid distribution. Volumes handled per trader are small, below 1000 kg per day for assembly agents or wholesalers and below 100 kg per day for retailers. The number of traders is very high and the marketing channel can be characterized as atomistic. The bad storage quality of the product takes its toll not only through postharvest losses but also through labor-intensive and costly marketing. These costs change cassava from a cheap rural staple into an expensive urban food crop.

The ability to store the crop in the ground for an undefined period compensates somewhat for the inability to store it after harvest. Cassava is shipped to the urban markets from different production zones in different periods of the year and seasonal price fluctuations are limited. Postharvest storage problems, however, cause average price fluctuations at retail level to be larger than at farm level.

The limited storage capability also explains the non-existence of interaction between urban cassava markets. Prices in some urban markets were positively correlated only because the markets were supplied by the same production areas (an indirect relationship). There was no indication of a direct positive relationship between price formation in different towns.

The bulky nature and perishability of the crop limit its geographical market. Consequently, as prices over the years are unstable, the sales risk to the farmer increases. Production conditions are not equal in all parts of the region, and farmers might be faced with bad prices in conjunction with bad harvests, as often as they are faced with good prices and good harvests. The resulting income variability implies a large risk to the farmer in cassava production and decreases his eagerness to grow the crop.

Cassava marketing provides other unattractive characteristics for the farmer as well. More than 10 percent of the roots is not of acceptable quality for the fresh market. Cassava sales have to be arranged in advance at considerable cost to the farmer. If the farmer does not arrange sales he may be stuck with unsaleable roots. There is a 20% price difference between the price received for commercial cassava and the average farm gate price for all cassava produced. Problems of cassava marketing are strongest in areas with little access to urban markets. In these areas the importance of cassava in the farm system decreases and is partly compensated for by crops such as maize.

Storage in the ground allows staggered harvesting of cassava during an interval of several months. This enables the farmer to maintain an even cash flow. Cassava is almost always intercropped (i.e. with yams and maize) to overcome the long growing period for cassava and the deficient credit availability, to improve land utilization, and to even out risks. When a farmer has land above what is needed for subsistence, he will try to raise cattle, a low-risk and low-income activity. Cattle holding has a flexible labor pattern, supplies milk to the family and serves to accumulate capital. The introduction of appropriate savings institutions might diminish the need for cattle and increase productivity of the small farm.

Growing cassava is more important for small than for large farmers. Its potential in the region is bigger than presently realized, with the limited and unstable market being largely responsible for this. In the present situation, the importance of cassava within the agricultural sector is decreasing. Given its prominent role as a source of income for small farmers this is a depressing development.

Cassava is a crop which has many potential final products, some of which affect market behavior more than others. For example, a small proportion of production is processed into starch or snack foods, but without much influence on the market behavior, whereas the incipient drying industry that processes cassava into an animal feed component may strongly affect the market. This market opens considerable growth perspectives (given the growing demand for poultry products and pork), and the handling of a storable and less bulky product allows producers more control over their marketing. The incipient drying industry has very favorable perspectives in the region.

9.2 The effect of market improvement on cassava in the Atlantic Coast region of Colombia

The diminishing role of cassava in the study region is not caused by lack of production potential, which is greater than presently used. Marketing and consumption problems for the traditional uses of cassava are the main constraints to realization of its production potential.

Two market improvement strategies for cassava were evaluated. The first one concerns the improvement of the present marketing channel for fresh cassava by the introduction of a storage method. This strategy would have two effects: marketing costs would decrease because of less deterioration and time pressure, and final demand would increase since the product would better fulfill purchasing convenience exigencies.

Fresh cassava storage would considerably decrease the marketing margin for the metropolitan areas, while for the other areas the expected decrease in the marketing margin would be outweighed by the costs needed to store cassava. The effect of cassava storage on demand was measured in a procedure which relates the consumption of different crops to their prices, to the opinions of consumers, and to incomes. Consumer opinions towards different products were bundled in an attitude complex by means of a factor analysis. These attitude complexes were afterwards included in a linear regression model to explain consumption levels. The bad storage characteristics of cassava and the related negative attitude as regards convenience explained a reduction of annual cassava consumption by up to 30 kg per capita in different environments. It was estimated that cassava storage could increase annual cassava consumption per capita by 15 kg in the metropolitan areas and by 10 kg in smaller towns or large villages.

The second strategy concerns the development of dried cassava production for balanced animal feed. The rapid growth of the animal feed industry opens favorable demand perspectives for dried cassava. Entering the animal feed market would allow cassava production to expand considerably without experiencing a price decrease. The very price-elastic demand for dried cassava would also stabilize the cassava price and diminish cassava's market risk to the farmer.

A demand of some 100,000 tons of dried cassava per year exists in the region, equal to about half the present production of cassava. Demand for dried cassava grows very quickly. The decrease in market risk as a consequence of the opening of the dried cassava market would cause a supply shift. The expected size of the shift was measured with quadratric programming models and with a linear regression procedure. Supply in small farms (smaller than 5 ha) would increase by 27%, and in intermediate (between 5 and 10 hectares) or large (between 10 and 20 hectares) farms by almost 80%. Credit and land availability constrained the production response of small farmers. The impact of dried cassava industry development could be enlarged with effective credit programs. Farm income could increase by up to 20%. The dried cassava industry would cause a shift to more simple cropping systems and would reduce the area under pastures.

The effects caused by improvements in marketing or processing extend beyond marketing itself, which acts as a bridge between production and consumption. If the bridging function of marketing is improved it is logical to encounter changes on both sides. Most literature written on tropical marketing has not taken these effects into account, yet their measurement is crucial to an understanding of market impact. This necessitates integrated analyses of the production marketing consumption system, so a simulation model of the Atlantic Coast cassava system was built, to facilitate evaluations of the aforementioned different market improvement strategies.

The impact of the two strategies would be very distinct. Cassava storage improvement would benefit the metropolitan consumer most, while benefits for other urban consumers would be more limited. The demand increase would bring considerable benefits to producers, equally divided over different size groups. These benefits would mainly reach zones with reasonable access to fresh cassava markets. Industrial consumers of cassava would not benefit. Employment would increase slightly. The cassava price would tend to increase, contrary to the non-intervention situation in which it would slowly fall.

Development of a cassava drying industry would mainly benefit the producer. Benefits would be directed towards farms with relatively ample land resources, i.e. those capable of expanding production. The development of the cassava drying industry would benefit all groups more than cassava storage development. The drying industry would strongly benefit farmers with poor market access. Cassava production would increase strongly which would lead to pressure on the land market; dried cassava production could also bring considerable savings in foreign exchange. The animal feed industry would also benefit considerably from the development of a dried cassava industry. The strategy would create considerable rural employment, on both the drying and production levels. The establishment of a drying industry would increase the price of fresh cassava to the urban consumer. If cassava production could grow more rapidly than expected, the conflict between producers versus consumers receiving the benefits could be resolved.

Although the benefits of the two strategies are very different, the size of the benefits justifies the development of each one. In the case of cassava drying, an investment in seed money for plant construction of some 3 million dollars would have a pay-off in social benefits of some 35 million dollars. The internal rate of return of the project at international prices was estimated at 44%. Dried cassava production is preferable above sorghum production in the Atlantic Coast region.

For fresh cassava, storage investment costs are low, and are mostly institutional costs. If the same amount of money would have to be invested in storage as in drying industry development, then the strategy would have a very positive final balance, since the discounted benefits over the first ten years would amount to 50 million US dollars.

Cassava market improvement is a very attractive way to improve the contribution of the crop to the development of the region. Investments needed are low, since the basic value of the market development strategies is in the reallocation of existing production potential. This enables cassava producers to improve their incomes with traditional crops, rather than forcing them to supplant these with less familiar products.

The policy values of the two strategies are very different. Cassava drying is specifically effective for rural development programs and might help to slow down migration. It creates considerable rural employment and benefits farmers at the cost of consumers. The regional distribution of the benefits will favor isolated areas which have poor access to markets at present. Pressure on land and credit resources will rise and the program could be supplemented by land reform, small farm credit and savings programs.

Fresh cassava storage benefits the metropolitan consumer and creates some urban employment. This might stimulate rather than slow down migration. Producers receive less benefits than in the case of cassava drying and these benefits will be concentrated in areas with present access to good markets.

Migration is a continuous problem in Colombia. Low income possibilities for small farmers and poor living conditions in the countryside force people to try their luck in urban areas. This factor suggests that benefits should be concentrated towards the producers rather than to the consumers; thus, the establishment of a cassava drying industry should receive priority over improvement of cassava storage.

9.3 The universality of market development strategies

Market improvement has proven to be a useful concept for cassava development in the Atlantic Coast region of Colombia, as its implementation will expand the potential of the crop. It is of interest to determine if this concept could also be useful in other circumstances, by applying it to cassava development in other regions or on other continents, and by applying it to other crops.

As far as cassava in other regions is concerned, the critical factor is to define feasible alternative market possibilities. Where access exists to metropolitan markets, cassava storage could improve the role of the crop in income formation of the farmer, and consumption patterns of the urban dweller. Within tropical Latin America this could be possible in Brazil, Venezuela, Peru, Paraguay, Panama and the Dominican Republic. The expected benefits of a storage strategy depend on present consumption levels. Where these are low, the expected benefits will also be low. Cassava storage could also have value for opening new markets, e.g. in exports to developed countries.

Where fresh cassava is not used for human consumption, markets for processed cassava need to be considered. Processing can take different forms, from mixing with other feedstuffs for on-farm feeding, to fermentation to make alternative protein sources. The technical and economic feasibility of any process and the proposed market must first be explored. Ideally production and processing costs should allow profitable access to the new market from the start. A new processing activity could start on the basis of residual and non-commercial roots, but this increases assembly costs and makes the project dependent on the development of the main market. Within the group of markets that are economically feasible, the final choice should be made on the basis of profit margins, absorption capacity, and the ease of entry.

Market improvement strategies allow for better utilization of existing resources. This implies that one of the conditions for market improvement is the availability of production potential. This condition is more easily satisfied in land-abundant regions (most of South America) than in land-scarce regions (Asia and parts of Africa). The identification of the potential to expand production is therefore a critical component in the feasibility study of market improvement programs. If this potential is not available, market improvement programs become conditional to production increasing efforts.

For other products, the potential for successful market improvement depends on the flexibility of the product, that is, in how many ways it can be used. Milk, potato and maize are products that are used in many different ways. Potato and maize mimic cassava's pattern in the development and urbanization process, as demand for traditional uses declines and new uses have to be found to preserve the income potential of the product. Milk demand increases as income increases but quality exigencies and forms of consumption (cheese, butter, yogurt, cream) change strongly.

The issue with maize, potato, and milk again is to define markets which can be entered at present cost of production and which offer the potential for increasing production. For any product the type of markets and the type of processing need to be defined in great detail. The broad range of dairy products offers a favorable market perspective for milk. Maize, like cassava, could enter animal feed markets. Potato has more difficult market perspectives because of its high production costs.

In the case of a current product being directed to a new market, a pilot plant approach to technology development and market introduction is sensible. Technology can be made optimal at low cost, failure costs are minimized, and the methods to direct the program to the target farmers can be easily defined. The criteria elaborated for market, technology, and production appropriateness in Chapter 8 are equally true for other products. For those products that have difficultly entering new markets, market improvement can only be accomplished in the traditional market. Attention should be focused on market understanding and on the identification of appropriate intervention methods. Improvement of present markets is often quality-dependent and production research should stress quality above yield.

The secret of many successful development efforts hinges on creative innovation. The appropriateness of the outlined strategies for market improvement in other regions or with other products is contingent on a sensitive and intelligent understanding of the problems of the region and on the willingness to apply creative solutions.

9.4 Cassava in agricultural research and development

Cassava is a typical small farm crop in many parts of the world, characterized by remarkable flexibility in adapting itself to marginal production circumstances and by an increasing number of potential end products. These points give the crop a very competitive edge in development programs. To understand the potential of cassava, three phases in agricultural development can be distinguished.

In the first phase, agriculture is subsistence-oriented. This is the situation in most parts of Africa today, wherein cassava provides calories to the farmer and his family and strongly increases food security. Its ability to be stored in the ground and to survive periodic severe drought have turned it from a neglected and unappreciated crop into a cornerstone of African agricultural development. The availability of cassava, and the security its presence supplies, allow the farmer to venture into more attractive but also more risky crops.

In the second phase, agricultural orientation shifts from subsistence to markets (e.g. in the frontier zones of Asia and Latin America). In this situation cassava, because of its multiple purposes, allows the farmer to enter a number of different markets while the crop maintains its role in the family diet. The introduction of the small farmer into the market is eased and made less risky by the fact that he can eat the product that he sells. Without compromising on food security the farmer obtains a cash income.

In the third phase, agriculture is market-oriented. This is the situation in large parts of Latin America and some parts of Asia. Cassava has the flexibility to enter different markets and to create cash income for its producers, while at the same time, probably saving foreign exchange and fomenting agroindustrial development. The product might enter markets with safe and secure sales perspectives, allowing the small farmer to capitalize his operation and begin reaping an increasing income.

Cassava is appropriate for the small farmer all the way from its subsistence level dietary function, up to its function as a profit-making trade item. In many situations the crop has to accompany the farmer the whole way through, because other crops cannot be produced in the same circumstances. However, there is no automatic guarantee that the crop will always contribute to the welfare of the small farmer. Once farmers have left the subsistence stage, market improvement is a vital and critical intervention strategy for optimizing utilization possibilities. Market improvement forms the key to renewed use in changing economic conditions of cassava's traditional production potential. Improved production methods will further enlarge the impact on producers and consumers.

Production research should be determined to a large extent by the utilization that the crop will have, causing market characteristics to become determining criteria for production research, even at project level. Cassava should not be included in development projects on the basis of its production potential but on the basis of its utilization potential. It is only justified to stimulate cassava production if utilizations with promising income potential can be determined.

At the same moment utilization should be appropriate for the existing production and socio-economic circumstances. In the case of small farm development, this means that applied technologies should be simple and the organization of the processing appropriate for the farmers involved in the project. Cooperatives or associations will be very useful in enabling small farmers to enter markets they could not conquer individually.

Realizing cassava's development potential depends on correct integration of marketing, processing, and production. However, the integration process has to start from the market and move back to production. Market improvement and introduction of new processing technology are often sufficient to generate an increase in cassava production and farmers' income, whereas improved production methods are not.

9.5 An evaluation of the research approach

An ubiquitous issue in market studies has been the capability of the market system to provide sufficient competition. The question whether the market system satisfies the requests of consumers and producers has hardly been approached and was assumed to depend on the degree of competition. Frequently, qualitative judgments were made and translated into policy recommendations, without estimating the expected benefits to come from acting on these recommendations. Most estimates were limited to the effect within the marketing channel, regarding the cost structure before and after the recommended change.

This approach to market improvement neglects the integrating role of marketing within the product system. Marketing forms the bridge between consumer and producer, for the communication of needs, the transfer of products, and the exchange of resources. It has great impact on allocation of resources by the producer, and on the satisfaction of the consumer. Any study which measures the effectiveness of a market system should be explicitly concerned with this impact. Rather than studying how well a market system fits competition criteria, it appears more sensible to understand how a marketing channel satisfies objectives of the consumers, traders, producers, and governments involved. The next step in recommendations for market improvements would be to identify and quantify the impact that these improvements would have on the behavior and satisfaction of the involved groups. Only in this way can the full impact of the market system on development be estimated.

This more integrated approach to market studies necessitates study of production and consumption issues. This study takes an integrated approach and has given about equal attention to production, marketing, and consumption. The remarkable changes in producer and consumer behavior as a consequence of changes in market circumstances justify the approach above a marketing channel analysis. The focus of the study shifts from the trading and transferring process to the ex- ante estimation of potential benefits of market improvement.

Such a study necessitates considerable data availability at production, marketing, and consumption levels. For appropriate analysis these data have to be analyzed in an integrated way, taking the dynamics of the market system into account. In the present study, all data were explicitly collected for this purpose, because reliable secondary sources were absent. However, surveying is not very appropriate to the understanding of historic developments. Marketing needs to be studied in a dynamic context and the absence of data on the historic development of the market system becomes a severe handicap. This study has tried to obtain insight into the dynamics of cassava markets by exchanging traditional time series analysis for cross section analysis and by the use of elicitation games with regard to price changes. The available knowledge on the cassava system was integrated in a dynamic context in a simulation model. The obtained results are intuitively valid but cannot be submitted to rigid statistical analysis. The availability of improved statistical sources would greatly increase the reliability of the analysis made and the conclusions drawn.

In the present study, market risk and purchasing convenience strongly influenced the commodity system. For other products or other situations the issues will be different. A systems approach where the interlinkages between different parts of the commodity system are explicitly taken into account, will prove useful for integrated analysis.

Appendix 1. Correlation coefficients and average values of variables used in the linear regressions to estimate market risk aversion, regression (1) to (4).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Price x Price Risk (1)	1.0	0.72	0.52	-0.78	-0.60	-0.53	0.90	0.63	0.30	-0.71	-0.56	-0.36
Price x Price Risk x Area (2)		1.0	0.93	-0.82	-0.92	-0.91	0.51	0.89	0.66	-0.63	-0.89	-0.71
Price x Price Risk x Area^2 (3)			1.0	-0.69	-0.86	-0.91	-0.34	0.91	0.85	-0.51	-0.89	-0.85
Price x covariance (4)				1.0	0.88	0.81	-0.57	-0.63	-0.37	0.91	0.84	0.56
Price x covariance x Area (5)					1.0	0.98	-0.36	-0.73	-0.53	0.68	0.94	0.73
Price x covariance x Area^2 (6)						1.0	-0.30	-0.77	-0.66	0.60	0.96	0.85
Price Risk (7)							1.0	0.55	0.24	-0.61	-0.36	-0.23
Price Risk x Area (8)								1.0	0.86	-0.53	-0.82	-0.79
Price Risk x Area^2 (9)									1.0	-0.30	-0.71	-0.89
Covariance (10)										1.0	0.72	0.46
Covariance x Area (11)											1.0	0.89
Covariance x Area^2 (12)												1.0
Average values:	98.0	1096.5	27111.8	-636.5	-8609	-241099.3	10.55	110.2	2700.1	-66.4	-789.4	-21662.7

Appendix 1. Continuation

Correlation coefficients and average values of variables used in the linear regressions to estimate market risk aversion, regression (5) and (6).

	(13)	(14)	(15)	(16)
Transformed Price x Price Risk (13)	1.0	-0.76	0.96	-0.73
Transformed Price x Covariance (14)		1.0	-0.67	0.96
Transformed Price Risk (15)			1.0	-0.69
Transformed Covariance (16)				1.0
Average values	2898378	-1788175	318115	-184951

Appendix 2. The activities / constraints matrix for the quadratic programming model

Constraints \ Activities	Cassava sales	Green maize-sales	Maize dry second semester sales	Maize dry first semester sales	Yam sales	Cattle early sales	Cattle late sales	Milk wet season sales	Milk dry season sales	Cassava/maize/ yam production	Cassava/maize production	Cassava monoculture	Maize monoculture
	7.6	14.5	16.88	17.0	10.0	35000	35000	22	44	-8314	-7910	-11300	-6700
Land availability						1				1	1	1	1
Wet land constraint (1)										1	1	1	1
Wet land constraint (2)													
Land rent constraint (1)													
Land rent constraint (2)										-1	-1	-1	-1
Rotation										-6	-6	-6	-6
April: Unbound labor													
Bound labor										13.0	8.0	14.0	10.0
May: Unbound labor										23.8	16.0	13.0	23.0
August: Unbound labor										5.5	8.0		7.0
Nov/Dec: Unbound labor										12.0	12.0		7.0
Bound labor										7.0	7.0	11.5	
Rest: Unbound labor			0.004	0.004						34.2	25.0	17.0	19.0
Bound labor										7.0	7.0	11.5	
April: Available family labor													
May: Available family labor													
August: Available family labor													
Nov/Dec: Available family labor													
Rest: Available family labor													
April: Available rented labor													
May: Available rented labor													
August: Available rented labor													
Nov/Dec: Available rented labor													
Rest: Available rented labor													
Sales: Cassava	1.0									-7134	-9000	-10893	
Cassava-non commercial										-1066	-1345	-2555	
Cassava-home consumption													
Sales: Maize-green		1								-370	-476		-714
Dry maize first semester				1						-493.4	-634		-951
Dry maize second semester			1										-750
Maize home consumption													
Sales: Yam					1					-4000			
Yam home-consumption													
Sales: Milk rainy season								1					
Milk dry season									1				
Milk rainy season-home consumption													
Milk dry season home-consumption													
Cattle Stock - start						1							
Stock - end							-1						
Stock - equality													
Capital Needs first semester						-35000				7514	6910	10580	5500
Needs second semester		-14.5		-17.0				-12		800	800	800	1200
Capital available													

* For the three hectare farm value in brackets.

1/ Changes in constraints if farm is of 8 ha.

2/ Changes in constraints if farm is of 15 ha.

Note: Prices are expressed in Colombian pesos, 1 US dollar = 80 Colombian pesos.

Constraints \ Activities	May	August	Nov./Dec.	Rest	Combined labor April	Combined labor Nov./Dec.	Combined labor rest	Cassava non commercial sales	Cassava home consumption
	-370	-370	-370	-370	(-520)* -570	(-520)* -570	(-520)* -570	1.66	10.0
Land availability									
Wet land constraint (1)									
Wet land constraint (2)									
Land rent constraint (1)									
Land rent constraint (2)									
Rotation									
April: Unbound labor									
Bound labor					-2				
May: Unbound labor	-1								
August: Unbound labor		-1							
Nov/Dec: Unbound labor			-1						
Bound labor						-3			
Rest: Unbound labor				-1					
Bound labor							-3		
April: Available family labor					1				
May: Available family labor									
August: Available family labor									
Nov/Dec: Available family labor						1			
Rest: Available family labor							1		
April: Available rented labor					1				
May: Available rented labor	1								
August: Available rented labor		1							
Nov/Dec: Available rented labor			1			2			
Rest: Available rented labor				1			2		
Sales: Cassava									1
Cassava-non commercial								1	
Cassava-home consumption									1
Sales: Maize-green									
Dry maize first semester									
Dry maize second semester									
Maize home consumption									
Sales: Yam									
Yam home-consumption									
Sales: Milk rainy season									
Milk dry season									
Milk rainy season-home consumption									
Milk dry season home-consumption									
Cattle Stock - start									
Stock - end									
Stock - equality									
Capital Needs first semester	370			185	370		185		
Needs second semester		370	370	185		370	185		
Capital available									

* For the three hectare farm value in brackets.

1/ Changes in constraints if farm is of 8 ha.

2/ Changes in constraints if farm is of 15 ha.

Note: Prices are expressed in Colombian pesos, 1 US dollar = 80 Colombian pesos.

Constraints	Activities	Cattle on dry land	Cattle on wet land	Renting land out	Renting land in	Family labor April	May	August	Nov./Dec.	Rest	Rented labor April
		-781	-781	4200	-4600	(-150)* -200	(-150)* -200	(-150)* -200	(-150)* -200	(-150)* -200	-370
Land availability		1	1	1	-1						
Wet land constraint (1)		1			-1						
Wet land constraint (2)			1								
Land rent constraint (1)					1						
Land rent constraint (2)					1						
Rotation		1									
April:	Unbound labor	2.48	2.48			-1					-1
	Bound labor										
May:	Unbound labor	2.48	2.48				-1				
August:	Unbound labor	2.48	2.48					-1			
Nov/Dec:	Unbound labor	4.96	4.96						-1		
	Bound labor										
Rest:	Unbound labor	17.3	20.0							-1	
	Bound labor										
April:	Available family labor					1					
May:	Available family labor						1				
August:	Available family labor							1			
Nov/Dec:	Available family labor								1		
Rest:	Available family labor									1	
April:	Available rented labor										
May:	Available rented labor										
August:	Available rented labor										
Nov/Dec:	Available rented labor										
Rest:	Available rented labor										
Sales:	Cassava										
	Cassava-non commercial										
	Cassava-home consumption										
Sales:	Maize-green										
	Dry maize first semester										
	Dry maize second semester										
	Maize home consumption										
Sales:	Yam										
	Yam home-consumption										
Sales:	Milk rainy season	-250	-350								
	Milk dry season	-50	-150								
	Milk rainy season-home consumption										
	Milk dry season home-consumption										
Cattle	Stock - start	1.3	1.4								
	Stock - end	1.6	1.8								
	Stock - equality										
Capital	Needs first semester	781	781	-4200	4600						370
	Needs second semester										
	Capital available										

* For the three hectare farm value in brackets.

1/ Changes in constraints if farm is of 8 ha.

2/ Changes in constraints if farm is of 15 ha.

Note: Prices are expressed in Colombian pesos, 1 US dollar = 80 Colombian pesos.

Constraints \ Activities	Maize home consumption	Maize home consumption	Yam home consumption	Milk wet season home consumption	Milk dry season home consumption	Cattle stock begin	Cattle stock end	Borrowing capital	Transferring capital	R H S		
	20.0	20.0	15.0	30.0	50.0			-0.15	-0.05			
Land availability										3	8 1/	15 2/
Wet land constraint (1)										2.25	6	11.25
Wet land constraint (2)										0.75	2	3.75
Land rent constraint (1)										3.0	8	15
Land rent constraint (2)										0		
Rotation										0		
April: Unbound labor										0		
Bound labor										0		
May: Unbound labor										0		
August: Unbound labor										0		
Nov/Dec: Unbound labor										0		
Bound labor										0		
Rest: Unbound labor										0		
Bound labor										0		
April: Available family labor										33		
May: Available family labor										33		
August: Available family labor										33		
Nov/Dec: Available family labor										66		
Rest: Available family labor										231		
April: Available rented labor										66		
May: Available rented labor										66		
August: Available rented labor										66		
Nov/Dec: Available rented labor										132		
Rest: Available rented labor										462		
Sales: Cassava										0		
Cassava-non commercial										0		
Cassava-home consumption										1250		
Sales: Maize-green												
Dry maize first semester	1									0		
Dry maize second semester		1								0		
Maize home consumption	1	1								500		
Sales: Yam			1							0		
Yam home-consumption			1							600		
Sales: Milk rainy season				1						0		
Milk dry season					1					0		
Milk rainy season-home consumption				1						1200		
Milk dry season home-consumption					1					600		
Cattle Stock - start						-1				0		
Stock - end							-1			0		
Stock - equality						1	1			0		
Capital Needs first semester								-1	1	-12000		
Needs second semester									-1	-12000		
Capital available								+1		20000	70000 1/	120000 2/

* For the three hectare farm value in brackets.

1/ Changes in constraints if farm is of 8 ha.

2/ Changes in constraints if farm is of 15 ha.

Note: Prices are expressed in Colombian pesos, 1 US dollar = 80 Colombian pesos.

Appendix 3. Presumptions for the estimation of the variance-covariance matrices of the Quadratic Programming Models.

Coefficients of variation and correlations between cropping activities	Cassava		Maize (green)		Dry maize, first semester		Dry maize, second semester		Yam	
	Yield	Price	Yield	Price	Yield	Price	Yield	Price	Yield	Price
Cassava:										
Yield	1.0	-0.32	0.7	0.0	0.7	0.0	0.7	0.0	0.7	-0.25
Price		1.0	-0.25	0.0	-0.25	0.0	-0.25	0.0	-0.25	0.5
Maize (green)										
Yield			1.0	0.0	0.9	0.0	0.9	0.0	0.7	-0.25
Price				1.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry maize, first semester										
Yield					1.0	0.0	0.9	0.0	0.7	-0.25
Price						1.0	0.0	0.0	0.0	0.0
Dry maize, second semester										
Yield							1.0	0.0	0.7	-0.25
Price								1.0	0.0	0.0
Yam										
Yield									1.0	-0.43
Price										1.0
Coefficient of variation:	0.33	0.39	0.33	0.0	0.33	0.0	0.33	0.0	0.40	0.41

Appendix 3. Continuation

Coefficients of variation and correlations between cattle activities:	Herd increase first semester		Herd increase second semester		Milk production first semester		Milk Production second semester	
	Yield	Price	Yield	Price	Yield	Price	Yield	Price
Herd increase first semester								
Yield	1.0	-0.5	0.4	-0.25	0.80	-0.25	0.6	-0.20
Price		1.0	-0.25	0.75	-0.15	0.0	-0.1	0.0
Herd increase second semester								
Yield			1.0	-0.5	0.6	-0.20	0.80	-0.25
Price				1.0	-0.10	0.0	-0.15	0.0
Milk production first semester								
Yield					1.0	-0.6	0.4	-0.4
Price						1.0	-0.4	0.8
Milk production second semester								
Yield							1.0	-0.6
Price								1.0
Coefficient of variation :	0.15	0.10	0.15	0.10	0.15	0.15	0.30	0.20

Correlations between cattle activities and cropping activities: Correlations between these sets of activities appear to be low. Since farmers maintain cattle and crops together for a large part to diminish their total risk, it was decided to assume zero correlations between the two sets.

Note: If cassava prices are stabilized, its covariance with yields becomes zero, as well as its coefficient of variation, but the average price stays the same. If cassava prices are partly increased and stabilized because of the drying industry, covariance with yields decreases with about 1% and its coefficient of variation decreases with 21%. Price increases with some 10%.

In the case where the effect of price increase is considered separately, the old assumptions on coefficient of variation and covariances stay valid, but at a higher price than used originally.

In the case where the risk decrease is considered separately, the new assumptions on covariance and coefficient of variation are used but at the old price level.

Appendix 4. Cassava prices and covariance matrices used in Quadratic Programming Models.

Matrix A: Present situation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Commercial cassava (1)	9.24	6.33	7.15	6.99	7.39	0	0	0	0
Green maize (2)	6.33	25.76	26.22	25.62	10.28	0	0	0	0
Second semester Maize (3)	7.15	26.22	32.94	28.98	11.62	0	0	0	0
First semester Maize (4)	6.99	25.62	28.98	31.47	11.36	0	0	0	0
Yam (5)	7.39	10.28	11.62	11.36	20.25	0	0	0	0
Cattle first semester sales (6)	0	0	0	0	0	20702550	10765300	6587	28529
Cattle second semester sales (7)	0	0	0	0	0	10765300	20702550	6026	38038
Milk first semester sales (8)	0	0	0	0	0	6587	6026	9.49	19.31
Cattle second semester sales (9)	0	0	0	0	0	28529	38038	19.31	121

Commercial cassava price = \$7.6 1/ kg.
Non commercial cassava price = \$1.66/kg.

1/ Price in Colombian Pesos. 1 US dollar = 80 Colombian Pesos.

Appendix 4. Continuation

Matrix B. Completely stabilized cassava prices at average present price.

Change top left corner of matrix A in:				
5.08	7.99	9.04	8.84	4.56
7.99				
9.04				
8.84				
4.56				

Rest of matrix stays as it was.

Commercial cassava price = \$6.83/kg
Non commercial cassava price = \$6.83/kg

Matrix C: Situation that would result if a farmer could choose to sell to a drying industry or to the fresh market.

Change top left corner of matrix A in:				
7.71	6.98	7.90	7.72	7.51
6.98				
7.90				
7.72				
7.51				

Rest of matrix stays as it was.

Commercial cassava price = \$8.12/kg
Non commercial cassava price = \$4.56/kg

Appendix 4. Continuation

Matrix D. Effect of partial risk reduction that results if drying industry would be established, but without any price increase resulting.

Change top left corner of matrix A in:

6.13	6.23	7.04	6.88	6.69
6.23				
7.04				
6.88				
6.69				

Rest of matrix stays as it was.

Commercial cassava price = \$7.24/kg
Non commercial cassava price = \$4.07/kg

Matrix E. Effect of the price increase that results if drying industry would be established, but without any risk-decrease resulting.

Change top left corner of matrix A in:

10.55	6.76	7.64	7.47	7.89
6.76				
7.64				
7.47				
7.89				

Rest of matrix stays as it was.

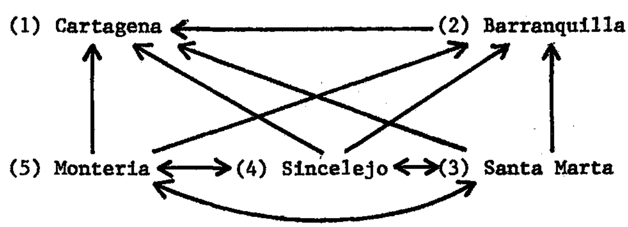
Commercial cassava price = \$8.12/kg
Non commercial cassava price = \$4.56/kg

Appendix 5: Additional information on path and correlation coefficients analysis of the retail price series in the Atlantic Coast regions of Colombia, 1970-1984.

Cassava: Correlation coefficients between deflated retail price series:

	Cartagena	Santa Marta	Sincelejo	Monteria
Barranquilla	0.475	0.543	0.630	0.464
Cartagena		0.486	0.767	0.405
Santa Marta			0.269	0.409
Sincelejo				0.480

Path diagram to explain casual relationship between cassava prices:



Normal equations solved:

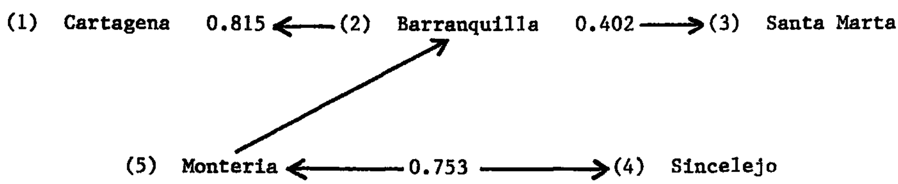
$$PC_{42} = 0.630 - P_{52} * 0.480 - P_{32} * 0.269$$
$$PC_{52} = 0.464 - P_{32} * 0.409 - P_{42} * 0.480$$
$$PC_{32} = 0.543 - P_{52} * 0.409 - P_{32} * 0.269$$
$$PC_{41} = 0.767 - P_{51} * 0.480 - P_{31} * 0.269 - P_{21} * 0.630$$
$$PC_{51} = 0.405 - P_{31} * 0.409 - P_{41} * 0.480 - P_{21} * 0.464$$
$$PC_{31} = 0.486 - P_{51} * 0.409 - P_{41} * 0.269 - P_{21} * 0.543$$
$$PC_{21} = 0.475 - P_{51} * 0.464 - P_{31} * 0.543 - P_{41} * 0.630$$

Appendix 5. Continuation

<u>Yam</u>: Correlation coefficients between deflated retail price series.

	Cartagena	Santa Marta	Sincelejo	Monteria
Barranquilla	0.815	0.402	0.685	0.865
Cartagena		0.243	0.743	0.704
Santa Marta			0.437	0.591
Sincelejo				0.753

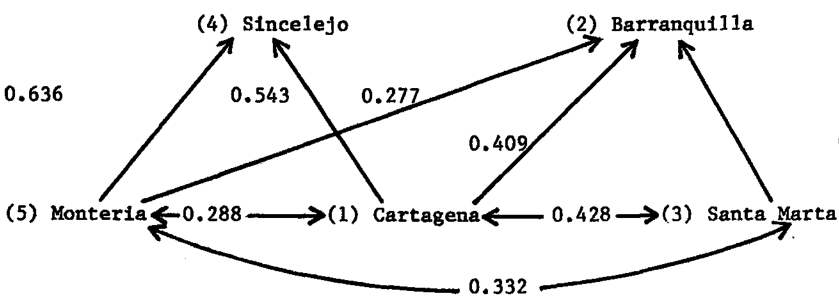
Best resulting path diagram



<u>Plantain</u>: Correlation coefficients between deflated retail price series.

	Cartagena	Santa Marta	Sincelejo	Monteria
Barranquilla	0.578	0.491	0.552	0.468
Cartagena		0.428	0.726	0.288
Santa Marta			0.422	0.332
Sincelejo				0.792

Best resulting path diagram:



Appendix 5: Continuation

Potato: Correlation coefficients between deflated retail price series

	Cartagena	Santa Marta	Sincelejo	Monteria
Barranquilla	0.910	0.904	0.776	0.899
Cartagena		0.894	0.771	0.859
Santa Marta			0.708	0.856
Sincelejo				0.852

Rice: Correlation coefficients between deflated retail price series.

	Cartagena	Santa Marta	Sincelejo	Monteria
Barranquilla	0.52	0.77	0.60	0.38
Cartagena		0.84	0.87	0.89
Santa Marta			0.53	0.72
Sincelejo				0.83

Appendix 6. Correlation coefficients between variables included in the regression models to explain crop consumption.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Calorie consumption per crop per year (1)	1.0	-0.71	0.04	-0.24	-0.32	0.47	-0.53
Price per calorie of the different crops (2)		1.0	-0.04	-0.04	-0.12	-0.45	0.67
Income per capita per year (3)			1.0	-0.10	-0.09	-0.08	-0.03
"Buying inconvenience factor" (4)				1.0	0.00	0.00	0.00
"Intrinsic value factor" (5)					1.0	0.00	0.00
"In shop-availability factor" (6)						1.0	0.00
"Short term price appreciation factor" (7)							1.0

APPENDIX 7

Appendix 7: <u>The computer program to simulate the future development of the Atlantic Coast cassava market system</u>

The computer program used was written in a large number of small modules. Here the modules will be presented in the sequence in which they are used in the execution of the program, except for some small support routines in the FORTRAN main part of the program that are presented after the other FORTRAN routines.

<u>UNO: PROGRAM TO REPEAT THE EXECUTION OF THE SIMULATION MODEL (ROUTINE YUCA1) FOR A GIVEN NUMBER OF TIMES</u>

```
&CONTROL OFF
* THE SEED VALUE IS A UNEVEN NUMBER BELOW 2147483647
EXEC YUCA1 DATOS1 10 1 1  1  0 0 1741
&TYPE OK
EXEC YUCA1 DATOS2 10 1 1  1  0 0 25403
&TYPE OK
EXEC YUCA1 DATOS3 10 1 1  1  0 0 39805
&TYPE OK
EXEC YUCA1 DATOS4 10 1 1  1  0 0 164287
&TYPE OK
EXEC YUCA1 DATOS5 10 1 1  1  0 0 983801
&TYPE OK
EXEC YUCA1 DATOS6 10 1 1  1  0 0 45
&TYPE OK
EXEC YUCA1 DATOS7 10 1 1  1  0 0 137
&TYPE OK
EXEC YUCA1 DATOS8 10 1 1  1  0 0 809
&TYPE OK
EXEC YUCA1 DATOS9 10 1 1  1  0 0 4971
&TYPE OK
EXEC YUCA1 DATOS10 10 1 1  1  0 0 49765
&TYPE OK
EXEC YUCA1 DATOS11 10 1 1  1  0 0 6301289
&TYPE OK
EXEC YUCA1 DATOS12 10 1 1  1  0 0 4983
&TYPE OK
EXEC YUCA1 DATOS13 10 1 1  1  0 0 763
&TYPE OK
EXEC YUCA1 DATOS14 10 1 1  1  0 0 6449
&TYPE OK
EXEC YUCA1 DATOS15 10 1 1  1  0 0 98555
&TYPE OK
EXEC YUCA1 DATOS16 10 1 1  1  0 0 207
&TYPE OK
EXEC YUCA1 DATOS17 10 1 1  1  0 0 13
&TYPE OK
EXEC YUCA1 DATOS18 10 1 1  1  0 0 26987
&TYPE OK
EXEC YUCA1 DATOS19 10 1 1  1  0 0 567821
&TYPE OK
EXEC YUCA1 DATOS20 10 1 1  1  0 0 17925
&TYPE OK
EXEC YUCA1 DATOS21 10 1 1  1  0 0 439
&TYPE OK
EXEC YUCA1 DATOS22 10 1 1  1  0 0 583207
```

APPENDIX 7

```
&TYPE OK
EXEC YUCA1 DATOS23 10 1 1  1  0 0 1985
&TYPE OK
EXEC YUCA1 DATOS24 10 1 1  1  0 0 79291
&TYPE OK
EXEC YUCA1 DATOS25 10 1 1  1  0 0 645321
&TYPE OK
```

<u>YYCC1: ROUTINE TO DEFINE AND LOAD MAIN PROGRAM IN AND OUTPUT</u>

```
&CONTROL OFF
&TIPO = &1
&NSIM = &2
&TSIM = &3
&T    = &4
&TS   = &5
&T1   = &6
&T2   = &7
&SEM  = &8
&TIPO &NSIM &TSIM &T &TS &T1 &T2 &SEM
FI FT06F001 TERMINAL
FI FT07F001 DISK YUCA DATOS A (RECFM F LRECL 80 BLKSIZE 80
FI FT03F001 DISK YUCA1 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT08F001 DISK YUCA2 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT10F001 DISK YUCA3 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT11F001 DISK YUCA4 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT12F001 DISK YUCA5 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT13F001 DISK YUCA6 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT14F001 DISK YUCA7 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
FI FT15F001 DISK YUCA8 &TIPO A (LRECL 80 RECFM F BLKSIZE 80
&STACK &NSIM &TSIM &T &TS &T1 &T2 &SEM
LOAD YUCA1
START
ERASE LOAD MAP A
```

APPENDIX 7, MAIN PROGRAM ROUTINE YUCA1

```
C-----------------------------------------------------------------------
C      SIMULATION OF ATLANTIC COAST REGION CASSAVA MARKETS
C
C      ENTRY PARAMETERS:
C      ----------------
C        NSIM     : NUMBER OF YEARS OF SIMULATION
C        TSIM     : TYPE OF SIMULATION
C                   1 LINEAR
C                   2 LOGARITMIC APPROXIMATIONS
C        T        : YEARS BEFORE STORAGE TECHNOLOGY IS INTRODUCED
C        TS       : YEARS BEFORE DRYING INDUSTRY IS DEVELOPED
C        T1       : YEAR IN WHICH SORGHUM PRICE TENDENCY CHANGES
C        T2       : YEAR IN WHICH SOYA PRICE TENDENCY CHANGES
C        EPDA     : PRICE ELASTICITY OF CASSAVA DEMAND FOR STARCH
C        DTA      : CASSAVA DEMAND BY STARCH INDUSTRY
C        REBAJA   : PRICE DISCOUNT FOR STARCH INDUSTRY
C        PYS      : DRIED CASSAVA PRICE
C        PISOR    : SORGHUM PRICE, DOMESTIC
C        PISOY    : SOYA PRICE, DOMESTIC
C        PMISR    : WORLD MARKET PRICE OF SORGHUM
C        PMISY    : WORLD MARKET PRICE OF SOYA
C        EPDS     : PRICE ELASTICITY OF DRIED CASSAVA DEMAND
C        DTS      : DRIED CASSAVA DEMAND
C        NOSE     : DISCOUNT TO ASSURE CASSAVA MARKET ACCESS
C        TQP      : NATURAL GROWTH RATE OF CASSAVA DRYING PLANTS
C        QSINI    : INITIAL DRIED CASSAVA PRODUCTION CAPACITY
C        TS1      : GROWTH OF DOMESTIC SORGHUM PRICE UNTIL T1
C        TS2      : GROWTH OF DOMESTIC SORGHUM PRICE AFTER T1
C        TSY1     : GROWTH OF DOMESTIC SOYA PRICE UNTIL T2
C        TSY2     : GROWTH OF DOMESTIC SOYA PRICE AFTER T2
C        TMS      : GROWTH OF WORLD MARKET SORGHUM PRICE
C        TMSY     : GROWTH OF WORLD MARKET SOYA PRICE
C        TIM      : INTERNATIONAL INTEREST RATE
C            ---PARAMETERS PER URBANIZATION STRATUM---
C        ITIPO    : URBANIZATION STRATUM
C        DTF      : FRESH CASSAVA DEMAND
C        PRECIO   : CONSUMERS FRESH CASSAVA PRICE
C        EPDF     : PRICE ELASTICITY OF FRESH CASSAVA DEMAND
C        EYDF     : INCOME ELASTICITY OF FRESH CASSAVA DEMAND
C        YAF      : AVERAGE INCOME
C        TCY      : INCOME GROWTH RATE
C        TPOB     : POPULATION GROWTH RATE
C        TDET     : DETERIORATION FACTOR
C        TTEC     : STORAGE METHOD EFFECT ON FRESH CASSAVA CONSUMPTION
C        FINT     : INTEREST COST FACTOR
C        FMOB     : LABOR COST FACTOR
C        FDET     : DETERIORATION COST FACTOR
C        FTRS     : TRANSPORT COST FACTOR
C        FOCO     : OTHER COSTS FACTOR
C              ---PARAMETERS PER FARM TYPE---
C        IACC     : FARM TYPE
C        AFP      : AREA PLANTED IN THE BEFORE LAST YEAR
C        AFU      : AREA PLANTED IN THE LAST YEAR
C        TAF      : DISTRIBUTED LAG OF AREA SUPPLY EQUATION
C        RFP      : YIELD IN THE BEFORE LAST YEAR
C        RFU      : YIELD IN THE LAST YEAR
C        TREND    : DISTRIBUTED LAG OF YIELD SUPPLY EQUATION
C        EPO      : CHANGE IN AREA PER UNIT OF CHANGE IN PRICE
C        ERO      : CHANGE IN YIELD PER UNIT OF CHANGE IN PRICE
C        CREA     : INCREASE IN AREA PLANTED BECAUSE OF MARKET RISK
C                   REDUCTION
```

APPENDIX 7, MAIN PROGRAM ROUTINE YUCA1

```
C        CREC     : INCREASE IN EXPECTED YIELD LEVEL BECAUSE OF MARKET
C                   REDUCTION
C              ---ACCUMULATED SOCIAL BENEFITS CALCULATION---
C        BSF1U    :ACCUMULATED SOCIAL BENEFITS FOR METROPOLITAN CONSUMERS
C        BSF2U    :ACCUMULATED SOCIAL BENEFITS FOR INTERMEDIATE
C                  URBAN CONSUMERS
C        BSF3U    :ACCUMULATED SOCIAL BENEFITS FOR RURAL CONSUMERS
C        BSF4U    :ACCUMULATED SOCIAL BENEFITS FOR HOME CONSUMPTION
C        BSPRU1   :ACCUMULATED SOCIAL BENEFITS FOR SMALL CASSAVA PRODUCERS
C        BSPRU2   :ACCUMULATED SOCIAL BENEFITS FOR INTERMEDIATE
C                  SIZED CASSAVA PRODUCERS
C        BSPRU3   :ACCUMULATED SOCIAL BENEFITS FOR LARGE CASSAVA PRODUCERS
C        BSAU     :ACCUMULATED SOCIAL BENEFITS FOR CASSAVA STARCH INDUSTRY
C        BSSU     :ACCUMULATED SOCIAL BENEFITS FOR DRIED CASSAVA INDUSTRY
C        BSCU     :TOTAL ACCUMULATED SOCIAL BENEFITS FOR CONSUMERS
C        BSIU     :TOTAL ACCUMULATED SOCIAL BENEFITS FOR THE INDUSTRY
C        BSPU     :TOTAL ACCUMULATED BENEFITS FOR CASSAVA PRODUCERS
C        BSTU     :OVERALL TOTAL ACCUMULATED SOCIAL BENEFITS
C
C-----------------------------------------------------------------------
      REAL * 8 EPDA,DTA,REBAJA,PYS,EPDS,DTS,PISOR,PISOY,TS1,TS2,TSY1,
     1TSY2,DTF(4),PRECIO(4),EPDF(4),EYDF(4),YAF(4),TCY(4),TPOB(4),
     2TDET(4),TTEC(4),FINT(4),FMOB(4), FDET(4),FTRS(4),FOCO(4),AFP(3),
     3AFU(3),TAF(3),RFP(3),RFU(3), TREND(3),PKF,MARGEN(4),CORTEF(4)
     4,TANGF(4),CORTEA,TANGA,INCRE(4),ERO(3),CREA(3),CREC(3),COSTO
      REAL * 8 NOSE,CORTES,TANGS,CORTED,TANGD,CORTEO(3),TANGO(3),
     1CORTEP(3),TANGP(3),PEQUIL,PCONS(4),AREAOP(3),AREAO(3),AREAA(3),
     2AREAE(3),DATOT,DFTOT,PSECA,AREA(3),EPO(3),CTE(3),BFA(3),YSIM(2),
     3PEQUIU,DF(4),PMISR,PMISY,TMS,TMSY,BSAU,BSSU,BSCU,BSIU,BSPU,BSTU,
     4BSF1U,BSF2U,BSF3U,BSF4U,BSPRU1,BSPRU2,BSPRU3,TIM,QS,QSINI,GXT
      REAL *8 RENDOP(3),RENDO(3),REND(3),RENDF(3),XDET(4),CORTYF(3)
      REAL * 8 XNSIME,XTSIME,XTE,XTSE,XT1E,XT2E,TANGYF(3)
     1XNSIMS,XTSIMS,XTS,XTSS,XT1S,XT2S,BLANCO
      REAL * 4 P(11),D1(11)
      LOGICAL * 1 STATUS
      LOGICAL STRING
      DATA YSIM/'LINEAL','AP. LOG.'/,BLANCO/' '/
      INTEGER * 4 N,T,TS,TSIM,T1,T2,DIR01(7),DIR02(7)
      IX=0
      R1=0
      R2=0
      DCERDO=63000.
C-----------------------------------------------------------------------
C     READ PARAMETERS
C-----------------------------------------------------------------------
      READ(7,100) XNSIME,XTSIME,XTE,XTSE,XT1E,XT2E
100   FORMAT(6A3)
      CALL LEFJUS(XNSIME,8)
      CALL LEFJUS(XTSIME,8)
      CALL LEFJUS(XTE,8)
      CALL LEFJUS(XTSE,8)
      CALL LEFJUS(XT1E,8)
      CALL LEFJUS(XT2E,8)
      XNSIMS=XNSIME
      XTSIMS=XTSIME
      XTS=XTE
      XTSS=XTSE
      XT1S=XT1E
      XT2S=XT2E
      READ(7,200) EPDA,DTA,REBAJA
200   FORMAT(8F10.2)
```

APPENDIX 7, MAIN PROGRAM ROUTINE YUCA1

```
      READ(7,200) EPDS,DTS,PYS,NOSE,TQP,QSINI,GXT
      READ(7,200) PISOR,PISOY,TS1,TS2,TSY1,TSY2
      READ(7,200) PMISR,PMISY,TMS,TMSY,TIM
C-----------------------------------------------------------------------
C     READ CONSUMPTION PARAMETERS
C-----------------------------------------------------------------------
      DO 10 I=1,4
      READ(7,200) EPDF(I),DTF(I),PRECIO(I)
      READ(7,200) EYDF(I),YAF(I),TCY(I),TPOB(I),TDET(I),TTEC(I)
      READ(7,200) FINT(I),FMOB(I),FDET(I),FTRS(I),FOCO(I)
10    CONTINUE
C-----------------------------------------------------------------------
C     READ FARM TYPE PARAMETERS
C-----------------------------------------------------------------------
      DO 20 I=1,3
      READ(7,200)AFP(I),AFU(I),TAF(I),RFP(I),PFU(I),TREND(I),ERO(I),
     1EPO(I)
20    READ(7,200)CREA(I),CREC(I)
      READ(6,*) XNSIMS,XTSIMS,XTS,XTSS,XT1S,XT2S,IX
      WRITE(6,97)XNSIMS,XTSIMS,XTS,XTSS,XT1S,XT2S,IX
 97   FORMAT(T2,'LEYO PANEL Y SEM',6F6.0,I8)
      CALL LEFJUS(XNSIMS,8)
      CALL LEFJUS(XTSIMS,8)
      CALL LEFJUS(XTS,8)
      CALL LEFJUS(XTSS,8)
      CALL LEFJUS(XT1S,8)
      CALL LEFJUS(XT2S,8)
      CALL FIXIN(NSIM,XNSIMS,STATUS)
      CALL FIXIN(TSIM,XTSIMS,STATUS)
      CALL FIXIN(T,XTS,STATUS)
      CALL FIXIN(TS,XTSS,STATUS)
      CALL FIXIN(T1,XT1S,STATUS)
      CALL FIXIN(T2,XT2S,STATUS)
      IF(STRING(XNSIMS,BLANCO,8)) GO TO 99
      BSF1U=0.
      BSF2U=0.
      BSF3U=0.
      BSF4U=0.
      BSPRU1=0.
      BSPRU2=0.
      BSPRU3=0.
      BSAU=0.
      BSSU=0.
      BSCU=0.
      BSIU=0.
      BSPU=0.
      BSTU=0.
C-----------------------------------------------------------------------
C     ITERATIVE PROCESS FOR EACH YEAR OF SIMULATION
C-----------------------------------------------------------------------
      PKF=PRECIO(4)
      PEQUIU=PRECIO(4)
      QS=QSINI
      DO 30 N=1,NSIM
C-----------------------------------------------------------------------
C     CALCULATE FRESH CASSAVA DEMAND ACCORDING TO URBANIZATION STRATUM
C-----------------------------------------------------------------------
      DO 40 ITIPO=1,4
C-----------------------------------------------------------------------
C     MARKETING MARGIN OVER FARMERS CASSAVA PRICE
C-----------------------------------------------------------------------
```

```
      MARGEN(ITIPO)=0.
      INCRE(ITIPO)=0.
      CALL SOBRE1(ITIPO,FINT(ITIPO),FMOB(ITIPO),FDET(ITIPO),FTRS(ITIPO)
     1,FOCO(ITIPO),N,T,MARGEN(ITIPO),INCRE(ITIPO),XDET(ITIPO))
C-----------------------------------------------------------------------
C     FRESH CASSAVA DEMAND COEFFICIENTS
C-----------------------------------------------------------------------
      CALL FRESC1(ITIPO,EPDF(ITIPO),DTF(ITIPO),PRECIO(ITIPO),
     1EYDF(ITIPO),YAF(ITIPO),TCY(ITIPO),TPOB(ITIPO),XDET(ITIPO),
     2TDET(ITIPO),TTEC(ITIPO),MARGEN(ITIPO),INCRE(ITIPO),T,N,
     2CORTEF(ITIPO),TANGF(ITIPO))
40    CONTINUE
C-----------------------------------------------------------------------
C     CASSAVA DEMAND COEFFICIENTS FOR STARCH PRODUCTION
C-----------------------------------------------------------------------
      CALL ALMID1(EPDA,DTA,REBAJA,PKF,TCY(1),N,CORTEA,TANGA)
C-----------------------------------------------------------------------
C     DRIED CASSAVA DEMAND COEFFICIENTS
C-----------------------------------------------------------------------
      CALL SECA1(PKF,FINT(3),FMOB(3),FDET(3),FTRS(3),FOCO(3),PYS,N,EPDS
     1,DTS,TCY(1),NOSE,PISOR,PISOY,T1,T2,TS1,TS2,TSY1,TSY2,COSTC,CORTES
     2,TANGS)
C-----------------------------------------------------------------------
C     AREA SUPPLY COEFFICIENTS
C-----------------------------------------------------------------------
      CALL PRODU1(EPC,AFP,AFU,TAF,N,TSIM,QS,PKF,CREA,PEQUIU,CTE,
     1BFA,AREAA,AREAB,AREAOP,AREAO,CORTEP,TANGP)
C-----------------------------------------------------------------------
C     YIELD ACCORDING TO FARM TYPE AND PRODUCTION COEFFICIENTS
C-----------------------------------------------------------------------
      CALL RENDI1(RFP,RFU,TREND,ERO,PKF,N,TSIM,IX,P1,P2,CORTEP,TANGP,
     1AREAA,AREAB,QS,CREC,PEQUIU,REND,RENDF,RENDO,RENDOP,CORTYF,
     1TANGYF)
C-----------------------------------------------------------------------
C     CALCULATE EQUILIBRIUM PRICE
C-----------------------------------------------------------------------
      CALL PEQUI1(CORTEF,TANGF,CORTEA,TANGA,CORTES,TANGS,DCERDO,REND,
     1CORTEP,TANGP,TQP,QS,N,TS,PKF,CORTED,TANGD,PEQUIU,PEQUIL,CORTEO,
     1TANGO)
C-----------------------------------------------------------------------
C     CALCULATE OUTPUT INFORMATION
C-----------------------------------------------------------------------
      CALL CRITI1(PEQUIL,MARGEN,INCRE,CORTEF,TANGF,CORTEA,TANGA,CORTES
     1,TANGS,NOSE,COSTC,TQP,CORTEP,TANGP,CORTED,TANGD,N,TS,NSIM,REND,
     2DCERDO,PEQUIU,PCONS,DF,DATOT,DSTOT,PSECA,AREA,DTOTAL,XDET,
     3FMOB(3),QS,QSINI,GXT,CORTEO,TANGO)
C-----------------------------------------------------------------------
C     CALCULATE EMPLOYMENT INFORMATION
C-----------------------------------------------------------------------
      CALL MOBRA1(PEQUIL,PCONS,DF,DATOT,DSTOT,AREA,PMISR,PMISY,TMS,TMSY
     1XDET,N,NSIM,REND)
C-----------------------------------------------------------------------
C     CALCULATE SOCIAL BENEFITS
C-----------------------------------------------------------------------
      CALL BENEF1(PEQUIL,CORTEF,TANGF,PCONS,NOSE,CORTEA,TANGA,
     1DSTOT,DATOT,DF,CORTES,TANGS,PEQUIU,CORTEP,TANGP,PSECA,REND,N,
     1CORTYF,TANGYF,
     2NSIM,TIM,BSAU,BSSU,BSCU,BSIU,BSPU,BSTU,BSF1U,BSF2U,BSF3U,BSF4U,
     3BSPRU1,BSPRU2,BSPRU3,BSAN,BSSN,BSCN,BSIN,BSPN,BSTN,BSF1N,BSF2N,
     4BSF3N,BSF4N,BSPRN1,BSPRN2,BSPRN3)
      PEQUIU=PEQUIL
```

APPENDIX 7, MAIN PROGRAM ROUTINE YUCA1

```
      BSAU=BSAN
      BSSU=BSSN
      BSCU=BSCN
      BSIU=BSIN
      BSPU=BSPN
      BSTU=BSTN
      BSF1U=BSF1N
      BSF2U=BSF2N
      BSF3U=BSF3N
      BSF4U=BSF4N
      BSPRU1=BSPRN1
      BSPRU2=BSPRN2
      BSPRU3=BSPRN3
      P(N)=PEQUIU/100.0
      D1(N)=DTOTAL/1000.0
      IF(TSIM.EQ.1) GO TO 2
C-----------------------------------------------------------------
C     RECALCULATE VALUES FOR NEXT YEAR OF SIMULATION
C-----------------------------------------------------------------
      PKF=PEQUIL
      DO 60 I=1,4
      PRECIO(I)=PCONS(I)
60    DTF(I)=DF(I)
      DTA=DATOT
      DTS=DSTOT/2.5
      PYS=PSECA
2     DO 70 I=1,3
      AFP(I)=AFU(I)
      AFU(I)=AREA(I)
      RFP(I)=RFU(I)
      RFU(I)=RENDF(I)
      AREAOP(I)=AREAO(I)
70    RENDOP(I)=RENDO(I)
30    CONTINUE
99    CONTINUE
      END
```

APPENDIX 7, SUBROUTINE SOBRE1

```
      SUBROUTINE SOBRE1(ITIPO,FINT,FMOB,FDET,FTRS,FOCO,N,T,MARGEN,
     1INCRE,XDET)
C-----------------------------------------------------------------------
C       SUBROUTINE TO CALCULATE FRESH CASSAVA MARKETING MARGINS
C
C       ENTRY PARAMETERS:
C       ----------------
C         ITIPO    : URBANIZATION STRATUM
C         PRECIO   : FRESH CASSAVA CONSUMER PRICE
C         PKF      : FARMERS PRICE
C         FINT     : INTEREST COST FACTOR
C         FMOB     : LABOR COST FACTOR
C         FDET     : DETERIORATION COST FACTOR
C         FTRS     : TRANSPORT COST FACTOR
C         FOCO     : OTHER COSTS FACTOR
C         FALM     : COST FACTOR FOR CASSAVA STORAGE METHOD
C         N        : YEAR OF SIMULATION
C         T        : NUMBER OF YEARS BEFORE CASSAVA STORAGE IS INTRODUCED
C       RETURN PARAMETERS:
C       -----------------
C         MARGEN   : FRESH CASSAVA MARKETING MARGIN IN DIFFERENT
C                    URBANIZATION STRATA
C         INCRE    : INCREMENTAL FACTOR IN THE MARKETING MARGIN
C         XDET     : DETERIORATION LOSSES FRACTION
C-----------------------------------------------------------------------
      REAL * 8 FINT,FMOB,FDET,FTRS,FOCO,MARGEN,RIESGO,XDET,INCRE,FALM
      REAL * 8 KINT(4),KMOB(4),KDET(4),KTRS(4),KOCO(4),KRIE(4)
      REAL * 8 KDMO1(4),KDMO2(4)
      INTEGER * 4 N,T,IND
      DATA KINT/3.,3.,3.,0./
      DATA KMOB/15.4,15.,15.,0./
      DATA KDET/32000.,20000.,20000.,0./
      DATA KTRS/1000.,1000.,1000.,0./
      DATA KOCO/1000.,1000.,1000.,0./
      DATA KDMO1/0.08117,0.08333,0.08333,0./
      DATA KDMO2/0.3506,0.3333,0.3333,0./
      DATA KRIE/3.0,2.0,2.0,0./
      IND=N-T
C-----------------------------------------------------------------------
C       INTRODUCTION OF CASSAVA STORAGE AFFECTS THE DETERIORATION
C       COEFFICIENT DURING THREE SUBSEQUENT YEARS
C-----------------------------------------------------------------------
      IF(IND.LE.0) IND=1
      IF(IND.GT.3) IND=3
      XDET=FDET/IND
      RIESGO=1.1+KRIE(ITIPO)*XDET
      INCRE=(KINT(ITIPO)/8.)*FINT+KDMO1(ITIPO)*(KMOB(ITIPO)/1000.)*FMOB
      INCRE=INCRE*RIESGO
      FALM=(IND-1)*1000
      IF(ITIPO.EQ.4)FALM=0
      MARGEN=KDMO2(ITIPO)*KMOB(ITIPO)*FMOB+KDET(ITIPO)*XDET
      MARGEN=(MARGEN+KTRS(ITIPO)*FTRS+KOCO(ITIPO)*FOCO+FALM)*RIESGO
      RETURN
      END
```

APPENDIX 7, SUBROUTINE FRESC1

```
      SUBROUTINE FRESC1(ITIPO,EPDF,DTF,PRECIO,EYDF,YAF,TCY,TPOB,TDET,
     1TTEC,XDET,MARGEN,INCRE,T,N,CORTEF,TANGF)
C-----------------------------------------------------------------------
C     SUBROUTINE TO CALCULATE FRESH CASSAVA DEMAND COEFFICIENTS
C
C     ENTRY PARAMETERS:
C     ----------------
C       ITIPO    : URBANIZATION STRATUM
C       EPDF     : PRICE ELASTICITY OF FRESH CASSAVA DEMAND
C       DTF      : FRESH CASSAVA DEMAND
C       PRECIO   : CONSUMER FRESH CASSAVA PRICE
C       EYDF     : INCOME ELASTICITY
C       YAF      : AVERAGE ANNUAL INCOME
C       TCY      : YEARLY RATE OF INCOME GROWTH
C       TPOB     : YEARLY RATE OF POPULATION GROWTH
C       TDET     : DETERIORATION RATE
C       TTEC     : STORAGE METHOD EFFECT ON FRESH CASSAVA CONSUMPTION
C       T        : NUMBER OF YEARS BEFORE CASSAVA STORAGE IS INTRODUCED
C       N        : YEAR OF SIMULATION
C       XDET     : DETERIORATION LOSSES FRACTION
C     RETURN PARAMETERS:
C     ------------------
C       CORTEF   : INTERCEPT OF FRESH CASSAVA DEMAND CURVE
C       TANGF    : SLOPE OP FRESH CASSAVA DEMAND CURVE
C
C-----------------------------------------------------------------------
      REAL * 8 EPDF,DTF,PRECIO,BFP,IFP,EYDF,YAF,BFY,IFY,TCY,TPOB,TDET,
     1TTEC,XDET,MARGEN,INCRE,CORTEF,TANGF
      INTEGER * 4 T,N
C-----------------------------------------------------------------------
C     CALCULATE DEMAND CURVE COEFFICIENTS WITH REGARD TO PRICE
C-----------------------------------------------------------------------
      CALL RECTA1(EPDF,DTF,PRECIO,BFP,IFP)
C-----------------------------------------------------------------------
C     CALCULATE DEMAND CURVE COEFFICIENTS WITH REGARD TO INCOME
C-----------------------------------------------------------------------
      CALL RECTA1(EYDF,DTF,YAF,BFY,IFY)
      IFY=BFY*YAF
C-----------------------------------------------------------------------
C     CALCULATE FINAL COEFFICIENTS
C-----------------------------------------------------------------------
      IOTR=N
      IULT=T+3
C-----------------------------------------------------------------------
C     DETERIORATION DECREASES ACTUAL DEMAND UP TO THE MOMENT THAT
C     STORAGE TECHNOLOGY IS INTRODUCED
C-----------------------------------------------------------------------
      IF(IOTR.GT.IULT) IOTR=IULT
      XOTR=IOTR
      IDIF=N-T
      IF(IDIF.LT.0) IDIF=0
C-----------------------------------------------------------------------
C     IN THE FIRST THREE YEARS AFTER THAT STORAGE TECHNOLOGY IS
C     INTRODUCED, DEMAND DOES INCREASE
C-----------------------------------------------------------------------
      IF(IDIF.GT.3) IDIF=3
      XDIF=IDIF
      XN=N
      TERM1=((1+TPOB)**XN)
      TERM1=TERM1*((1+TDET)**XOTR)
      TERM1=TERM1*((1+TTEC)**XDIF)
```

APPENDIX 7, SUBROUTINE FRESC1

```
      TANGF=(BFP+BFP*INCRE)*TERM1*(1+XDET)
      CORTEF=(IFP-IFY+BFP*MARGEN+BFY*YAF*((1
     1+TCY)**XN))*TERM1*(1+XDET)
      RETURN
      END
```

APPENDIX 7, SUBROUTINE ALMID1

```
SUBROUTINE ALMID1(EPDA,DTA,REBAJA,PKF,TCY,N,CORTEA,TANGA)
C-----------------------------------------------------------------------
C      SUBROUTINE TO CALCULATE CASSAVA DEMAND COEFFICIENTS FOR STARCH
C      PRODUCTION
C
C      ENTRY PARAMETERS:
C      ----------------
C        EPDA     : PRICE ELASTICITY OF CASSAVA DEMAND FOR STARCH
C        DTA      : CASSAVA DEMAND FOR STARCH PRODUCTION
C        REBAJA   : DISCOUNT FOR STARCH INDUSTRY
C        PKF      : PRICE TO THE FARMER
C        N        : YEAR OF SIMULATION
C      RETURN PARAMETERS:
C      -----------------
C        CORTEA   : INTERCEPT OF THE CASSAVA DEMAND CURVE FOR STARCH
C        TANGA    : SLOPE OF THE CASSAVA DEMAND CURVE FOR STARCH
C
C-----------------------------------------------------------------------
      REAL * 8 EPDA,DTA,REBAJA,PKF,CORTEA,TANGA,PKA,IAP,BAP,TCY,PKA
      INTEGER * 4 N
      PKA=PKF-REBAJA
      CALL RECTA1(EPDA,DTA,PKA,BAP,IAP)
      CORTEA=(IAP-BAP*REBAJA)*((1+TCY)**N)
      TANGA=BAP*((1+TCY)**N)
      RETURN
      END
```

APPENDIX 7, SUBROUTINE SECA1

```
      SUBROUTINE SECA1(PKF,FINT,FMOB,FDET,FTRS,FOCO,PYS,N,EPDS,DTS,TCY,
     1NOSE,PISOR,PISOY,T1,T2,TS1,TS2,TSY1,TSY2,COSTO,CORTES,TANGS)
C-----------------------------------------------------------------------
C      SUBROUTINE TO CALCULATE DRIED CASSAVA DEMAND COEFFICIENTS
C
C      ENTRY PARAMETERS
C      ----------------
C        PKF      : FARMERS PRICE
C        FINT     : INTEREST COST FACTOR
C        FMOB     : LABOR COST FACTOR
C        FDET     : DETERIORATION COST FACTOR
C        FTRS     : TRANSPORT COST FACTOR
C        FOCO     : OTHER COSTS FACTOR
C        PYS      : DRIED CASSAVA PRICE
C        N        : YEAR OF SIMULATION
C        EPDS     : PRICE ELASTICITY OF DRIED CASSAVA DEMAND
C        DTS      : TOTAL DRIED CASSAVA DEMAND
C        NOSE     : DISCOUNT TO ASSURE CASSAVA MARKET ACCESS
C        PISOR    : SORGHUM PRICE, DOMESTIC
C        PISOY    : SOYA PRICE, DOMESTIC
C        T1       : YEAR IN WHICH SORGHUM PRICE TENDENCY CHANGES
C        T2       : YEAR IN WHICH SOYA PRICE TENDENCY CHANGES
C        TS1      : GROWTH IN SORGHUM PRICE UNTIL T1
C        TS2      : GROWTH IN SORGHUM PRICE AFTER T1
C        TSY1     : GROWTH IN SOYA PRICE UNTIL T2
C        TSY2     : GROWTH IN SORGHUM PRICE AFTER T2
C      RETURN PARAMETERS:
C      ------------------
C        COSTO    : PROCESSING COST OF DRIED CASSAVA
C        CORTES   : INTERCEPT OF DRIED CASSAVA DEMAND CURVE
C        TANGS    : SLOPE OF DRIED CASSAVA DEMAND CURVE
C-----------------------------------------------------------------------
       REAL * 8 PKF,FINT,FMOB,FDET,FTRS,FOCO,PYS,KINT,KMOB,KTRS,KOCO,
     1KDET,COSTO,NOSE,CORTES,TANGS,EPDS,DTS,BSP,ISP,TCY,APSOM,BPSOM,
     2CPSOM,PSORG,PSOYA,PSOMB,TS1,TS2,TSY1,TSY2,PISOR,PISOY
       INTEGER * 4 N,T1,T2,IND1,IND2
C-----------------------------------------------------------------------
C      VALUES ASSIGNED TO COEFFICIENTS OF DRIED CASSAVA SHADOW PRICE
C      CALCULATION
C-----------------------------------------------------------------------
       APSOM =  0.093
       BPSOM =  1.2
       CPSOM = -0.2
C-----------------------------------------------------------------------
C      COEFFICIENTS ASSIGNED TO DIFFERENT COST COEFFICIENTS
C-----------------------------------------------------------------------
       KINT   = 3250.
       KMOB   = 4.5
       KTRS   = 930.
       KOCO   = 130.
       KDET   = 0.0
C-----------------------------------------------------------------------
C      PROCESSING COST CALCULATION
C-----------------------------------------------------------------------
       COSTO=KINT*FINT+KMOB*FMOB+KTRS*FTRS+KOCO*FOCO+KDET*FDET
C-----------------------------------------------------------------------
C      CALCULATION OF SOYA, SORGHUM AND DRIED CASSAVA SHADOW PRICES
C-----------------------------------------------------------------------
       IND1=N-T1
       IF(IND1.LT.0)IND1=0
       XN=N
```

APPENDIX 7, SUBROUTINE SECA1

```
      PSORG=PISOR*((1+TS1)**XN)*((1+TS2)**IND1)
      IND2=N-T2
      IF(IND2.LT.0)IND2=0
      PSOYA=PISOY*((1+TSY1)**XN)*((1+TSY2)**IND2)
      PSOMB = APSOM + BPSOM*PSORG + CPSOM*PSOYA
C-----------------------------------------------------------------------
C     DRIED CASSAVA DEMAND CURVE COEFFICIENTS
C-----------------------------------------------------------------------
      CALL RECTA1(EPDS,DTS,PSOMB,BSP,ISP)
      ISP=DTS-BSP*(PYS-PSOMB)
      CORTES=(ISP+BSP*COSTO-2.5*BSP*NOSE-BSP*PSOMB)*((1+2*TCY)**XN)
      CORTES=CORTES*2.5
      TANGS=2.5*BSP*((1+2*TCY)**XN)
      TANGS=TANGS*2.5
      RETURN
      END
```

APPENDIX 7, SUBROUTINE PRODU1

```
      SUBROUTINE PRODU1(EPO,AFP,AFU,TAF,N,TSIM,QS,PKF,CREA,PEQUIU,
     1CTE,BFA,AREAA,AREAB,AREAOP,AREAO,CORTEP,TANGP)
C-----------------------------------------------------------------------
C      SUBROUTINE TO CALCULATE PRODUCTION COEFFICIENTS
C
C      ENTRY PARAMETERS:
C      ----------------
C        EPO      : CHANGE IN AREA PER UNIT OF CHANGE IN PRICE
C        AFP      : AREA PLANTED IN THE BEFORE LAST YEAR
C        AFU      : AREA PLANTED IN THE LAST YEAR
C        TAF      : DISTRIBUTED LAG OF THE AREA EQUATION
C        N        : YEAR OF SIMULATION
C        TSIM     : TYPE OF SIMULATION
C        PKF      : FARMERS PRICE
C        CREA     : INCREASE IN AREA PLANTED BECAUSE OF MARKET
C                   STABILIZATION
C      RETURN PARAMETERS:
C      -----------------
C        AREAB    : TOTAL AREA PLANTED
C        AREAOP   : AREA PLANTED BY FARMERS NOT INFLUENCED BY DRYING
C                   PLANTS
C        AREAA    : AREA PLANTED BY FARMERS INFLUENCED BY DRYING PLANTS
C        AREAO    : AREA PLANTED LAST YEAR BY FARMERS NOT INFLUENCED BY
C                   DRYING PLANTS
C        BFA      : ORIGINAL SLOPE OF THE AREA SUPPLY CURVE
C        CTE      : CONSTANT OF THE AREA SUPPLY CURVE
C        CORTEP   : INTERCEPT OF THE FINAL AREA EQUATION
C        TANGP    : SLOPE OF THE FINAL AREA EQUATION
C-----------------------------------------------------------------------
       REAL * 8 EPO(1),AFP(1),AFU(1),TAF(1),BFA(1),CORTEP(3),TANGP(3),
     1IFA,CTE(1),CORTET(3),TANGT(3),AREAB(3),AREAOP(3),CUBIER,CREA(1)
     1,PKF,AREAO(3),AREAA(3),INFLA(3)
       INTEGER * 4 N,TS,TSIM
       IF(TSIM.EQ.1.AND.N.NE.1) GO TO 1
       DO 10 I=1,3
       AREAOP(I)=AFU(I)
       CALL RECTA1(EPO(I),AFU(I),PKF,BFA(I),IFA)
       CTE(I)=AFU(I)-TAF(I)*AFP(I)-BFA(I)*PKF
10     CONTINUE
1      CUBIER=QS*0.89/70253.
       IF(CUBIER.GT.1.)CUBIER=1.
       DO 20 I=1,3
       INFLA(I)= CUBIER*CREA(I)
       CORTEP(I)=TAF(I)*AFU(I)+CTE(I)*(1+INFLA(I))
       TANGP(I)=BFA(I)*(1+INFLA(I))
20     CONTINUE
       DO 30 I=1,3
       CORTET(I)=TAF(I)*AREAOP(I)+CTE(I)
       TANGT(I)=BFA(I)
       AREAB(I)=CORTEP(I)+TANGP(I)*PEQUIU
       AREAO(I)=CORTET(I)+TANGT(I)*PEQUIU
       AREAA(I)=AREAB(I)-AREAO(I)*(1-CUBIER)
30     CONTINUE
       RETURN
       END
```

APPENDIX 7, SUBROUTINE RENDI1

```
      SUBROUTINE RENDI1(RFP,RFU,TREND,ERO,PKF,N,TSIM,IX,R1,R2,CORTEP,
     1TANGP,AREAA,AREAB,QS,CREC,PEQUIU,REND,RENDF,RENDO,RENDOP,
     2CORTYF,TANGYF)
C-----------------------------------------------------------------------
C       SUBROUTINE TO CALCULATE EXPECTED YIELD LEVEL
C
C       ENTRY PARAMETERS:
C       ----------------
C         RFP     : YIELD IN BEFORE LAST YEAR
C         RFU     : YIELD IN LAST YEAR
C         TREND   : DISTRIBUTED LAG IN YIELD EQUATION
C         N       : YEAR OF SIMULATION
C         TSIM    : TYPE OF SIMULATION
C         IX      : SEED VALUE TO GENERATE RANDOM NUMBERS
C         PKF     : FARMERS PRICE
C       RETURN PARAMETERS:
C       -----------------
C         REND    : EXPECTED YIELD LEVEL
C         CORTYF  : FINAL YIELD EQUATION INTERCEPT
C         TANGYF  : FINAL YIELD EQUATION SLOPE
C-----------------------------------------------------------------------
        REAL * 8 RFP(1),RFU(1),TREND(1),REND(3),ERO(1),PKF,BFR(3),IFR,
     1CORTEP(3),TANGP(3),AREAA(3),AREAB(3),RENDOP(3),QS,CREC(1),
     1PEQUIU,INFLC(3),CUBIER,RENDB(3), CTE(3), CUBIER, AARE(3),
     1CORTER(3),TANGR(3),RENDO(3),RENDA(3),RENDF(3),CORTEQ(3),TANGQ(3)
     2CORTAY(3),TANGAY(3),CORTYF(3),TANGYF(3)
        INTEGER * 4 N,IND,TSIM
        IF(TSIM.EQ.1.AND.N.NE.1) GO TO 1
        DO 10 I=1,3
        RENDOP(I)=RFU(I)
        CALL RECTA1(ERO(I),RFU(I),PKF,BFR(I),IFR)
        CTE(I)=RFU(I)-TREND(I)*RFP(I)-BFR(I)*PKF
10      CONTINUE
1       CUBIER=(QS*0.89)/70253.
        IF(CUBIER.GT.1)CUBIER=1
        R1=AZAR1(IX)
        R2=AZAR1(IX)
        DO 20 I=1,3
        INFLC(I)=CUBIER*CREC(I)
        CORTER(I)=TREND(I)*RFU(I)+CTE(I)*(1+INFLC(I))
        TANGR(I)=BFR(I)*(1+INFLC(I))
        RENDB(I)=CORTER(I)+TANGR(I)*PEQUIU
        CORTEQ(I)=TREND(I)*RENDOP(I)+CTE(I)
        TANGQ(I)=BFR(I)
        RENDO(I)=CORTEQ(I)+TANGQ(I)*PEQUIU
        CORTAY(I)=(CORTER(I)-CORTEQ(I)*(1-CUBIER))/CUBIER
        TANGAY(I)=(TANGR(I)-TANGQ(I)*(1-CUBIER))/CUBIER
        RENDA(I)=(RENDB(I)-RENDO(I)*(1-CUBIER))/CUBIER
        AARE(I)=AREAB(I)-AREAA(I)
        CORTYF(I)=(CORTAY(I)*AREAA(I)+CORTEQ(I)*AARE(I))/AREAB(I)
        TANGYF(I)=(TANGAY(I)*AREAA(I)+TANGQ(I)*AARE(I)/AREAB(I)
        RENDF(I)=(RENDA(I)*AREAA(I)+RENDO(I)*AARE(I))/AREAB(I)
        REND(I)=RENDF(I)
        REND(I)=XNOR1(REND(I),0.13254*REND(I),R1,R2)
        CORTYF(I)=CORTYF(I)*REND(I)/RENDF(I)
        TANGYF(I)=TANGYF(I)*REND(I)/RENDF(I)
20      CONTINUE
        RETURN
        END
```

APPENDIX 7, SUBROUTINE PEQUI1

```
      SUBROUTINE PEQUI1(CORTEF,TANGF,CORTEA,TANGA,CORTES,TANGS,DCERDO
     1REND,CORTEP,TANGP,TQP,QS,N,TS,PKF,CORTED,TANGD,PEQUIU,PEQUIL,
     1CORTEO,TANGO)
C-----------------------------------------------------------------------
C       SUBROUTINE TO CALCULATE EQUILIBRIUM PRICE
C
C       ENTRY PARAMETERS
C       ----------------
C         CORTED  : INTERCEPT OF TOTAL DEMAND FUNCTION
C         TANGD   : SLOPE OF TOTAL DEMAND FUNCTION
C         CORTEP  : INTERCEPT OF TOTAL AREA SUPPLY FUNCTION
C         TANGP   : SLOPE OF TOTAL AREA SUPPLY FUNCTION
C         CORTES  : INTERCEPT OF DRIED CASSAVA DEMAND FUNCTION
C         TANGS   : SLOPE OF DRIED CASSAVA DEMAND FUNCTION
C         TQP     : NATURAL GROWTH RATE OF DRIED CASSAVA PLANTS
C         QS      : INSTITUTIONAL CAPACITY TO CREATE DRYING PLANTS
C         N       : YEAR OF SIMULATION
C         TS      : YEARS BEFORE DRYING INDUSTRY DEVELOPS
C         PEQUIU  : EQUILIBRIUM PRICE OF LAST YEAR
C       RETURN PARAMETERS:
C       ----------------------
C         PEQUIL  : EQUILIBRIUM PRICE
C
C-----------------------------------------------------------------------
       REAL * 8 CORTEF(1),TANGF(1),CORTEA,TANGA,CORTES,TANGS,DCERDO,
     1PEQUIL,CORTEX,TANGX,CORTEP(1),TANGP(1),REND(1),CORTED,TANGD,DS,
     1QS,PEQUIU,CORTEO,TANGO
       INTEGER * 4 N,TS,IND
       IND=N-TS
       IF(IND.LT.0) IND=0
       CORTEX=0.
       TANGX=0.
       DO 10 I=1,4
       CORTEX=CORTEX+CORTEF(I)
       TANGX=TANGX+TANGF(I)
10     CONTINUE
       CORTEO=0.
       TANGO=0.
       DO 20 I=1,3
       CORTEO=CORTEO+CORTEP(I)*REND(I)
       TANGO=TANGO+TANGP(I)*REND(I)
20     CONTINUE
       CORTED=CORTEX+CORTEA+CORTES+DCERDO
       TANGD=TANGX+TANGA+TANGS
       PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
       DS=(CORTES+PEQUIL*TANGS)/2.5
       DA=CORTEA+PEQUIL*TANGA
C-----------------------------------------------------------------------
C      CHECK NEGATIVE DEMANDS
C-----------------------------------------------------------------------
       IF(DS.GT.0.AND.DA.GT.0.) GO TO 88
       IF(DA.LE.0.) GO TO 77
C-----------------------------------------------------------------------
C      IF DRIED CASSAVA DEMAND IS NEGATIVE, MAKE IT EQUAL TO ZERO
C-----------------------------------------------------------------------
       CORTED=CORTEX+CORTEA+DCERDO
       TANGD=TANGX+TANGA
       PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
       DA=CORTEA+TANGA*PEQUIL
       IF(DA.LE.0.) GO TO 66
       CORTES=0.0001
```

```
      TANGS=0.0001
      RETURN
66    CONTINUE
      CORTED=CORTEX+CORTES+DCERDO
      TANGD=TANGX+TANGS
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      DS=(CORTES+TANGS*PEQUIL)/2.5
      IF(DS.LT.0.) GO TO 55
      GO TO 111
55    CONTINUE
      CORTED=CORTEX+DCERDO
      TANGD=TANGX
      CORTEA=0.0001
      TANGA=0.0001
      CORTES=0.0001
      TANGS=0.0001
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      RETURN
77    CONTINUE
C-----------------------------------------------------------------------
C     IF STARCH DEMAND IS NEGATIVE, MAKE IT EQUAL TO ZERO
C-----------------------------------------------------------------------
      CORTED=CORTEX+CORTES+DCERDO
      TANGD=TANGX+TANGS
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      DS=(CORTES+TANGS*PEQUIL)/2.5
      IF(DS.LE.0.) GO TO 44
111   IF(DS.LE.QS) GO TO 99
C-----------------------------------------------------------------------
C     IF DRIED CASSAVA DEMAND IS BIGGER THAN THE DRYING CAPACITY, MAKE
C     IT EQUAL TO THE DRYING CAPACITY
C-----------------------------------------------------------------------
      CORTED=CORTEX+CORTEA+2.5*QS+DCERDO
      TANGD=TANGX+TANGA
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      DA=CORTEA+TANGA*PEQUIL
      IF(DA.GE.0) RETURN
      CORTED=CORTEX+2.5*QS+DCERDO
      TANGD=TANGX
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      CORTEA=0.0001
      TANGA=0.0001
      RETURN
99    CORTEA=0.0001
      TANGA=0.0001
      RETURN
44    CONTINUE
      CORTED=CORTEX+CORTEA+DCERDO
      TANGD=TANGX+TANGA
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      DA=CORTEA+TANGA*PEQUIL
      IF(DA.LT.0.) GO TO 33
      CORTES=0.0001
      TANGS=0.0001
      RETURN
33    CONTINUE
      CORTED=CORTEX+DCERDO
      TANGD=TANGX
      CORTEA=0.0001
      TANGA=0.0001
      CORTES=0.0001
```

APPENDIX 7, SUBROUTINE PEQUIl

```
      TANGS=0.0001
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      RETURN
88    IF(DS.LE.QS) RETURN
C-----------------------------------------------------------------------
C     IF DRIED CASSAVA DEMAND IS BIGGER THAN THE DRYING CAPACITY, MAKE
C     IT EQUAL TO THE DRYING CAPACITY
C-----------------------------------------------------------------------
      CORTED=CORTEX+CORTEA+2.5*QS+DCERDO
      TANGD=TANGX+TANGA
      PEQUIL=(CORTEO+TANGO*PEQUIU-CORTED)/TANGD
      RETURN
      END
```

APPENDIX 7, SUBROUTINE CRITIC1

```
      SUBROUTINE CRITI1(PEQUIL,MARGEN,INCRE,CORTEF,TANGF,CORTEA,TANGA,
     1CORTES,TANGS,NOSE,COSTO,TQP,CORTEP,TANGP,CORTED,TANGD,XDET,
     2N,TS,NSIM,REND,DCERDO,PEQUIU,PCONS,DF,DATOT,DSTOT,PSECA,AREA,
     3DTOTAL,FMOB,QS,QSINI,GXT,CORTEO,TANGO)
C-----------------------------------------------------------------------
C       SUBROUTINE TO CALCULATE EQUILIBRIUM PRICE AND QUANTITY
C
C       ENTRY PARAMETERS:
C       -----------------
C         PEQUIL  : EQUILIBRIUM PRICE
C         MARGEN  : FRESH CASSAVA MARKETING MARGIN
C         CORTEF  : INTERCEPT OF FRESH CASSAVA DEMAND CURVE
C         TANGF   : SLOPE OF FRESH CASSAVA DEMAND CURVE
C         CORTEA  : INTERCEPT OF STARCH DEMAND CURVE
C         TANGA   : SLOPE OF STARCH DEMAND CURVE
C         CORTES  : INTERCEPT OF DRIED CASSAVA DEMAND CURVE
C         TANGS   : SLOPE OF DRIED CASSAVA DEMAND CURVE
C         NOSE    : DISCOUNT TO ASSURE CASSAVA MARKET ACCESS
C         COSTO   : PROCESSING COSTS FOR DRIED CASSAVA
C         TQP     : GROWTH RATE OF ESTABLISHED CASSAVA DRYING PLANTS
C         CORTEP  : INTERCEPT OF AREA SUPPLY CURVE
C         TANGP   : SLOPE OF AREA SUPPLY CURVE
C         N       : YEAR OF SIMULATION
C         TS      : YEARS BEFORE DRYING INDUSTRY STARTS TO DEVELOP
C         REND    : YIELD ACCORDING TO FARM TYPE
C         PEQUIU  : EQULIBRIUM PRICE OF LAST YEAR
C         XDET    : DETERIORATION LOSSES FRACTION
C       RETURN PARAMETERS:
C       ------------------
C         PCONS   : FRESH CASSAVA PRICE ACCORDING TO URBANIZATION STRATUM
C         DF      : FRESH CASSAVA DEMAND ACCORDING TO URBANIZATION STRATUM
C         DATOT   : TOTAL CASSAVA DEMAND FOR STARCH PRODUCTION
C         DSTOT   : DRIED CASSAVA DEMAND IN FRESH CASSAVA EQUIVALENTS
C         DSECA   : DRIED CASSAVA DEMAND
C         PSECA   : DRIED CASSAVA PRICE
C         AREA    : AREA PLANTED ACCORDING TO FARM TYPE
C         DTOTAL  : TOTAL DEMAND
C-----------------------------------------------------------------------
       REAL * 8 PEQUIL,MARGEN(1),CORTEF(1),TANGF(1),CORTEA,TANGA,CORTES,
     1TANGS,NOSE,COSTO,TQP,CORTEP(1),TANGP(1),PCONS(4),DF(4),DFTOT,
     2DATOT,DSTOT,PSECA,AREA(3),REND(1),PROD(3),PTOTAL,DTOTAL,DTTOTA,
     3PP,PEQUIU,PQIMP,PICON(4),PISEC,AREAT,COTON,QS,QSINI,STIM,XDET(4)
     4,STI1,GXT,DCP,FMOB,INCRE(4),COST,RENDI,CORTEO,TANGO,DSECA
       REAL * 8 TCONS(2,4)
       INTEGER * 4 N,TS,IND
       DATA TCONS/'METROPOL','ITANOS','CAP. REG','IONALES','RURALES',' ',
     1'AUTOCONS','UMIDORES'/
       IND=N-TS
       IF(IND.LT.0) IND=0
       DFTOT=0
       DO 10 I=1,4
       PCONS(I)=PEQUIL+PEQUIL*INCRE(I)+MARGEN(I)
       PICON(I)=PCONS(I)/1000
       DF(I)=(CORTEF(I)+PEQUIL*TANGF(I))/(1+XDET(I))
10     DFTOT=DFTOT+DF(I)
       DATOT=CORTEA+PEQUIL*TANGA
       DSTOT=CORTES+PEQUIL*TANGS
       DSECA=DSTOT/2.5
       PSECA=2.5*(PEQUIL-NOSE)+COSTO
       PISEC=PSECA/1000
       IF(DSECA.LT.QS) GO TO 1
```

APPENDIX 7, SUBROUTINE CRITIC1

```
      DSECA=QS
      DSTOT=DSECA*2.5
1     DTTOTA=DFTOT+DATOT+DSTOT+DCERDO
      DTOTAL=CORTED+PEQUIL*TANGD
      PP=0
      AREAT=0
      DO 20 I=1,3
      AREA(I)=CORTEP(I)+PEQUIU*TANGP(I)
      PROD(I)=AREA(I)*REND(I)
      PP=PP+PROD(I)
   20 AREAT=AREAT+AREA(I)
      RENDI=PP/AREAT
      COST=RENDI*2.5*FMOB + 40*FMOB +9450
      COTON=COST/RENDI
      STI1=(DSTOT-CORTES)/TANGS - COTON -(NOSE+GXT)
      STIM=STI1/1854.8155
      IF(STIM.GT.1) STIM=1
      DCP=QSINI*(2-TQP)*STIM + QS*TQP*STIM - (QS-DSECA)
      IF(N.LT.TS) DCP=0
      IF(DCP.LT.0) DCP=0
      PTOTAL=CORTEO+TANGO*PEQUIU
      PQIMP=PEQUIL/1000
      WRITE(3,201) N,(PICON(I),DF(I),I=1,4),PISEC,DSECA,QS,DATOT
201   FORMAT(I2,5(F5.2,F7.0),F8.1,F8.1,1X,'1')
      WRITE(8,301)N,(AREA(I),REND(I),PROD(I),I=1,3),PTOTAL,DTOTAL
301   FORMAT(I2,3(F7.1,F5.2,F8.1),F8.1,F9.1,'2')
      QS=QS+DCP
      RETURN
      END
```

APPENDIX 7, SUBROUTINE MOBRA1

```
      SUBROUTINE MOBRA1(PEQUIL,PCONS,DF,DATOT,DSTOT,AREA,PMISR,PMISY,
     1TMS,TMSY,N,NSIM,REND,XDET)
C-----------------------------------------------------------------------
C       SUBROUTINE TO CALCULATE EMPLOYMENT DATA
C
C       ENTRY PARAMETERS:
C       -----------------
C         PEQUIL  : EQUILIBRIUM PRICE
C         PCONS   : FRESH CASSAVA PRICE ACCORDING TO URBANIZATION STRATUM
C         DF      : FRESH CASSAVA DEMAND ACCORDING TO URBANIZATION STRATUM
C         DATOT   : TOTAL STARCH DEMAND
C         DSTOT   : DRIED CASSAVA DEMAND IN FRESH CASSAVA EQUIVALENTS
C         AREA    : AREA PLANTED ACCORDING TO FARM TYPE
C         PMISR   : WORLD MARKET PRICE OF SORGHUM
C         PMISY   : WORLD MARKET PRICE OF SOYA
C         TMS     : WORLD MARKET PRICE OF SORGHUM, GROWTH RATE
C         TMSY    : WORLD MARKET PRICE OF SOYA, GROWTH RATE
C         N       : YEAR OF SIMULATION
C         NSIM    : NUMBER OF YEARS OF SIMULATION
C         REND    : YIELD ACCORDING TO FARM TYPE
C         XDET    : DETERIORATION LOSSES FRACTION
C       RETURN PARAMETERS
C       ----------------------
C-----------------------------------------------------------------------
       REAL * 8 PEQUIL,PCONS(1),DF(1),DATOT,DSTOT,AREA(1),PMSOR,PMSOY,
      1TMS,TMSY,MOU,MOR,MOT,AD,PMARG(3),AT,REND(3),PROD(3),XDET(4)
       INTEGER * 4 N,NSIM
       DO 10 I=1,3
  10   PMARG(I)=PCONS(I)-PEQUIL
       MOU=0.00031*DF(1)*PMARG(1) + 0.00024*DF(2)*PMARG(2)
       MOU=MOU+0.00024*DF(3)*PMARG(3) + DATOT
       MOU=MOU/260.
       AT=0.
       DO 20 I=1,3
       PROD(I)=AREA(I)*REND(I)
  20   AT=AT + AREA(I)
       MOR=AT*55+(PROD(1)+PROD(2)+PROD(3))*2.5
       MOR=MOR + DSTOT*2.55 + 0.00007*DF(1)*PMARG(1)*(1+XDET(1))
       MOR=MOR +0.00014*DF(2)*PMARG(2)*(1+XDET(2))
       MOR=MOR+ 0.00014*DF(3)*PMARG(3)*(1+XDET(3))
       MOR=MOR/260.
       MOT= MOU+MOR
       XN=N
       PMSOR=PMISR*((1+TMS)**XN)
       PMSOY=PMISY*((1+TMSY)**XN)
       AD=(DSTOT/2.5)*(1.2*PMSOR-0.2*PMSOY)
       WRITE(10,402)N,MOR,MOU,MOT,PMSOR,PMSOY,AD
 402   FORMAT(I2,F9.2,F8.2,F9.2,F7.2,F7.2,F11.2,26X,'3')
       RETURN
       END
```

APPENDIX 7, SUBROUTINE BENEF1

```
      SUBROUTINE BENEF1(PEQUIL,CORTEF,TANGF,PCONS,NOSE,CORTEA,TANGA,
     1DSTOT,DATOT,DF,CORTES,TANGS,PEQUIU,CORTEP,TANGP,PSECA,REND,N,NSIM,
     2TIM,CORTYF,TANGYF,
     2BSAU,BSSU,BSCU,BSIU,BSPU,BSTU,BSF1U,BSF2U,BSF3U,BSF4U,BSPRU1,
     3BSPRU2,BSPRU3,BSAN,BSSN,BSCN,BSIN,BSPN,BSTN,BSF1N,BSF2N,BSF3N,
     4BSF4N,BSPRN1,BSPRN2,BSPRN3)
C-----------------------------------------------------------------------
C      SUBROUTINE TO CALCULATE AND PRINT SOCIAL BENEFITS
C
C      ENTRY PARAMETERS:
C      ----------------
C         PEQUIL  : EQUILIBRIUM PRICE
C         CORTEF  : INTERCEPT OF FRESH CASSAVA DEMAND CURVE
C         TANGF   : SLOPE OF FRESH CASSAVA DEMAND CURVE
C         PCONS   : CONSUMER PRICE IN DIFFERENT ENVIRONMENTS
C         NOSE    : DISCOUNT TO ASSURE CASSAVA MARKET ACCESS
C         CORTEA  : INTERCEPT OF STARCH DEMAND CURVE
C         TANGA   : SLOPE OF STARCH DEMAND CURVE
C         DSTOT   : TOTAL DRIED CASSAVA DEMAND (FRESH CASSAVA EQUIVALENTS)
C         DATOT   : TOTAL STARCH DEMAND
C         DF      : TOTAL FRESH CASSAVA DEMAND
C         CORTES  : INTERCEPT OF DRIED CASSAVA DEMAND CURVE
C         TANGS   : SLOPE OF DRIED CASSAVA DEMAND CURVE
C         PEQUIU  : EQUILIBRIUM PRICE OF LAST YEAR
C         CORTEP  : INTERCEPT OF AREA SUPPLY CURVE
C         TANGP   : SLOPE OF AREA SUPPLY CURVE
C         PSECA   : DRIED CASSAVA PRICE
C         REND    : YIELD IN DIFFERENT FARM TYPES
C         N       : YEAR OF SIMULATION
C         NSIM    : NUMBER OF YEARS OF SIMULATION
C         TIM     : INTEREST RATE IN THE INTERNATIONAL MARKET
C         CORTYF  : FINAL INTERCEPT OF THE YIELD EQUATION
C         TANGYF  : FINAL SLOPE OF THE YIELD EQUATION
C      RETURN PARAMETERS
C      ---------------
C         BSF1N   : PRESENT VALUE OF SOCIAL BENEFITS IN METROPOLITAN AREA
C         BSF2N   : PRESENT VALUE OF SOCIAL BENEFITS IN INTERMEDIATE
C                   URBAN AREA
C         BSF3N   : PRESENT VALUE OF SOCIAL BENEFITS IN RURAL AREAS
C         BSF4N   : PRESENT VALUE OF SOCIAL BENEFITS FOR HOME CONSUMPTION
C         BSAN    : PRESENT VALUE OF SOCIAL BENEFITS FOR STARCH INDUSTRY
C         BSSN    : PRESENT VALUE OF SOCIAL BENEFITS FOR DRIED CASSAVA
C                   INDUSTRY
C         BSPRN1  : PRESENT VALUE OF SOCIAL BENEFITS FOR SMALL FARMS
C         BSPRN2  : PRESENT VALUE OF SOCIAL BENEFITS FOR MEDIUM SIZED
C                   FARMS
C         BSPRN3  : PRESENT VALUE OF SOCIAL BENEFITS FOR LARGE FARMS
C         BSCN    : PRESENT VALUE OF SOCIAL BENEFITS FOR CONSUMERS
C         BSIN    : PRESENT VALUE OF SOCIAL BENEFITS FOR THE INDUSTRY
C         BSPN    : PRESENT VALUE OF SOCIAL BENEFITS FOR PRODUCERS
C         BSTN    : PRESENT VALUE OF TOTAL SOCIAL BENEFITS
C-----------------------------------------------------------------------
       REAL * 8 PEQUIL,CORTEF(1),TANGF(1),PCONS(1),NOSE,CORTEA,TANGA,
     1CORTES,TANGS,PEQUIU,CORTEP(3),TANGP(3),PROD(3),REND(3),PSECA,
     2TIM,AREA(3),CORTRR(3),TANGRR(3),BSF(4),BSA,BSS,BSPRO(3),BSCONS,
     3ANUAL,BSIND,BSPRT,BSTOT,BSAU,BSSU,BSCU,BSIU,BSPU,BSTU,
     4BSF1U,BSF2U,BSF3U,BSF4U,BSPRU1,BSPRU2,BSPRU3,BSAN,BSSN,BSCN,
     5BSIN,BSPN,BSTN,BSF1N,BSF2N,BSF3N,BSF4N,BF(4),
     5CORTYF(3),TANGYF(3),SUPER(3),NUL(3),NULO(3),XINTE(3),
     5BSPRN1,BSPRN2,BSPRN3,DSTOT,DF(4),DSECA,DATOT,BS1
       INTEGER * 4 N,NSIM
```

```
      DO 10 I=1,4
      BSF(I)=-0.5*(DF(I)**2)/TANGF(I)
10    IF(BSF(I).LT.0)BSF(I)=0
      IF(TANGA.EQ.0) TANGA=1
      IF(TANGS.EQ.0) TANGS=1
      BSA=-0.5*((DATOT)**2)/TANGA
      IF(BSA.LT.0)BSA=0
      DSECA=DSTOT/2.5
      BS1=((DSECA-CORTES)/TANGS)-PEQUIL
      BSS=2.5*BS1*DSECA -(0.5*(DSECA**2)*2.5)/TANGS
      IF(BSS.LT.0)BSS=0
      DO 20 I=1,3
      AREA(I)=CORTEP(I)+PEQUIU*TANGP(I)
      PROD(I)=AREA(I)*REND(I)
      CORTRR(I)=CORTEP(I)*CORTYF(I)
      TANGRR(I)=TANGP(I)*CORTYF(I)+CORTEP(I)*TANGYF(I)
      SUPER(I)=TANGP(I)*TANGYF(I)
      NUL(I)=-CORTRR(I)
      XINTE(I)=TANGRR(I)**2-4.*CORTRR(I)*SUPER(I)
      NUL(I)=(NUL(I)+XINTE(I)**0.5)/2.*CORTRR(I)
      NULO(I)=-CORTRR(I)
      NULO(I)=(NULO(I)-XINTE(I)**0.5)/2.*CORTRR(I)
      IF(NULO(I).GT.NUL(I))NULO(I)=NUL(I)
      BSPRO(I)=PROD(I)*(PEQUIL-PEQUIU)+CORTRR(I)*PEQUIU
     1+0.5*TANGRR(I)*PEQUIU**2+(SUPER(I)*PEQUIU**3)/3
     1-CORTRR(I)*NUL(I)-0.5*TANGRR(I)*NUL(I)**2
     1-(SUPER(I)*NUL(I)**3)/3
  20  IF(BSPRO(I).LT.0)BSPRO(I)=0
      BSCONS=0.
      DO 30 I=1,3
  30  BSCONS=BSCONS+BSF(I)
      BSIND=BSA+BSS
      BSPRT=BSF(4)+BSPRO(1)+BSPRO(2)+BSPRO(3)
      BSTOT=BSCONS+BSIND+BSPRT
      XN=N
      ANUAL=(1+TIM)**XN
      BSF1N=(BSF(1)/ANUAL)+BSF1U
      BSF2N=(BSF(2)/ANUAL)+BSF2U
      BSF3N=(BSF(3)/ANUAL)+BSF3U
      BSF4N=(BSF(4)/ANUAL)+BSF4U
      BSAN=(BSA/ANUAL)+BSAU
      BSSN=(BSS/ANUAL)+BSSU
      BSPRN1=(BSPRO(1)/ANUAL)+BSPRU1
      BSPRN2=(BSPRO(2)/ANUAL)+BSPRU2
      BSPRN3=(BSPRO(3)/ANUAL)+BSPRU3
      BSCN=(BSCONS/ANUAL)+BSCU
      BSIN=(BSIND/ANUAL)+BSIU
      BSPN=(BSPRT/ANUAL)+BSPU
      BSTN=(BSTOT/ANUAL)+BSTU
      WRITE(11,411)N,(BSF(I),I=1,4),BSA
 411  FORMAT(I2,4(F15.3),F14.3,3X,'4')
      WRITE(12,414)N,BSS,(BSPRO(J),J=1,3)
 414  FORMAT(I2,F15.3,3(F16.3),14X,'5')
      WRITE(13,417)N,BSCONS,BSIND,BSPRT,BSTOT
 417  FORMAT(I2,4(F17.3),9X,'6')
      IF(N.EQ.NSIM) GOTO 999
      GOTO 1000
999   BSF1N  = BSF1N/1000000
      BSF2N  = BSF2N/1000000
      BSF3N  = BSF3N/1000000
      BSF4N  = BSF4N/1000000
```

```
      BSAN   = BSAN/1000000
      BSSN   = BSSN/1000000
      BSPRN1 = BSPRN1/1000000
      BSPRN2 = BSPRN2/1000000
      BSPRN3 = BSPRN3/1000000
      BSCN   = BSCN/1000000
      BSIN   = BSIN/1000000
      BSPN   = BSPN/1000000
      BSTN   = BSTN/1000000
      WRITE(14,419)BSF1N,BSF2N,BSF3N,BSF4N,BSAN,BSSN
 419  FORMAT(6(F10.3),19X,'7')
      WRITE(15,420)BSPRN1,BSPRN2,BSPRN3,BSCN,BSIN,BSPN,BSTN
 420  FORMAT(7F10.3,9X,'8')
1000  RETURN
      END
```

APPENDIX 7, SUBROUTINE RECTA1

```
      SUBROUTINE RECTA1(ELASTI,DEMAND,PRECIO,PENDIE,INTERC)
C-----------------------------------------------------------------------
C      SUBROUTINE TO CALCULATE SUPPLY AND DEMAND CURVE COEFFICIENTS
C
C      ENTRY PARAMETERS:
C      -----------------
C        ELASTI  : ELASTICITY
C        DEMAND  : PRESENT DEMAND OR PRODUCTION LEVEL
C        PRECIO  : PRICE
C      RETURN PARAMETERS:
C      ------------------
C        PENDIE  : SLOPE OF THE CURVE
C        INTERC  : INTERCEPT OF THE CURVE
C
C-----------------------------------------------------------------------
       REAL * 8 ELASTI,DEMAND,PRECIO,PENDIE,INTERC
       PENDIE=ELASTI*DEMAND/PRECIO
       INTERC=DEMAND-PENDIE*PRECIO
       RETURN
       END
```

APPENDIX 7, SUBROUTINE AZAR1

```
SUBROUTINE AZAR1(IY)
C       REAL * 8 AZAR1
C**********************************************************************
C       RANDOM NUMBER GENERATION OF NUMBERS BETWEEN ZERO AND ONE
C       FOR THE FIRST CALL IY HAS TO BE ASSIGNED A NUMBER SMALLER OR
C       EQUAL TO 2147483647
C**********************************************************************
        IF(IY.NE.0) GO TO 1
        WRITE(6,100)
100     FORMAT(T2,'OJO: LA SEMILLA ES CERO')
1       IX=1220703125*IY
        IF(IX) 2,3,3
2       IX=IX+2147483647+1
3       IY=IX
        YFL=IX
        YFL=YFL*.4656613E-9
        AZAR1=YFL
        RETURN
        END
```

APPENDIX 7, SUBROUTINE XNOR1

```
      FUNCTION XNOR1(MU,SIGMA,R1,R2)
      REAL * 4 MU,SIGMA
C-----------------------------------------------------------------------
C     GENERATION OF A NORMAL DISTRIBUTION WITH MEAN MU AND STANDARD
C     DEVIATION SIGMA (IX IS THE SEED VALUE USED)
C-----------------------------------------------------------------------
      A1=R1
      A2=R2
      A1=SQRT(-2.*ALOG(A1))
      A2=SIN(6.2832*A2)
      XNOR1=MU+A1*A2*SIGMA
      RETURN
      END
```

APPENDIX 7, ROUTINE TO GROUP OUTPUT OF MAIN PROGRAM ITERATIONS

```
&CONTROL OFF
&BEGTYPE
******************************************
* NAME OF OUTPUT FILE: FN
* MUST BE YUCA1 TO YUCA8
******************************************
&END
&READ VARS &NOM
COPY  &NOM DATOS1  A &NOM DATA1 A
ERASE &NOM DATOS1  A
COPY  &NOM DATOS2  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS2  A
COPY  &NOM DATOS3  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS3  A
COPY  &NOM DATOS4  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS4  A
COPY  &NOM DATOS5  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS5  A
COPY  &NOM DATOS6  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS6  A
COPY  &NOM DATOS7  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS7  A
COPY  &NOM DATOS8  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS8  A
COPY  &NOM DATOS9  A &NOM DATA1 A(APPEND
ERASE &NOM DATOS9  A
COPY  &NOM DATOS10 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS10 A
COPY  &NOM DATOS11 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS11 A
COPY  &NOM DATOS12 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS12 A
COPY  &NOM DATOS13 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS13 A
COPY  &NOM DATOS14 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS14 A
COPY  &NOM DATOS15 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS15 A
COPY  &NOM DATOS16 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS16 A
COPY  &NOM DATOS17 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS17 A
COPY  &NOM DATOS18 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS18 A
COPY  &NOM DATOS19 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS19 A
COPY  &NOM DATOS20 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS20 A
COPY  &NOM DATOS21 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS21 A
COPY  &NOM DATOS22 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS22 A
COPY  &NOM DATOS23 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS23 A
COPY  &NOM DATOS24 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS24 A
COPY  &NOM DATOS25 A &NOM DATA1 A(APPEND
ERASE &NOM DATOS25 A
```

APPENDIX 7, PROGRAM TO CALCULATE MEAN VALUES OF ITERATIONS

```
MACRO MEDIAS
DROP TAR;
PROC SORT;BY N; PROC PRINT;
TITLE1 DATA OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 ___________________________________________________________;
PROC MEANS;BY N;
TITLE1 MEANS OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 _______________________________________________________________; %
CMS FILEDEF Y1 DISK YUCA1 DATA1 A ;
CMS FILEDEF Y2 DISK YUCA2 DATA1 A ;
CMS FILEDEF Y3 DISK YUCA3 DATA1 A ;
CMS FILEDEF Y4 DISK YUCA4 DATA1 A ;
CMS FILEDEF Y5 DISK YUCA5 DATA1 A ;
CMS FILEDEF Y6 DISK YUCA6 DATA1 A ;
CMS FILEDEF Y7 DISK YUCA7 DATA1 A ;
CMS FILEDEF Y8 DISK YUCA8 DATA1 A ;
***********************************************************;
DATA UNO;INPUT N 1-2 PRECON1 3-7 DFRES1 8-14 PRECON2 15-19 DFRES2 20-26
   PRECON3 27-31 DFRES3 32-38 PRECON4 39-43 DFRES4 44-50 PRESEC 51-55
   DSECA 56-62 QS 63-70 DALMIDON 71-78 TAR 80 ; INFILE Y1;
   LABEL PRECON1=PRICE TO THE METROPOLITAN CONSUMER
         PRECON2=PRICE TO THE INTERMEDIATE URBAN CONSUMER
         PRECON3=PRICE TO THE RURAL CONSUMER
         PRECON4=PRICE TO THE HOME CONSUMER
         DFRES1=DEMAND OF FRESH CASSAVA IN METROPOLITAN AREA
         DFRES2=DEMAND OF FRESH CASSAVA IN INTERMEDIATE URBAN AREA
         DFRES3=DEMAND OF FRESH CASSAVA IN RURAL AREAS
         DFRES4=DEMAND OF FRESH CASSAVA BY HOME CONSUMERS
         PRESEC=PRICE OF DRIED CASSAVA
         DSECA=DEMAND OF DRIED CASSAVA
         QS=DRIED CASSAVA PROCESSING CAPACITY
         DALMIDON=CASSAVA DEMAND FOR STARCH;
         MEDIAS;
DATA DOS;INPUT N 1-2 AREA1 3-9 REND1 10-14 PROD1 15-22 AREA2 23-29
   REND2 30-34 PROD2 35-42 AREA3 43-49 REND3 50-54 PROD3 55-62 PTOTAL
   63-70 DTOTAL 71-79  TAR 80 ; INFILE Y2;
   LABEL AREA1=AREA OF SMALL FARMEQUENA
         AREA2=AREA OF INTERMEDIATE FARM
         AREA3=AREA OF LARGE FARM
         REND1=YIELD IN THE SMALL FARM
         REND2=YIELD IN THE INTERMEDIATE FARM
         REND3=YIELD IN THE LARGE FARM
         PROD1=PRODUCTION OF THE SMALL FARM
         PROD2=PRODUCTION OF THE INTERMEDIATE FARM
         PROD3=PRODUCTION OF THE LARGE FARM
         PTOTAL=TOTAL PRODUCTION DTOTAL=TOTAL DEMAND ;
         MEDIAS;
DATA TRES;INPUT N 1-2 MORURAL 3-11 MOURBANA 12-19 MOTOTAL 20-28 PSORGO
   29-35 PSOYA 36-42 ADIVISA 43-53 TAR 80; INFILE Y3;
   LABEL MORURAL=RURAL EMPLOYMENT MOURBANA=URBAN EMPLOYMENT
         MOTOTAL=TOTAL EMPLOYMENT PSORGO=SORGHUM PRICE
         PSOYA=SOYA PRICE ADIVISA=FOREIGN EXCHANGE SAVED ; MEDIAS;
DATA CUAT; INPUT N 1-2 BSF1 3-17 BSF2 18-32 BSF3 33-47 BSF4 48-62 BSA
   63-76 TAR 80; INFILE Y4;
   LABEL BSF1=SOCIAL BEN. IN METROPOLITAN AREA
         BSF2=SOCIAL BEN. IN INTERMEDIATE URBAN AREA
         BSF3=SOCIAL BEN. IN RURAL AREA
         BSF4=SOCIAL BEN. FOR HOME CONSUMPTION
         BSA=SOCIAL BEN. FOR STARCH INDUSTRY;MEDIAS;

DATA CINCO;INPUT N 1-2 BSS 3-17 BSPRO1 18-33 BSPRO2 34-49 BSPRO3 50-65
```

APPENDIX 7, PROGRAM TO CALCULATE MEAN VALUES OF ITERATIONS

```
   TAR 80; INFILE Y5;
   LABEL BSS=SOC. BEN. OF DRIED CASSAVA INDUSTRY
     BSPRO1=SOC. BEN. OF SMALL FARMS
     BSPRO2=SOC. BEN. OF INTERMEDIATE FARMS
     BSPRO3=SOC. BEN. OF LARGE FARMS;MEDIAS;
DATA SEIS; INPUT N 1-2 BSCONS 3-19 BSIND 20-36 BSPRT 37-53 BSTOT 54-70
   TAR 80; INFILE Y6;
   LABEL BSCONS=SOC. BEN. OF CONSUMERS
         BSIND=SOC. BEN. OF INDUSTRY
         BSPRT=SOC. BEN. OF PRODUCERS
         BSTOT=TOTAL SOCIAL BENEFITS; MEDIAS;
DATA SIETE;INPUT BSF1N 1-10 BSF2N 11-20 BSF3N 21-30 BSF4N 31-40 BSAN
   41-50 BSSN 51-60 TAR 80;INFILE Y7;
   LABEL BSF1N=PRES. VAL. OF METR. SOC. BEN.
         BSF2N=PRES. VAL. OF INT. SOC. BEN.
         BSF3N=PRES. VAL. OF RUR. SOC. BEN.
         BSF4N=PRES. VAL. OF HOME CONS. SOC. BEN.
         BSAN=PRES. VAL. OF STARCH IND. SOC. BEN.
         BSSN=PRES. VAL. OF DRIED CASSAVA IND. SOC. BEN.;
DROP TAR;
PROC PRINT;
TITLE1 DATA OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 ____________________________________________________________;
PROC MEANS;
TITLE1 MEANS OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 ________________________________________________________________;

DATA OCHO;INPUT BSPRN1 1-10 BSPRN2 11-20 BSPRN3 21-30 BSCON 31-40 BSIND
   41-50 BSPROD 51-60 BSTOT 61-70 TAR 80; INFILE Y8;
   LABEL BSPRN1=PRES. VAL. OF SOC. BEN. FOR SMALL PROD.
         BSPRN2=PRES. VAL. OF SOC. BEN. FOR INTERM. PROD.
         BSPRN3=PRES. VAL. OF SOC. BEN. FOR LARGE PROD.
         BSCON=PRES. VAL. OF SOC. BEN. FOR CONSUMERS
         BSIND=PRES. VAL. OF SOC. BEN. FOR INDUSTRY
         BSPROD=PRES. VAL. OF SOC. BEN. FOR PRODUCERS
         BSTOT=PRES. VAL. OF TOTAL SOC. BEN.;
DROP TAR;
PROC PRINT;
TITLE1 DATA OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 ____________________________________________________________;
PROC MEANS;
TITLE1 MEANS OF THE 25 RUNS TO SIMULATE THE CASSAVA MARKET SYSTEM;
TITLE2 ________________________________________________________________;
```

Appendix 8: Calculation of the stochastic element in the yield equations of the simulation model

To calculate the stochastic element in the yield equations of the model on the basis of the price variability observed, demand and supply functions at farm level have to be known. In that case the stochastic element can be calculated after that the production variability, caused by the distributed lag nature of the supply function has been calculated and separated out.

The first step to calculate the stochastic element in the yield equation is to calculate the production variability, caused by the distributed lag. This is done below in equations 6 to 16 where the variability in the planned production (variability caused by the distributed lag) is expressed as a function of the variability of the price.

Assume that:

$QP = b*QP_{-1} + c*P_{-1}$ (1)

$S = \tilde{N}(1, sd)$ (2)

$Q = QP* S$ (3)

$D = e - f*P$ (4)

$Q = D$ (5)

where:

QP = Planned production in a certain year
S = Variability of production
Q = Realized production
D = Demand
P = Price at production level
b,c,e,f = Coefficients to express supply and demand reactions

Appendix 8

$\tilde{N}$ = Normal distribution that generates the variability of production

If this is a stable system ,than:

$QP = QP_{-1}$ and $var(QP) = var(QP_{-1})$ (6)

$P = P_{-1}$ and $var(P) = var(P_{-1})$ (7)

The variability of the planned production can be described as:

$$var(QP) = b^2*var(QP_{-1}) + c^2*var(P_{-1}) + 2*c*b*cov(QP_{-1}, P_{-1}) \quad (8)$$

Now by elaborating the last term of (8):

$$cov(QP_{-1}, P_{-1}) = -cov(QP_{-1}, Q_{-1}/f) \quad (9)$$

$$cov(QP_{-1}, Q_{-1})/f = cov(QP_{-1}, S*QP_{-1})/f \quad (10)$$

$$= QP*cov(S, QP_{-1})/f + cov(QP_{-1}, QP_{-1})/f \quad (11)$$

In equation 11 the first term is zero since the covariance between random variable S and QP_{-1} is zero.

$$cov(QP_{-1}, Q_{-1})/f = var(QP_{-1})/f = var(QP)/f \quad (12)$$

$$cov(QP_{-1}, P_{-1}) = var(QP)/f \quad (13)$$

substituting this back into (8):

$$var(QP) = b^2*var(QP_{-1}) + c^2*var(P_{-1}) - 2*c*b*var(QP)/f \quad (14)$$

$$(1 - b^2 + 2*c*b/f)*var(QP) = c^2*var(P_{-1}) \quad (15)$$

$$var(QP) = var(P_{-1})*c^2/(1 - b^2 + 2*c*b/f) \quad (16)$$

Now the variability in realized production can be expressed as a function of the variability in the planned production and the stochastic variability.

$$var(Q) = var(S*QP) \quad (17)$$

Since:

$$cov(S,QP) = 0 \quad (18)$$

This can be rewritten as

$$var(Q) = var(QP) + (QP)^2*var(S) \quad (19)$$

And from equation 18, the stochastic variability can be calculated by reordering:

$$(QP)^2*var(S) = var(Q) - var(QP) \quad (20)$$

From equation 4 and 5 it follows that:

$$var(QP) = f^2*var(P)$$

and equation 20 can be rewritten as:

$$(QP)^2*var(S) = f^2*var(P) - var(P_{-1})*c^2/(1 - b^2 + 2*c*b/f) \quad (21)$$

which leads to the final solution for the variability of S:

$$var(S) = [(f^2 - c^2/(1 - b^2 + 2*c*b/f))*var(P)]/(QP)^2 \quad (22)$$

At the assumption that the cassava market system has been relatively stable over the last years, equations 1 to 5 can be estimated. For the planned production equation this is done by multiplying the original yield equation with the area equation and approaching the production reaction to changing prices with a linear function. This is permissible when the interval in which linearization takes place is small. For the demand equation the effect of changes in consumer prices has to be translated in the effect of price changes at farm level.

After equation 1 to 5 were estimated, equation 22 was solved to find a value for the standard deviation of the stochastic element of 0.13.

Appendix 9. Economic parameters of sorghum production in the Atlantic Coast region of Colombia, 1984.

A. Investments per hectare:

	Nominal Price (US$)	Correction factor	Corrected Price (US$)	Economic life time (years)
Tractor + equipment	347	0.83	288	10
Combine	119	0.82	98	10
Spraying Airplane	25	0.65	16	10

B. Production costs per hectare:

	Units Needed		Nominal Price/Unit (US$)	Correction Factor	Corrected Price (US$)
Land	1		75	1.0	75
Land preparation	1		77	0.57	44
Seeds	15	kg	1.69	1.0	75
Pre-emergent herbicide	3	liters	4	0.74	9
Application	2.2	hours	4.2	0.57	5
Insecticides	3	flights	7	0.59	12
Application	5	flights	7.5	0.75	17
Fertilizer	100	kg	0.35	0.83	29
Application	1.2	hours	3.3	0.57	2
Harvest	33.6	sacks	1.5	0.57	29
Loading	1		4.35	0.75	3
Transport	1		5.3	0.57	3
Second collection	2	persons	4.2	0.75	6
Other harvest costs			1.67	1	2
Technical assistance	1	person	8.3	0.90	8
Plot management and control	4	mandays	4.2	0.80	13
Other costs			10.8	1.0	11
Costs of first harvest					302
Mowing and Burning	1		8.75	0.80	7
Fertilizer	60	kg	0.35	0.83	17
Application	1	hours	3.3	0.57	2
Insecticides	2	flights	7	0.59	8
Application	2	flights	7.5	0.75	11

	Units Needed	Nominal Price/Unit (US$)	Correction Factor	Corrected Price (US$)
Technical assistance and control	2 mandays	4.2	0.80	7
Harvest	11.2 sacks	1.5	0.57	10
Other harvest costs		5.8	0.90	5
Transport	1 hour	4.9	0.57	3
Benefits from cattle grazing		-4.2	1.0	-4
Cost of rattoon				66
Administration costs	10% of national costs		0.90	45
Transport to mill	2.8 tons	8.3	1.00	23
Total costs				436
Yield:	2800 kg			

C. Cash flow per hectare

	Year 0	1	2	3	4	5	6	Residual value
Investments	-201	-201						161
Costs of extension service	-8	-4						8
Production costs	-109	-436	-436	-436	-436	-436	-327	
Foreign exchange saved		448	448	448	448	448	448	
Cash flow	-318	-193	12	12	15	12	115	169

For further details, see Borren (1983)

Appendix 10. Economic parameters of dried cassava production in the Atlantic Coast region of Colombia, 1984 1/

A. Investments per plant:	Nominal Price (US$)	Correction factor	Corrected Price (US$)	Economic life-time (years)
Concrete drying floor	6562	0.84	5512	20
Warehouse	1650	0.84	1386	20
Fence	93	0.89	83	5
Cover for chipper	75	0.87	65	15
Chipper	626	0.9	563	10
Motor	1187	0.7	831	5
Scale	188	0.66	124	10
Wheelbarrows	225	1.0	225	5
Spades	56	1.0	56	5
Rakes	38	1.0	38	2
Gatherers	38	1.0	38	2
Sacks	750	1.0	750	2
Plastic Cover	938	1.0	938	4
Unforeseen	5% of investments		530	8
Working Capital			5062	
Total Investments			16201	
Cassava Production:				
Tractor + Equipment	15263	0.83	12668	10

B. Production costs of the cassava/maize intercropping system per hectare:	Units needed	Nominal price (US$)	Correction factor	Corrected Price (US$)
Machinery				
Ploughing	2.5	17.5	0.57	25
Disking	1.0	17.5	0.57	10
Furrowing	10.0	17.5	0.57	10
Internal transport	1.5	14.0	0.57	12

1/ Drying plant of 1500 m^2.

	Units needed	Nominal price (US$)	Correction factor	Corrected Price (US$)
Labor				
Seed preparation	1	4.2	1.0	4
Planting cassava	6	4.2	1.0	25
Planting maize	2	4.2	1.0	8
Chemical weed control	2	4.2	1.0	8
Manual weed control	35	4.2	0.72	105
Pest control	2	4.2	0.8	7
Cassava harvesting	20.7	4.2	0.54	47
Maize harvesting	6	4.2	0.75	19
Inputs				
Maize seed	10 kg	0.18	1.0	2
Insecticides	1 treatment	11.75	0.59	7
Herbicides	1 treatment	16.67	0.74	12
Land	1 ha	75	1.0	75
Administration costs	10% of national costs			10
Benefits from cattle grazing	-4.2			-4
Total costs				405
Cassava yield : 10345 kg/ha				
Maize yield : 1000 kg/ha				

C. Processing costs per plant:

	Units needed	Price/Unit (US$)	Correction factor	Corrected Price (US$)
Fixed costs				
Maintenance		423	1.0	423
Administration		1500	0.75	1125
Land-rent		42	1.0	42
Variable costs				
Labor	1008 mandays	4.2	0.5	2100
Fuel	1008 liters	0.125	2.0	252
Transport	403 tons	12	1.0	4838
Other Costs	1008 tons	0.67	1.0	672
Total processing costs				9452

D. Cash flow per plant:

	Year 0	1	2	3	4	5	6	Residual value
Investments in drying plant	-5569	-5569		-825		-1763	-1196	7113
Working capital	-2531	-2531						5062
Operation costs		-9452	-9452	-9452	-9452	-9452		
Investments in cassava production	-6334	-6334						5067
Production costs	-13139	-39417	-39417	-39417	-39417	-26278		
Institutional investments	-7500	-5625						9469
Foreign exchange saved with maize (corrected for transport costs)		15947	15947	15947	15947	15497	15947	
Foreign exchange saved with cassava		55709	55709	55709	55709	55709	55709	
Cash flow	-35074	2727	22787	21962	22787	21024	34710	26712

For more details on drying plant investments and processing costs, see Janssen and Ospina, 1983.

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Samenvatting

De invloed van markten op het ontwikkelingspotentieel van cassave in de Atlantische kuststreek van Colombia

De gemarginaliseerde positie van veel (kleine) boeren in ontwikkelingslanden wordt mede veroorzaakt doordat de vraag naar hun produkten niet stijgt of zelfs daalt. Dit leidt tot onevenwichtige ontwikkeling van de landbouwsector en vergroot het verschil in inkomen met de rest van de economie. De hypothese van deze studie is dat het openen van nieuwe of het verbeteren van bestaande markten de inkomensperspectieven in bepaalde delen van de landbouwsector kan verbeteren en zo kan bijdragen aan een meer evenwichtige ontwikkeling. Om deze vooronderstelling te verifiëren analyseert deze studie in hoeverre marktverbetering voor cassave, een typisch kleine boeren gewas, kan bijdragen aan landbouwontwikkeling in de Atlantische kuststreek van Colombia.

Alvorens de feitelijke situatie in het onderzoeksgebied te beschouwen, wordt de relatie tussen marktontwikkeling en landbouwgroei en de betekenis hiervan voor cassave beschreven (Hoofdstuk 1). Agrarische ontwikkeling wordt vaak beschouwd als zijnde afhankelijk van beschikbare produktiemiddelen en produktietechnologie. De relatie van de landbouwsector met andere sectoren wordt gezien in het licht van de concurrentie voor produktiemiddelen. Landbouwkundige ontwikkeling zou worden geoptimaliseerd door evenwichtige toewijzing van produktiemiddelen en hoge absorbtie van arbeid.

Ook het functioneren van markten beinvloedt de ontwikkeling van de landbouwsector. De agrarische produktie past zich aan aan de vraag, zoals die zich in de markt openbaart. De vraag voor dierlijke produkten en tarwe groeit snel in vele ontwikkelingslanden. De vraag naar traditionele voedselprodukten zoals knolgewassen stijgt slechts langzaam of is zelfs aan daling onderhevig. Het merendeel van de vraag concentreert zich in urbane gebieden. Vaak stijgt de

vraag voor produkten die niet binnenslands geproduceerd kunnen worden en die moeten worden geimporteerd.

De vraagontwikkeling stimuleert de binnenlandse produktie in bepaalde landbouwbedrijven en remt die af in andere. Zowel landbouw in de nabijheid van stedelijke gebieden als voedergranenverbouw voor de produktie van vlees, melk en eieren, zullen zich sterk ontwikkelen. Voor de producenten van traditionele voedselprodukten is er weinig marktperspectief. Vaak worden voedergranen verbouwd op grootschalige, gemechaniseerde bedrijven en traditionele voedselprodukten op kleinschalige arbeidsintensieve bedrijven. De veranderende vraag naar landbouwprodukten stimuleert de import van landbouwprodukten en de produktie op grote bedrijven. Het kleine bedrijf wordt voor een groot gedeelte afgezonderd van de goede ontwikkelingsmogelijkheden.

Als gevolg van de vraagontwikkeling wordt een deel van het produktiepotentieel van de landbouw niet optimaal benut. De mogelijke absorbtie van arbeid wordt verminderd en migratie wordt gestimuleerd. De grootschalige bedrijven gebruiken meer kapitaal dan de kleinschalige, wat de kapitaalbeschikbaarheid voor de rest van de economie vermindert.

Door markten met goede perspectieven te openen voor kleine boeren, kan kleinschalige produktie gestimuleerd worden. Dit geeft meer mogelijkheden om de doelstellingen van landbouwontwikkeling (onder meer: acceptabele inkomens voor boerenbedrijven; absorbtie van arbeid; verminderen van migratie) te bereiken. Vier strategieën ter verbetering van markten zijn mogelijk: 1) Het verbeteren van traditionele markten voor traditionele produkten. 2) Het openen van nieuwe markten voor traditionele produkten. 3) Het verkopen van nieuwe produkten in traditionele markten of 4) het verkopen van nieuwe produkten in nieuwe markten. Verbetering van de afzet van traditionele gewassen verdient de voorkeur daar hun produktiemogelijkheden bekend zijn.

Cassave wordt vaak door kleine boeren verbouwd en heeft een traditionele rol in de voedselpatronen van vele ontwikkelingslanden. Vaak verliest die traditionele rol aan belang in het ontwikkelingsproces. Haar slechte bewaareigenschappen na de oogst maken cassave belangrijker op het platteland dan in de stad.

Daarentegen opent de rijkdom aan verwerkingsmethoden de mogelijkheid om nieuwe markten te betreden of om de bestaande markten te verbeteren. Cassave is een ideaal gewas om de mogelijkheden van marktverbetering te bestuderen.

In hoofdstuk 2 wordt de Atlantische kuststreek van Colombia en de rol van cassave in de regio beschreven. In dit gebied van zo'n honderdduizend vierkante kilometer wonen vijf en een half miljoen mensen. Een klein miljoen mensen woont op het platteland, anderhalf miljoen mensen wonen in twee erg grote steden en de rest woont in kleinere steden of dorpen. De Noordkust heeft een dualistische landbouwstructuur. Het merendeel van het land is in het bezit van een kleine groep landbezitters. De vele kleine boeren bezitten slechts een gering gedeelte van het land en oefenen semi-subsistence landbouw uit: er worden produkten verkocht nadat de consumptiebehoeften van het huishouden voldaan zijn. De kleine boeren verbouwen cassave, plantaan (bakbanaan), yam en mais, vaak in mengbouw. Als er land over is, houden ze vee. Cassave produktie in de regio wordt geschat op 560.000 ton per jaar. Een geïntegreerd plattelandsontwikkelingsprogramma (DRI) probeert boereninkomens te verbeteren, onder meer door meer krediet ter beschikking te stellen. Voor cassava heeft dit slechts geleid tot verzadiging van de markt van verse cassave voor menselijke consumptie, de voornaamste afzetmogelijkheid op dit moment. Dit maakte de noodzaak van marktverbetering erg duidelijk. Twee opties voor marktverbetering zijn geidentificeerd. 1) Het verbeteren van de traditionele markt van verse cassave, door het ontwikkelen en introduceren van een bewaarmethode. 2) Het oprichten van boeren associaties die met behulp van zonne-energie cassave verwerken tot gedroogde chips voor gebruik in de veevoerindustrie.

In hoofdstuk 3 wordt een methode ontwikkeld voor het bestuderen van het marktpotentieel van cassave. Niet slechts het marktkanaal maar ook de invloeden daarvan op produktie en consumptie behoren te worden onderzocht. De integratie van systeemtheorie met "structure conduct performance" theorie levert hiervoor het geëigende middel: Eerst behoren produktie, vermarkting en consumptie afzonderlijk geanalyseerd te worden. Daarna dient de samenhang tussen de verschillende componenten van het cassave systeem bestudeerd te worden. Dit laatste kan het beste gebeuren door middel van een simulatie van het gehele cassave marktsysteem in het onderzoeksgebied. Het cassave marktsysteem en de mogelijkheden tot verbetering dienen geëvalueerd te worden aan de hand van de doelstellingen van de landbouwsector. Die optie die het meeste bijdraagt aan het realiseren van de doelstellingen van de landbouwsector verdient de voorkeur.

Data benodigdheden voor de studie van produktie, vermarkting en consumptie en hun samenhang zijn aanzienlijk. De data moeten grotendeels verkregen worden uit enquêtes, omdat secundaire informatie schaars is. Aan de hand van de onderzoeksprioriteiten, die in een orienterende enquête geformuleerd zijn, wordt de data verzameling besproken.

In <u>hoofdstuk 4</u> wordt de cassave produktie geanalyseerd: de rol van cassave binnen het kleine boerenbedrijf is een belangrijk aspect in deze analyse. De kleine boer verbouwt zo'n een tot twee hectare cassave in mengteelt. Cassave draagt sterk bij tot het cash inkomen in de droge tijd en tot de voeding van het huishouden in het grootste deel van het jaar. Het produktierisico is gering. De verkoop daarentegen gaat met veel inspanning en risico gepaard. De gebrekkige spaar- en kredietmogelijkheden in de regio stimuleren het bezit van vee, wat niet veel opbrengt maar flexibele arbeidseisen heeft. Het inkomen van kleine bedrijven en de effectiviteit van marktverbeteringsprogramma's zou kunnen worden verhoogd door goede spaar- en kredietmogelijkheden te openen die de noodzaak voor veehouderij zouden verminderen.

Een ander aspect is de reactie van boeren op wisselende prijzen en wisselende prijsvariabiliteit. De prijsvariabiliteit van cassave blijkt erg groot te zijn en maakt cassave tot een bijzonder onstabiele inkomensbron. Prijsstabilisatie en de daarmee gepaard gaande inkomensstabilisatie zou de aantrekkelijkheid van cassave verbouw verhogen.

Het maken van gedroogde cassave-chips zou zo'n prijsstabilisatie kunnen bewerkstelligen omdat de prijs van droge cassave gekoppeld is aan de, door de overheid, gecontroleerde sorghum prijs. De prijs voor verse cassave om te drogen is weliswaar lager dan de gemiddelde prijs in de verse markt maar functioneert als een bodemprijs. De bodemprijs vermindert de prijsvariabiliteit en verhoogt enigzins de gemiddelde prijs die de boer mag verwachten. Het effect van zo'n bodemprijs op het aanbod van cassave is met twee methodes geschat. In de eerste methode wordt boeren gevraagd hoeveel cassave ze zouden verbouwen als de oogst gecontracteerd zou worden tegen een vaste prijs per kilogram. Door de antwoorden op deze vragen te vergelijken met het huidige cassave areaal kan het effect van prijshoogte en van prijsvariabiliteit op het aanbod berekend worden. Nadat geschat is hoe de bodemprijs prijs en prijsvariabiliteit zou veranderen, wordt berekend hoeveel areaaluitbreiding dat zou opleveren. In de tweede methode wordt gebruikt gemaakt van een kwadratisch programmeringsmodel dat, gegeven te verwachten prijzen en prijsvariabiliteiten, het ideale produktieplan berekent voor bedrijven van verschillende grootte.

Introductie van cassave droogfabriekjes zou een positief effect hebben op het aanbod. De te verwachte verhoging ligt tussen 25% voor kleine bedrijven met weinig uitbreidingsmogelijkheden en 80% voor grote bedrijven. Inkomens zouden met 20% stijgen. Er zou een verschuiving optreden van mengbouw naar monocultuur.

In hoofdstuk 5 worden de marktkanalen van verse en droge cassave geanalyseerd. Het marktkanaal van verse cassave heeft een versnipperde structuur. Vele handelaren vermarkten kleine hoeveelheden; niet meer dan 1000 kg. cassave per dag per persoon voor groothandelaren of 150 kg. cassave per dag per persoon voor detailhandelaren. Vanwege de bederfelijkheid van verse cassave is het marktkanaal geheel gericht op snelle distributie. Binnen 35 uur na de oogst bereikt het gewas de consument. Bederf maakt het transport van cassave naar andere regio's problematisch. De kosten van vermarkting lopen op tot vier maal de prijs verkregen op de boerderij. Hierdoor is cassave goedkoop op het platteland, maar duur in de stad.

De samenhang tussen cassavemarkten in verschillende steden is onduidelijk. Prijsveranderingen zijn onregelmatig en onvergelijkbaar tussen steden. De markt voor verse cassave functioneert op een ondoorzichtige en inefficiënte wijze. Een bewaarmethode zou de noodzaak om snel te vermarkten verlagen, de omvang van het bederf verminderen en de samenhang in de prijsvorming van verschillende gebieden verbeteren. Dit zou een verlaging van de marge met maximaal 30% kunnen veroorzaken.

Het marktkanaal van droge cassave lijkt op dat van graan. Droge cassave is niet bederfelijk en heeft een gunstige gewicht-prijs verhouding. Het kan gemakkelijk getransporteerd worden naar andere delen van het land. Daar op het moment van de studie de vraag de produktie verre overschreed verkregen de droogfabriekjes goede verkoopvoorwaarden. Snelle uitbreiding van de droogcapaciteit zou verwerking en gebruik van droge cassave doen toenemen en zou cassave produktie stimuleren.

Cassave consumptie wordt beschouwd in <u>hoofdstuk 6</u>. Verse cassave consumptie is veel lager in de stad (30 kg./hoofd/jaar) dan op het platteland (80-160 kg./hoofd/jaar). Verse cassave consumptie lijkt te dalen. Een belangrijke oorzaak op het platteland is de verbeterde beschikbaarheid van andere voedingsmiddelen. In de stad is de noodzaak het produkt te kopen op de dag van consumptie en het frequente bederf aansprakelijk voor de daling van consumptie.

Attitudes ten opzichte van cassave en een aantal vergelijkbare gewassen zijn met elkaar vergeleken en gerelateerd aan consumptieniveaus. Het werd duidelijk dat het koopgemak van cassave als minimaal beschouwd wordt en dat dit consumptie negatief beinvloedt. Verbetering van het koopgemak is afhankelijk van verbeterde bewaarbaarheid van het produkt. Een adequate bewaarmethode zou verse cassave consumptie met 8 tot 15 kg. per hoofd per jaar kunnen verhogen.

Verse cassave is geen inferieur produkt. Consumptie is ongeveer even hoog in verschillende inkomensgroepen. Toch is het belang van cassave hoger voor de armen dan voor de rijken, omdat het verbruik van de meeste andere produkten wel stijgt met stijgend inkomen. Daarnaast blijken arme mensen het sterkst op cassave prijsveranderingen te reageren.

De vraag naar droge cassava voor veevoer is voldoende om cassaveproduktie in de regio te verdubbelen. Droge cassave zou voornamelijk gebruikt worden in voer voor varkens en rundvee. Aan de kwaliteitseisen voor veevoer kan gemakkelijk voldaan worden. Droge cassave produktie zou Colombia in staat stellen om sorghum importen te stoppen en om de nationale veevoerindustrie sneller te laten groeien.

In hoofdstuk 7 wordt een simulatiemodel gebruikt om de ontwikkeling van cassave produktie, vermarkting en consumptie in het onderzoeksgebied te voorspellen. Het model heeft zes componenten: consumptie, produktie, vermarkting, ontwikkeling van de droogindustrie, evenwichtscondities, sociale baten. Het model voorspelt de ontwikkeling van het cassave systeem tot aan 1994 en schat de effecten van verschillende marktverbeteringsmethodes.

De introductie van een cassave droogindustrie stimuleert, door de prijsstabilisatie die ervan uitgaat, zeer sterk de produktie. De verhoogde beschikbaarheid van cassave wordt geheel door de veevoerindustrie geabsorbeerd. Consumptie van verse cassave daalt meer dan indien het cassave systeem zich zou ontwikkelen zonder ontwikkeling van de droogindustrie. Tot 1994 tellen de gedisconteerde baten van deze strategie op tot 35 miljoen dollar. Deze baten komen bijna volledig terecht bij de boer. Grote boeren ontvangen wat meer baten dan kleine boeren omdat ze beter in staat zijn hun produktie uit te breiden. De baten verhouden zich erg gunstig tot de 3 miljoen dollar die nodig zijn voor de bouw van de droogfabriekjes. Colombia zou bovendien 11 miljoen dollar per jaar aan sorghumimporten besparen. Werkgelegenheid in cassave produktie en verwerking zou met meer dan drie procent per jaar groeien, meer dan de bevolkingsgroei. Het bouwen van droogfabriekjes bevoordeelt bij uitstek het platteland.

Versnelde constructie van droogfabriekjes zou de positieve effecten van cassave drogen nog verder verhogen. Boeren inkomens en rurale werkgelegenheid zouden nog sneller stijgen. Verhoging van cassave produktie zonder versnelde vergroting van de droogcapaciteit verlaagt de prijs in de markt en bevoordeelt consumenten boven boeren. De verwerkingscapaciteit en de verhoging van de vraag naar cassave die daarmee bereikt wordt is de sleutel tot de verbetering van de inkomens van de kleine cassave boeren.

Het invoeren van een bewaarmethode voor verse cassave om de "verse" markt te verbeteren heeft hogere verwachte baten dan het starten van cassave droogfabriekjes: zo'n 60 miljoen dollar over de beschouwde tien jaar. Deze baten zijn echter gevoeliger voor de gemaakte aannames en dalen snel indien de aannames wat minder gunstig zijn. Deze strategie bevoordeelt voornamelijk de consument in de grote steden die zijn cassave tegen een lagere prijs kan kopen. De baten voor cassave producenten met verschillende bedrijfsgrootte zijn gelijk, maar in alle gevallen kleiner dan bij de bouw van droogfabriekjes.

Het gezamenlijk invoeren van de bewaarmethode en de droogfabriekjes levert aanvankelijk sterke vraag-concurrentie op voor cassave. Vervolgens stijgt de produktie zo sterk dat de prijs voor cassave daalt beneden de verwachte prijs in het geval de bewaarmethode alleen wordt ingevoerd. Voor consumenten van verse cassave is de prijsdaling die met gezamenlijke introductie gepaard gaat een prima zaak. De veevoer industrie heeft minder profijt van gezamenlijke ontwikkeling omdat de vraag naar cassave vanuit de verbeterde "verse" markt nu sterker is en de prijzen verder stijgen. Producenten hebben zeer veel profijt bij de gezamenlijke introductie van een droogindustrie en een bewaarmethode, omdat de vraag naar hun product bijzonder snel stijgt. Een laatste conclusie die uit het simulatiemodel volgt is dat verbetering van cassave markten een grote bijdrage levert tot plattelandsontwikkeling en verhoging van boereninkomens doch dat het niet voldoende is. Marktverbetering hoort geintegreerd te worden in een breder pakket van ontwikkelingsmaatregelen.

<u>Hoofdstuk 8</u> beschouwt implementatieaspecten voor de twee voorgestelde strategieën. Een eerste punt van aandacht is de economische aantrekkelijkheid van de vervanging van sorghum door cassave. Cassave produktie blijkt voordeliger te zijn dan sorghum produktie: voor Colombia is het produceren van cassava voor veevoer aantrekkelijker dan het importeren van sorghum; Importeren van sorghum is echter aantrekkelijker dan het zelf produceren van sorghum in de Atlantische kuststreek.

Vervolgens wordt in het kort een aantal punten beschouwd die succesvolle implementatie beinvloeden. Droogfabriekjes komen het beste tot hun recht in gebieden met slechte toegang tot de verse markt, terwijl bewaarprojecten het beste gestart kunnen worden in gebieden met goede toegang tot de verse markt. Voor beide strategieën verdient eenvoudige technologie met weinig kapitaalinvesteringen de voorkeur boven gecompliceerde verfijnde technologie. Verbetering van cassave produktie moet zich in het geval van cassave drogen richten op een verhoogde droge stof produktie per hectare en in het geval van bewaartechnieken op het produceren van cassave met goede bereidings- en consumptie eigenschappen. Voor droge cassave is marktbewerking relatief eenvoudig omdat het aantal kopers gering is en hun motieven duidelijk zijn. Voor verse cassave moet marktbewerking er op gericht zijn de consument te overtuigen van de goede eigenschappen van bewaarbare cassave. Beide marktverbeteringsstrategieën moeten een adequate organisatiestructuur hebben. Boerenassociaties lijken hiervoor de geëigende oplossing in het geval van cassave drogen. Voor het introduceren van de bewaarmethode, lijkt de noodzaak van associaties minder, maar is het zeer belangrijk om de cassave handelaren in de uitvoering te betrekken. De projectstaf belast met implementatie van de marktverbeteringsmogelijkheden moet bekwaam zijn op gebied van produktie, vermarkting, consumptie en organisatie. Politieke steun moet niet gericht zijn op het verminderen van steun aan concurrerende produkten (bijv. sorghum) maar op het opnemen van cassave in dezelfde regelingen.

Hoofdstuk 9 vat de belangrijkste conclusies van de studie samen. Daarnaast trekt het conclusies over de mogelijkheden van marktverbetering bij andere produkten. Die worden voornamelijk bepaald door het aanwezige produktiepotentieel en door de mogelijkheid om met het produkt nieuwe niet-traditionele markten te betreden. Voor het uitvoeren van marktverbeteringsprogramma's lijkt het verstandig eerst op kleine schaal te experimenteren alvorens tot grotere investeringen over te gaan.

Het potentieel van cassave in de Derde wereld wordt bepaald door haar gebruiksmogelijkheden, meer dan door haar produktiemogelijkheden. Slechts als er een zinvol gebruik voor het gewas is geidentificeerd verdient het aanbeveling cassave in ontwikkelingsprojecten op te nemen. Produktiepotentieel alleen is niet voldoende om onderzoek aan en ontwikkeling van het gewas te rechtvaardigen.

De onderzoeksmethodes gebruikt in deze studie zijn niet vooraf aan het onderzoek bepaald doch hebben zich gedurende het onderzoek ontwikkeld. De inhoud van het onderzoek is tot op grote hoogte afhankelijk geweest van de problemen die in de loop van de studie gesignaleerd zijn. In tegenstelling tot gangbare marktstudies in ontwikkelingslanden heeft de studie niet geprobeerd te evalueren, in hoeverre het cassave marktkanaal overeenstemt met ideaaltypes uit de theorie, maar heeft het getracht de waarde van markt- en marktkanaal verbeteringen te schatten. De invalshoek die de studie heeft genomen komt voort uit de overtuiging dat de invloed van markten niet bestudeerd kan worden in de markt alleen, doch verbonden moet worden met produktie en consumptie vraagstukken. De systeem benadering die hiervoor gekozen is, biedt een algemeen onderzoekskader doch identificeert niet in detail de relevante onderzoeksaspecten. Dat hoort te gebeuren aan de hand van de oriënterende studies in de beginfase van het onderzoek. Deze benadering van marktonderzoek in de tropen is meer probleemgericht van aard dan de beschrijving van marktsystemen aan de hand van ideaalbeelden. De schrijver hoopt dat zo'n probleemgerichte benadering een verhoogde bijdrage kan leveren aan het bepalen van de bijdrage van verbeterde marktsystemen aan evenwichtige landbouwkundige ontwikkeling.

CURRICULUM VITAE

Willem G. Janssen werd op 16 Augustus 1956 geboren te Venray. Van 1968 tot en met 1974 doorliep hij het St. Oelbert Gymnasium te Oosterhout. Daarna ving hij de studie landbouweconomie aan de Landbouwhogeschool te Wageningen aan. In zijn studententijd was hij actief in, onder meer, studentenvereniging, studievereniging, sportvereniging en bestuur van de vakgroep Algemeen Agrarische Economie. In 1977 en 1978 werkte hij als studentassistent bij de vakgroep Wiskunde. In 1979 behaalde hij het kandidaatsdiploma en volbracht vervolgens zijn praktijktijd op Bloemenveiling Berkel en Omstreken en op het CIAT (Centro Internacional de Agricultura Tropical) te Cali, Colombia. In september 1981 behaalde hij het diploma van landbouwkundig ingenieur.

Hij werkte vervolgens op tijdelijke basis bij Bloemenveiling Berkel en Omstreken en bij Marketing Adviesbureau Winkelman en van Hessen in den Haag. In Mei 1982 werd hij uitgezonden door het Minsterie van Buitenlandse Zaken, Directoraat Generaal Internationale Samenwerking, naar CIAT, Colombia, als assistent- deskundige belast met de studie van cassave vermarktingsmogelijkheden. Hij verrichte hiervoor onderzoek in het Atlantische kustgebied van Colombia. Daarnaast droeg hij bij aan cassave ontwikkelingsprojecten en trainingsprogramma's in andere delen van Colombia, Panama, Mexico, Peru en Ecuador.