An Analysis of a Cassava Integrated Research and Development Approach: Has it Really Contributed to Poverty Alleviation?

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Abstract

In 1981, the Integrated Cassava Research and Development (ICRD) Project was implemented as an integrated set of institutional, organizational, and technological interventions designed to link small-scale cassava farmers to expanding markets. The Project's objective was to develop both technology and market opportunities for cassava producers in the northern Colombia, targeting especially small farm owners and landless farmers. The paper assesses the Project's impact on participating communities in terms of poverty alleviation, and identifies the avenues by which the Project was able to bring these positive changes. The ICRD Project showed that agricultural research can contribute tangibly to poverty alleviation, but with the following conditions that (1) market and post harvest research and development are integrated with production technology research agenda; (2) interinstitutional partnerships are

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developed, whereby different institutions with their own expertise, comparative advantages, and mandates ollaborate to respond to the demands of local community organizations and individuals; and (3) existing social and human capital is used to create intimate networking among institutions, local social organizations, and individuals.

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1. Introduction

Cassava is an important crop throughout the tropical world for small farmers with access to marginal lands. Its high tolerance, compared with other crops, of seasonal low rainfall, high temperatures and intermediately fertile soils makes it an essential source of food security and cash income in areas where few alternatives exist, such as in the semiarid North Coast of Colombia. In the early 1980s, the region grew 35% of the country's total cassava production. According to Janssen (1986), in the 1980s, the small farmers of the North Coast obtained 40% of their cropping income by marketing cassava. The crop was also important for on-farm consumption, and as an employment generator, creating about7.3 million wage-days per year. Despite its socioeconomic significance to the Colombian North Coast during the 1980s, marketing the crop was very difficult. Most of the cassava was used for on-farm consumption or sold on the fresh markets; only small quantities were used for starch production or the preparation of traditional snack foods. Regional urban consumers were supplied through a marketing channel that quickly transferred the cassava roots through several intermediaries. The short shelf life of harvested fresh roots made marketing cassava a risky business: losses were high and fluctuations of daily price large. Cassava margins were often more than double the farmgate price. Urban demand was declining because of high prices and uncertain quality, limiting the sale of cassava to regional markets.

Market alternatives were needed. The Centro Internacional de Agricultura Tropical (CIAT) identified dried cassava chips for the animal feed industry as a potential alternative. The Integrated Cassava Research and Development (ICRD) Project was set up in 1981 to widen market opportunities for small farmers in the North Coast, secure a price floor for cassava, and thus provide a sustainable source of income for the farmers. The Project targeted small landholders and tenant farmers working farms of less than 20 ha. About 80% of farms in this region fell into this category but in aggregate, represent less than 10% of total farmland (DANE 1974). In the early 1980s, the Colombian North Coast was characterized by poverty levels that were higher than the national ones: 76% of the population had unsatisfied basic needs and 55% were living in misery, compared with 64% and 36% at the national level respectively (Colombian Census 1985).

The small farmers targeted by , the ICRD Project were therefore among the poorest populations of the region, already poor by national standards. The ICRD Project lasted from 1981 to 1989.

This paper evaluates the main hypothesis driving the ICDR Project and its overall impact on poverty. To determine whether the ICRD Project reached its goal and whether the observed impact matched the expected ones, this paper focuses on assessing the impact the Project had on participating communities in terms of poverty alleviation within these communities. The paper also aims to identify the avenues by which the Project brought about these changes. The paper thus analyzes (1) the emergence of cassava drying organizations, especially within the targeted population, and the expansion of cassava drying capacity in the region; (2) the short-run intermediate effect of the new alternative market developed for cassava roots, (3) the new market influence on the adoption of modern varieties; (4) the contribution of the ICRD Project to poverty alleviation; and (5) the sustainability of the impact after the Project ended and after the national economy opened up to international competition. Lessons learned from the ICRD Project's experience are also discussed.

1.1. The Challenge

In 1981, cassava farmers in the North Coast faced depressed prices as a consequence of the initial approach taken by the Integrated Rural Development, (DRI) whose credit program, established in 1977 by the Colombian government, had the effect of encouraging farmers to greatly intensify cassava production (Janssen 1986). By 1981, cassava production was extremely high and unable to find buyers, many farmers plowed their crops without harvesting.

With prices falling below production costs, problems of massive credit default appeared. Limited markets for cassava belied the DRI's basic premise that production increases would improve small farmers' income. After the 1981 debacle, farmers were afraid to increase cassava production. Small-farm development in the North Coast region clearly did not depend on production increases alone, but also on marketing. The DRI therefore began searching for alternative markets for cassava.

In the same period, CIAT was concerned that, constrained by lack of markets, cassava farmers in Latin America were not adopting improved production technologies developed during the 1970s. CIAT therefore studied alternative uses for cassava to identify markets with growth potential, the most promising of which was the use of dried cassava chips as an energy component in animal feed concentrates (Pachico et al., 1983). This industry was originally developed in Asia, where millions of tons of dried cassava chips had been produced for export. After conducting economic studies, CIAT initiated an integrated approach to cassava research and development to introduce this market opportunity to South America (Cock 1985; Lynam 1987).

The program's strategy was to link small farmers with the expanding market for animal feed concentrates (Best et al. 1991). With secure, more profitable, markets established for their cassava crop, farmers would be more likely to adopt improved, cost-reducing production technologies, thus improving their cassava production and, consequently their incomes.

1.2. The Intervention

For the DRI, also facing the challenge of finding alternative markets for cassava, CIAT was a natural partner, because it had already identified such possibilities. The Center had also begun developing appropriate cassava processing technology, and conceptualizing the ICRD strategy. In 1981, then, together with the DRI-program, the ICRD Project was implemented through an integrated set of institutional, organizational, and technological interventions designed to link small-scale cassava farmers to expanding markets, thus to stimulate farmer demand for improved production technology with potential to improve small farmers' income and welfare.

The Project to establish an agroindustry based on drying and chipping cassava roots required the construction and operation of small-scale processing enterprises, owned and managed by small farmer associations. The technology was brought from Asia, but was tested, adjusted and diffused with small farmers' participation. This low-cost and appropriate technology consisted in chipping cassava roots, which were then spread on cement floors and sun dried.

The ICRD Project was coordinated by the DRI, in collaboration with other decentralized public and private institutions. Each institution assumed an agreed set of responsibilities in accordance with their own mandates and capacity as summarized in Table 1. The ICRD Project was executed in four (Best et al. 1991):

1.2.1. Experimental phase: 1981-1982

The Project began with a group of 15 farmers, selected from the municipality of San Juan de Betulia, Department of Sucre. A pilot plant was built, processing technology was evaluated and adapted, and an operational scheme was developed for local conditions. Seven tons of dried cassava chips were produced and distributed among several animal feed industries to obtain feedback on their potential interest in buying the product and the price they would pay. As a result, one industry committed itself to buying the entire production of the next cassava season.

1.2.2. Demonstration phase: 1982-1983

The pilot plant became semi-commercial, with the farmers themselves taking full responsibility for managing the plant. This period provided reliable data on the plant's operation and consolidated the market for the product. A technico-economic feasibility study was conducted, and its positive results prompted the DRI to create a line of promotional credit for establishing additional drying plants. The pilot plant itself expanded capacity and was used as a demonstration and training model for other farmer groups interested in building drying plants in their communities.

1.2.3. Replication phase: 1983-89

Drying plants were replicated at other sites in the North Coast. At the same time, the development and validation of production technologies were intensified, and the methodology of farmer participation was incorporated into technology development. By the period's end, 39 drying plants were being managed by small-farmer cooperatives, and private individuals had installed another five plants. As dried cassava chips production reached 5,600 tons, the product had to be promoted among a larger number of buyers. The National Association of Cassava Producers and

Processors (ANPPY), an association of small-farmer cooperatives, was created and took responsibility for marketing the dried cassava chips . In 1989, the ICRD Project, as a formal interinstitutional activity, ended.

1.2.4. Reduced Institutional Support Phase: 1989-1993

By 1993, 138 processing plants for drying cassava were operating. Small-farmer cooperatives managed 101 plants, while private individuals, who had adopted the processing technology but not the organizational model, built the remaining 37. The total drying capacity of all 138 plants was 179,715 m^2, of which private entrepreneurs installed 28% (Figure 1). This rapid growth in private investment occurred mainly during this phase, when the technology was completely adapted to local conditions, the market already established, and the economic feasibility of the investment proved. The risk therefore assumed by the private entrepreneurs was lower. In 1993, dried cassava production reached 35,000 tons, valued at US$6.2 million, and requiring 90,000 tons of fresh roots. This volume represented 10% of total cassava roots marketed in the region. Probably 36% of small cassava farmers in the region were selling cassava roots to the dried cassava agroindustry, and 15% of all small farmers were members of a cooperative.

1.3. Hypothesis on the Impact of the ICRD Project

The conceptual framework for the expected impact of the ICRD Project in the Colombian North Coast and its links with the adoption of cassava production technology are illustrated in Figure 2. The promotion of small-scale, cassava-based agroindustries was expected to create an alternative market for cassava roots, which, in its turn, was expected to establish a price floor for the product in the fresh market, narrow price fluctuations, and enhance farmers' bargaining power. These changes in demand and prices would thus reduce market risks faced by cassava farmers and create an incentive to increase cassava production.

Over the short term, cassava farmers would increase their production by expanding the area planted to cassava. The reduced market risk, over the longer term, would stimulate the adoption of improved cassava production technology, therefore improving productivity. Thus, cassava production in the region would be reflected by increased cassava area and crop productivity.

Hence, the changes in prices and production, hypothesized to be brought about by the technological changes in the region, would be translated into changes in consumer, processor, and producer surpluses. Thus, income would be raised and employment would be generated, not only as a consequence of increased cassava production in the region, but as a result of the established agroindustry. The increased income and additional employment opportunities for small-scale and landless farmers in the rural communities would be expected to encourage overall community development, foster social organization, and reduce poverty levels in the population.

2. Methodology

The hypothesis poses a series of questions on the effective impact of the ICRD Project, such as: did cooperatives emerge in poor communities? What were the attributes of the communities where cooperatives were established? To what extent did the ICRD Project have an impact on the community, first through the development of the new agroindustry, then later by encouraging the adoption of new production technology? How did the changes brought by the ICRD Project contribute to poverty alleviation?

To answer these questions, the analysis needs to be broken into three broad questions, which, while being individually analyzed, must be linked with each other. These questions are (1) where and to what extent cooperatives emerged; (2) how did cooperatives influence the adoption of new technology; and (3) what were the effects of both the agroindustry and production technological improvements on poverty.

2.1. Cooperatives Emergence Analysis

Using the Colombian municipality as our definition of a community, we first model the farmers' decision to enter the market of dried cassava chips, i.e. to build one or more cassava drying-plants in the community. Farmers will decide to build a plant if the profits from its operations outweigh the fixed costs involved in organizing the cooperative and building the plant. They first determine what the profits will be, which directly depend how much they can produce of cassava chips, i.e. the total drying capacity. A desired drying capacity will be determined given the cassava roots production, the transaction costs, the demand for fresh cassava in the municipality. This desired drying capacity is such as to maximize the profits from the drying activities. Let DC^* for municipality k represent this desired drying capacity, then:

$$DC_k^* = f(S_k, D_k, TC_k^{coop}) \qquad [1]$$

The vector S_k represents the factors affecting the potential supply of fresh cassava roots, that is, the land available to grow cassava, the productivity of farmers, and the farm size found in the municipality. The greater the potential supply of cassava to the drying plants, the greater is total drying capacity needed in the municipality. More land available to grow cassava (from increases in cropped land or substitutions of other crops for cassava), the greater is the potential supply of roots to the plant and thus desired drying capacity. Similarly, greater productivity suggests greater potential supply. Three measures of productivity are used: the percentage of farmers treating their seeds, the percentage of farmers using pesticides and the average experience at growing cassava. The last factor affecting potential supply is farm size distribution in the municipality. Traditionally, small farmers grow cassava as a cash crop, large farmers growing it only as feed for their cattle. Thus, smaller average farm size and a more uniform distribution of small farms should indicate greater potential supply to the drying plants.

The variable D_k represents the demand for fresh cassava roots in the municipality. Greater the demand of fresh cassava roots, less is the alternative market of dried cassava chips is needed as an income generator. The desired capacity should therefore be lower with a higher demand.

The TC_k^{coop} variable captures the transaction costs of selling the cassava to the drying plant. The greater the transaction costs of selling cassava roots to the plant, lower are the profits of the farmer to sell it to the plant. It implies a lower potential cassava supply to the plants and as such, less drying capacity will be needed.

Once the profits are determined, the farmers compare them to the fixed costs of building the plant. The farmers will decide to build the desired drying capacity if the net benefits are positive. This comparison can be represented by a net benefit index function:

$$I_k^* = I(S_k, D_k, TC_k^{coop}, TC_k^{fresh}, F_k) \quad [2]$$

$S_{k,}$ D_k and TC_k^{coop} capture the profits just as in desired capacity (expression [1]). The transaction costs of selling to the department fresh market, TC_k^{fresh}, and the organizational costs, F_k, are the fixed costs of building the drying capacity. The bigger, urban, fresh markets are found in the department capitals. The distance to these markets dictates transportation costs, which increase with distance. After a certain distance, the transportation costs become too high for these markets to be feasible alternatives. Hence, the transaction costs involved in selling to the fresh market should influence only the decision of to build a plant and access a new market, and not the desired plant capacity.

The vector F_k consists of variables that affect the organization of the cooperative and building of the plant specifically: previous experience with local community associations, presence of institutions[1] in the municipality, average formal education level of cassava farmers, and commitment of farmers to the community as represented by the percentage of farmers who own land in the municipality. The first three F_k variables capture the human and social capital found in the municipality. Previous experience with associations, measured by the number of community associations, and average formal education indicate the capacity and ability of the community to organize itself and how its members can work together. The presence of institutions, as measured by the number of production technology Projects, encourages and helps provide the social and human capital necessary to organize a cooperative.

The cassava-drying capacity of a municipality will equal the desired capacity if the benefits index is greater than zero. The complete decision process can be summarized as follows:

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[1] These institutions include the cassava-production technology research programs of CIAT and ICA, and extension activities of ICA, INCORA, and Caja Agraria. (see Table 1 for explanation of the acronyms).

$$DC_k = \begin{cases} DC_k^* & \text{if} \quad I_k^* > 0 \\ 0 & \text{if} \quad I_k^* \leq 0 \end{cases} \qquad [3]$$

A two-part model allows the econometric implementation of this decision. In the first stage, a probit over the presence of cooperatives in the municipality will estimate whether the benefits I_k^* were positive. Then, using the prediction on the probability of organizing a cooperative, the amount of drying capacity built will be estimated by an ordinary least square regression. The econometric system is therefore:

$$\begin{aligned} &\Pr(C > 0) = f(S_k, D_k, TC_k^{coop}, TC_k^{fresh}, F_k) \\ &DC_k = f(S_k, D_k, TC_k^{coop}, \hat{\Pr}(C > 0)) \qquad \text{if } I_k^* > 0 \end{aligned} \qquad [4]$$

This system will answer questions such as: Was the ICRD Project, aiming to create a market alternative for poor farmers, successful at establishing cooperatives in the poorer communities? And, Was the target of encouraging the Project in small-farmer communities (where most of farms are 20 ha or smaller) reached?

2.2. Production Technology Adoption

To analyze the long-term impact of the ICRD Project on yield increases through the adoption of modern varieties requires a conceptual framework of the adoption decision. The farmer can adopt a new variety and yet decide to continue planting some of his cassava area to a traditional variety. His decision consists therefore in choosing the proportion of cassava area to plant to modern varieties (M_i). To make this decision, the farmer will consider the factors affecting its production directly, opportunity costs, and the availability of information about the new varieties and their seed.

Factors affecting production include the farmer's productive assets such as the size of the land owned and of the land farmed, formal education, experience in growing cassava (Z_i), and the availability of credit and technical assistance (Z_k). The possibility of working off-farm constitutes the major opportunity cost for a farmer (C_k), and will influence all his cropping decisions, including whether to plant modern cassava varieties. The presence of community organizations and public institutions will influence adoption by providing information and planting material of the new varieties (I_k). Drying plants also provided information and planting material to farmers, and to capture this diffusion channel, two variables will be included in the analysis: the distance to the drying plant and the presence of a drying plant, using the predicted probability estimated in the previous step (Pr(C ≥ 1). The distance to the drying plant also captures the transaction costs the farmer must bear to sell his production to the drying plant (included in the C_k vector for purposes of estimation). All these factors and the outcome of the decision can be represented as follows:

$$M_i = f(Z_i, Z_k, C_k, I_k, \hat{\Pr}(C_k > 0)) \qquad [5]$$

Because the decision is measured as a percentage, truncated at 0 and 1, a tobit regression will be estimated. Such a framework will allow us to answer questions like: Did the presence of drying plants influence the adoption of new cassava varieties? And are new varieties planted more widely in municipalities where greater drying capacity is found?

2.3. Impact on Poverty

Ultimately, the interest of this analysis lies in whether the Project helped reduce poverty within the participating communities. To measure this contribution, changes in poverty levels from 1985 to 1993 are used. The presence of cooperatives in the communities and the adoption of modern varieties (Pr(C > 0) and M_i respectively) should partially explain these changes in poverty. These two parts of the ICRD Project will be included as the predictions from the previous calculations, as these contain the full information about the different decision levels. Community associations may also have a direct impact on poverty reduction (Ca). Therefore, they should be included as an aggregate to the analysis. Finally, poverty levels can be affected by diverse factors other than the Project. To capture these external effects, we include variables meant to characterize the municipality. These are the rate of urbanization (U), the distance to the department capital to measure economic opportunities (Km) and average family size (Fa) to measure poverty at the family level. Expression [6] summarizes the quantitative analysis performed:

$$\Delta \text{ in poverty}^{k}_{1985\text{-}1993} = f(\hat{\Pr}(C_k > 0), \overline{\hat{M}}_i, Ca_k, U_k, Km_k, F\overline{a}_k) \qquad [6]$$

The analysis will be carried out on two measures of poverty: the percentage of households with unsatisfied basic needs, which measures the percentage of people below the poverty line, and the percentage of households living in misery.

The data used to analyze the different questions came from the following sources: (1) a survey on adoption among cassava-farmer households; this was conducted in 1991 by CIAT (Henry et al. 1994); (2) 1985 and 1993 census data from the Colombian Department of Statistics (DANE); and (3) a national household survey conducted by DANE and DRI in 1981 (Sanint et al. 1985).

3. Reaching the Poor: Cooperative Emergence Analysis

Table 2 shows that cooperatives emerged in communities with higher potential production surplus, and higher social and human capital. With respect to cassava supply conditions, cassava drying agroindustries tended to emerge in municipalities with higher potential cropping land, smaller average farm size, and with more innovative farmers who previously adopted low-input use technologies such as seed treatment (see $Pr(C \geq 1)$ column, Table 2). Existing local demand for cassava also had a negative impact on the establishment of cassava-drying plants. Hence, the results for these variables indicate indeed that dry cassava agroindustries tended to emerge in communities with higher cassava production and lower fresh demand.

Social and human capital played an important role in the emergence of cooperatives, as captured by previous experience with community associations, institutional presence, and average education in the community. Human and social capital influenced the capacity that the community had to become organized and ask for institutional support to build a processing enterprise. The treatment of seed also indicates the presence and influence of technological programs (public institutions) in the municipality. This technique was suggested by public institutions involved in agricultural technology research. The institutions developed the technique through on-farm trials, providing at same time human capital to the farmers.

The results show the importance of community associations, institutions and education to the establishment of the dried-cassava agroindustry. Both technology development institutions and community organizations influenced the Project's implementation, suggesting that research institutions should work in partnership with local community organizations to enhance the probability of Project success.

For the communities that created one or more cooperatives (see “Total drying capacity” column, Table 2), two factors influenced their decisions on how much capacity to build. First, the more overall experience that a community has with growing cassava, the greater the drying capacity the community will build. This effect of level of experience can be interpreted in two ways: farmers with more experience are more productive, and therefore, have a greater potential production to supply a drying plant; or, alternatively, experience measured as an average can be proxy for the importance of cassava in the region, both in terms of production and income generation. The second factor influencing community decision is the extent of use of high input-use technologies, as measured by pesticide use. This effect is also directly linked to productivity of the farmers in the municipality. Thus, more experience and higher productivity represent higher potential production and greater importance of cassava to the municipality, thus creating a higher demand for drying capacity.

The Project’s target of reaching small farmers was achieved, because cooperatives emerged in communities where the average farm size was lower. However, the drying capacity built was neutral to farm size, and depended strictly on variables related to cassava production. Drying plants also emerged independently of land tenancy indicating that the Project reached equally those communities composed mostly of landowners and those mostly of landless peasants. Furthermore, the existing pre-Project human and social capital dictated in large part if a cooperative would emerge.

4. Short-Term Effect of the New Alternative Market for Cassava

The development of the dried-cassava agroindustry in the Colombian North Coast as was hypothesized by the ICRD methodology created an alternative market for cassava roots. A price floor for cassava was established and over the short-term, farmers reacted by increasing their cassava area. As shown in Figure 3, prices for fresh roots rose between 1983 and 1993 at an annual rate of 2.5%. Also, the price paid for cassava roots by the cassava-drying industry started to provide a price floor, which provided a secure market for cassava farmers. If the price of fresh cassava roots fell under the price floor or the quality of the roots was not acceptable to the fresh market, the farmer had the option of selling his or her product to a cassava-drying plant. As expressed by cassava farmers of Socorro

(San Juan de Betulia, 1993): *"I remember when I was child, there were producers that were left with their cassava… there were no markets for the product."* And *"… of course, it was the cooperative that has practically given life to cassava cropping in this region. Previously, there were years when nobody would buy the cassava, there was no market, and the roots were completely lost."* By linking farmers to expanding markets, the cassava market situation was improved. *"…Now, we have different market alternatives, the fresh market, the drying plant and the new starch plants that are being built. If the fresh market offers a better price, then farmers try to sell their roots to this market, but when things become complicated, farmers will surely sell their crop to the drying plant"*.

Over the short term, this new market alternative created an incentive to increase area planted to cassava. As presented in Figure 4, the area under cassava in the Colombian North Coast has increased at an annual rate of 7% between 1983 and 1993. Results from the 1991 cassava-farmer survey show that 42.7% of cassava farmers increased their area planted to cassava between 1983 and 1991. Of the farmers who responded that their cassava area was increased, 50% said it was because the market for cassava had improved, 22% said that land availability had increased, 12% had substituted yam for cassava, because of the incidence of a serious yam disease, and 5% received credit for cassava cropping.

This short-term effect of the Project is described by Alvaro Meza, cassava farmer and cooperative associate of Sabanas de Beltrán, Los Palmitos, Sucre. "*The construction of the drying plant has been one of the major achievements of this community, and the changes in the standard of living are obvious. The association has improved the market for cassava. Before farmers only planted a quarter or half of a hectare with cassava… mainly for home-consumption. Now, farmers plant 2-3 hectares of cassava because they have a secure market. The drying plant pays members and nonmembers in cash, therefore, they increased their cassava cropping area, and this means a higher income."*

5. Cooperative Impact on Adoption

The long-term impact of the new agroindustry was hypothesized to foster the adoption of improved production technology, such as new varieties to increase cassava yields. The results in Table 3 partially validate this hypothesis. About 77% and 5% of cassava farmers in the region adopted varieties Venezolana and P-12, respectively. On the average, cassava farmers also planted 82% of their cassava area to modern varieties. The presence of a drying plant in the municipality did not influence directly the farmers' decision to adopt. However, the proximity from the farmer's field to the nearest drying plant has a positive impact on the adoption of modern varieties. This result captures two possible effects of the drying plant on technology adoption. The first is related to the new market alternative and more stable fresh prices as discussed previously. As such, farmers have more incentive to increase their production by either increasing the area planted or adopting new technology to increase yields. The other effect of drying plants is to enhance technology diffusion in three ways: first, technological programs found cassava-drying cooperatives to be natural partners for technology diffusion, by allowing them to reach a larger number of farmers. Cassava farmer associations also foster farmer-to-farmer networking, which was found in previous adoption studies to be a major source of technology diffusion (Henry et al. 1994). Furthermore, a major constraint to adoption – availability of planting material -- was partially overcome by the cooperatives' establishing of seed multiplication plots.

The adoption decision was also influenced by the presence of technology development Projects implemented by cassava research institutions in their municipality. The percentage of cassava area planted to modern varieties was therefore higher where more technology projects were active in the municipality. The positive effect of land tenure on the adoption of modern varieties could be linked to institutional presence. In general, farmers who owned land were more willing and able to test new varieties on their farms, and therefore to participate in institutional on-farm trials. As a result, by participating in on-farm trials, farmers could experiment by themselves with the new varieties and were more prone to adopt them. Hence, as the amount of land owned increased, the cassava area under modern varieties also rose. Nevertheless, although modern varieties tended to be more readilly adopted by farmers who own land, they tended to reach small landholders more than large ones.

Finally, the opportunity costs of working off-farm faced by farmers also had an impact on the adoption. The higher the agricultural wage in the municipality, the lower the importance of cassava cropping as an income generation activity is for the farmer. Consequently, farmers will grow cassava mainly for on-farm consumption, and will have fewer incentives to increase cassava yields by adopting new varieties.

This analysis allows us to conclude that the cassava-drying agroindustry indirectly influenced the adoption of modern varieties through the transportation costs that farmers faced in marketing their cassava. It also provided a more secure market and a platform for diffusing technology and planting material. Adoption was also encouraged by the presence of technology research Projects in the communities. Therefore, the new agroindustries, the presence of institutions and access to drying plant each played an important role amd has an additive effect on the adoption of modern varieties.

6. Making a Difference for the Poor

Table 4 shows impact of the ICRD Project on poverty reduction. Changes in "unsatisfied basic needs" and in "misery" show that the ICRD Project contributed to poverty reduction, not directly through the emergence of cassava-drying cooperatives, but through the provision of new production technology and its diffusion as captured by the adoption of production technology. For both poverty indicators, the higher the percentage of cassava area planted to modern varieties in a municipality, the greater the reduction in poverty. An increase of 10% cassava area under modern varieties will reduce the percentage of households living under the poverty line by 0.8%, but the percentage of households living in misery will be reduced 1.2%.

An economic surplus model applied to the ICRD Project by Gottret et al. (1994), that shows the distribution of returns among the different groups of society, supports the above results. The study concluded that the direct benefits generated by the processing technology were only US$1.6 million for the 1984-1991 period (8.5% of total benefits). However, it was the indirect impact of the agroindustry on the adoption of improved cassava production technology that generated most of the economic surplus, estimated at a total of US$18.6 million.

Beyond what these results can explain, the Project had other direct impact on poverty in the communities that built plants. It created employment and stabilized incomes, as a focus group in Socorro expressed: *"There was a major change since the drying plant was built. Before, labor was only used for cassava cropping (planting, weeding, and harvesting). Now things are different and see the income that the crop generates for the community! He eats from cassava if he harvests it, transports it to the drying plant, works in the drying plant, processes it, grinds it, sells it, or even owns the truck that takes it to the feed plant. This is a source of employment and income…"*

The plants also provided some informal credit, with which farmers could buy durable goods or face health needs. *"… a few years ago, in my house there was no television, nor refrigerator or stove. I didn't have money to buy shoes for my children or send them to school. Now, I don't have that much money, but if I need some, I can go to the drying plant manager, and ask him to give me some in advance in exchange for cassava, and he will lend me the money"*.

Furthermore, income generated from cassava cropping has been used as a means to accumulate capital goods such as cattle, which most farmers aim for. As expressed by farmers in Socorro *"… farmers planted 4 to 5 hectares of cassava, and with what was left they would buy a cow… of course, with the profits obtained from cassava."*

The following testimony by Don Carlos, a cassava farmer and cooperative member of Segovia, Sampués, Sucre, validates the findings of the econometric model on the contribution of the ICRD Project to poverty alleviation. *"Before our situation was critical. We used to live with only one pair of pants; we were all day workers. For example, we didn't eat three meals per day… if we had breakfast; we didn't have lunch. And now… I said that there was a change. If you walk around the village, you can see that almost all the houses are built of brick and cement. The village has a water supply and part of it has a sewage system, and all of this was acquired with the little we obtained. We don't live in adobe houses anymore, where you could see the beds from outside. The hammocks used to be made with jute, and now we have at least a more comfortable bed. Now we have money to send the children to school and to dress them, to buy shoes and socks, and we have enough to eat three meals too… and well… sometimes we even have enough to buy some beers… ha, ha, ha…"*

In conclusion, the ICRD Project directly and indirectly reduced the levels of poverty by creating an alternative income-generation activity through selling roots, creating employment, and reducing production costs through improved production technology. The organization of communities around a tangible activity that generates income and employment also fostered existing levels of social and human capital, and therefore, further empowered the communities.

7. ICRD Project Sustainability

Four years after the Project officially ended, some institutional support for cassava continued in the region, but terminated after 1993. At the same time, the Colombian Government moved toward a neoliberal system by opening up the economy to international competition (economic aperture) and decreased its presence, both in size and intervention. Figure 5 shows that, after 1993, prices of both dried cassava and fresh roots paid by the agroindustry decreased at annual rates of 5.5% and 4.3%, respectively. These steep decreases in prices were a result of Colombia importing grains for animal feed at lower prices, which were at that time particularly low, reducing to almost zero the profit margins received by cassava-drying organizations. During the same period, the collapse of institutional support eliminated the availability of credit at low-interest rates for use as working capital. These two shocks, combined with the lack of accumulation of working capital by most associations, forced 28% of the cassava drying plants to stop processing between 1992 and 1993. Eight cassava associations also closed down because their members were displaced by violence in their respective communities. Hence, dried cassava production dropped from 35,000 tons in 1993 to only 7,000 tons in 1994.

Even though cassava farmers faced these two major shocks to the dry cassava agroindustry, in 1999, 56 cassava-drying plants are still operating. Of these 56 plants that still operate, 43 belong to small-farmers' cooperatives, although 15 rent their plant to individual entrepreneurs. Figure 5 also shows that dry-cassava production is starting to increase again as grain imports are becoming more expensive due to the recent devaluation of the Colombian peso. These results show that the sustainability of the program is highly dependent on the macroeconomic environment, which directly affects the viability of the developed marketing alternative.

8. Conclusions and Lessons Learned from the Project

As the analysis has shown, the emergence of the cassava-drying agroindustry created an incentive for adopting modern varieties, which, in turn, contributed to poverty alleviation. The central hypothesis of the ICRD Project methodology was therefore validated: if agricultural research institutions want to make a difference for the poor they should not only concentrate their efforts on production technology development, but also on postharvest and market research. At the same time, agricultural research should be articulated to a broader demand-led development process in order to achieve poverty alleviation goals. Such an integrated approach allows (1) better identification and articulation of farmers' needs in terms of production and postharvest technology, and market research; (2) development of an accordingly more complete set of technology; and thus 3) a more efficient contribution to poverty alleviation.

However, the emergence of cooperatives was influenced by previous existence of local community organizations, which helped communities demand support services from institutions (both governmental and nongovernmental). It also implies that national and international institutions should take advantage of these local community organizations and their expertise to identify and reach the poorer small farmers, and to help implement research and development programs.

Another type of partnership contributed to the success of the ICRD Project: interinstitutional partnership among national and international institutions involved in technology research and rural development. These partnerships allowed the conduct of demand-led research that was articulated to a multipurpose support system. Such cooperation among institutions permitted the inclusion of a broader range of services such as technical assistance on production, processing, marketing, management, and organization, as well as credit. Coordination with other governmental programs such as the land reform was also possible. These partnerships were built around the needs of targeted groups, permitting them to respond adequately and directly to the communities' demands and needs.

The experience of the ICRD Project in the Colombian North Coast shows that agricultural research can contribute tangibly to poverty alleviation. However, it requires three very important components: first, the integration of market and postharvest research and development to the production technology research agenda; second, the use of interinstitutional partnerships, where each institution provides its own expertise, comparative advantage, and mandate to respond to the demands of community organizations and individuals; and third, the fostering of an intimate networking among institutions and local social organizations and individuals, building on existing local social and human capital.

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Table 1. Private and public institutions and their responsibilities in the Integrated Cassava Research and Development (ICRD) Project, North Coast, Colombia.

Institution	Responsibilities
CIDA[a]	Finance the Project's experiment and demonstration phases, and the first two years of the replication phases.
ANPPY[b]	Marketing of dried cassava chips.
CAJA AGRARIA[c]	Provide credit for cassava production.
CIAT[d]	Develop production and processing technology, provide technical assistance and training to national personnel, conduct socioeconomic and market studies, and monitor and evaluate the Project's progress.
CECORA[e]	Provide technical assistance in processing, marketing, and management.
CORFAS[f]	Provide technical assistance in processing and marketing, investment and working capital credit, and credit advice.
Cooperatives[g]	Provide labor for constructing the drying plants and participate actively in the whole Project.
DANCOOP[h]	Provide legal advice to cooperatives.
DRI[i]	Provide institutional coordination and financing in DRI areas (municipalities where farms are smaller than 20 ha).
ICA[j]	Develop and adjust production technology and provide technical assistance.
INCORA[k]	Provide technical assistance on production and processing, and credit for land reform beneficiaries.
PMA[l]	Provide credit for the construction of drying plants, using funds obtained through sales of food aid, which were channeled through CORFAS.
PNR[m]	Provide institutional coordination and financing in PNR areas (municipalities with social and violence problems).
SENA[n]	Assist in community organization and provide business management training, including permanent consulting services.

[a] Canadian International Development Agency
[b] Asociación Nacional de Productores y Procesadores de Yuca
[c] Caja de Crédito Agrario, Industrial y Minero
[d] Centro Internacional de Agricultura Tropical
[e] Central de Cooperativas de la Reforma Agraria, Ltda.
[f] Corporación Fondo de Apoyo de Empresas Asociativas
[g] Organized communities for cassava-drying activities
[h] Departamento Administrivo Nacional de Cooperativas
[i] Fondo de Desarrollo Rural Integrado
[j] Instituto Colombiano Agropecuario
[k] Instituto Colombiano de la Reforma Agraria
[l] World Food Program
[m] Plan Nacional de Rehabilitación de la Presidencia de la República
[n] Servicio Nacional de Aprendizaje

Table 2. Cooperative emergence in small-farming communities participating in the Integrated Cassava Research and Development (ICRD) Project, North Coast, Colombia

	Pr(C ≥ 1) (0-1)[a]	**Total drying capacity (m^2 of drying floor)**
Supply conditions (S_k)		
Potential cropping land (km^2)	0.0028569 (0.041)	0.0187499 (0.997)
Average farm size (ha)	-0.0412731 (0.052)	-144.7366 (0.444)
Farm size ratio of large to small farms	-0.002028 (0.957)	-480.5438 (0.112)
Farmers who treat their seed in 1985 (%)	0.1569036 (0.035)	-103.646 (0.325)
Farmers who used pesticides in 1985 (%)	-0.0193325 (0.225)	515.0793 (0.000)
Average experience (years)	0.0415369 (0.235)	506.5765 (0.017)
Fresh cassava demand (D_k)		
Cassava consumption (tons in the municipality per year)	-0.0003901 (0.037)	0.6787577 (0.298)
Transaction costs to cooperative and fresh market (TC_k)		
Average distance to municipality center (km)	-0.025784 (0.251)	-239.6173 (0.110)
Distance to department capital (km)	0.0021942 (0.160)	
Factors influencing fixed costs (F_k)		
Number of community associations in 1985	0.0712221 (0.040)	
Institutional presence (dummy)	0.5814004 (0.039)	
Average formal education (years)	0.4408504 (0.030)	
Land tenure (percentage of farmers owning land)	0.0044131 (0.393)	
Constant		1055.27 (0.811)
Inverse mills ratio		-2381.347 (0.282)
Observed probability	0.4186047	
Predicted probability calculated at the mean	0.5610753	
Number of observations (municipalities)	43	18
Log likelihood	-13.1363	
Pseudo R^2	0.5506	
Adjusted. R^2		0.7329
Root mean square errors		3345.5

[a] In this table and in Tables 3 and 4, values in parentheses are the *p*-values, which indicate the level of significance ot the variables.

Table 3. Individual decision on the adoption of modern cassava varieties in small-farming communities participating in the Integrated Cassava Research and Development (ICRD) Project, North Coast, Colombia

	Percentage of cassava land under modern varieties (0 – 1)[a]
Percentage of farmers planting modern varieties	
Venezolana	77%
MP-12	5%
Average Cassava area with modern varieties	82%
Productive assets (Z_i)	
Farm size (ha)	-0.023093 (0.057)
Land owned (ha)	0.0248194 (0.040)
Formal education (years)	-0.0301515 (0.164)
Experience (years)	-0.0006649 (0.899)
Help for production (Z_k)	
Percentage of farmers receiving credit (%)	0.0025323 (0.416)
Percentage of farmers receiving technical assistance (%)	0.0017679 (0.445)
Transaction and opportunity costs (C_k)	
Agricultural wage (Col$ /day)	-0.0011691 (0.000)
Distance to drying plant (km)	-0.004106 (0.012)
Institutional and communitary presence (I_k)	
Institutional presence (number of technology programs)	0.7136442 (0.000)
Number of community associations in 1985	0.0006092 (0.881)
Presence of a drying plant, Pr(C≥1)	-0.0019026 (0.334)
Constant term	2.896443 (0.000)
Number of observations	481
Pseudo R^2	0.1763

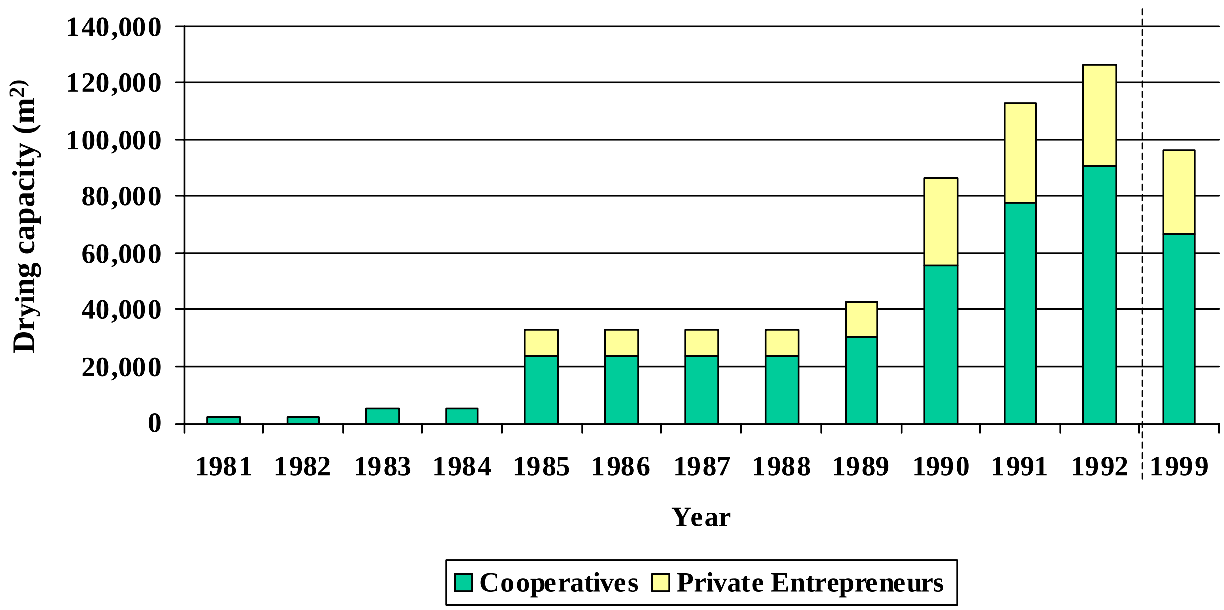
[a] See footnote a of Table 2.

Table 4. Impact of the emergence of processing plants and adoption of the modern cassava varieties on poverty reduction, in small-farming communities participating in the Integrated Cassava Research and Development (ICRD) Project, North Coast, Colombia.

	Change in Unsatisfied Basic Needs[a] (0 – 100)[b]	**Change in misery[a] (0 – 100)**
Emergence of a cooperative (Predicted Pr(C ≥ 1))	0.0075919 (0.813)	-0.03603 (0.271)
Adoption rate of modern varieties (average of predicted M_i)	-0.0786932 (0.089)	-0.12281 (0.011)
Number of community associations in 1985 (Ca)	0.0685485 (0.373)	0.061414 (0.430)
Urbanization level (Percentage of municipality population living in urban areas) (U)	0.0166886 (0.790)	0.280527 (0.000)
Distance to department capital (km)	-0.0003117 (0.980)	0.005693 (0.651)
Family size (Fa)	-1.716249 (0.064)	-2.57316 (0.008)
Constant term	2.997286 (0.697)	-6.57982 (0.400)
Number of observations	43	43
Adjusted R^2	0.0528	0.4652
Root mean square error	6.6294	6.7182

[a] All three changes represent the change in the percentage of households from 1985 to 1993 living under the conditions indicated. The unsatisfied basic needs indicator represent the poverty line.

[b] See footnote a in Table 2.



Data was obtained from the ICRD Project monitoring and evaluation system.

Figure 1. The emergence of the-cassava-drying agroindustry in the North Coast of Colombia, 1981-1992.

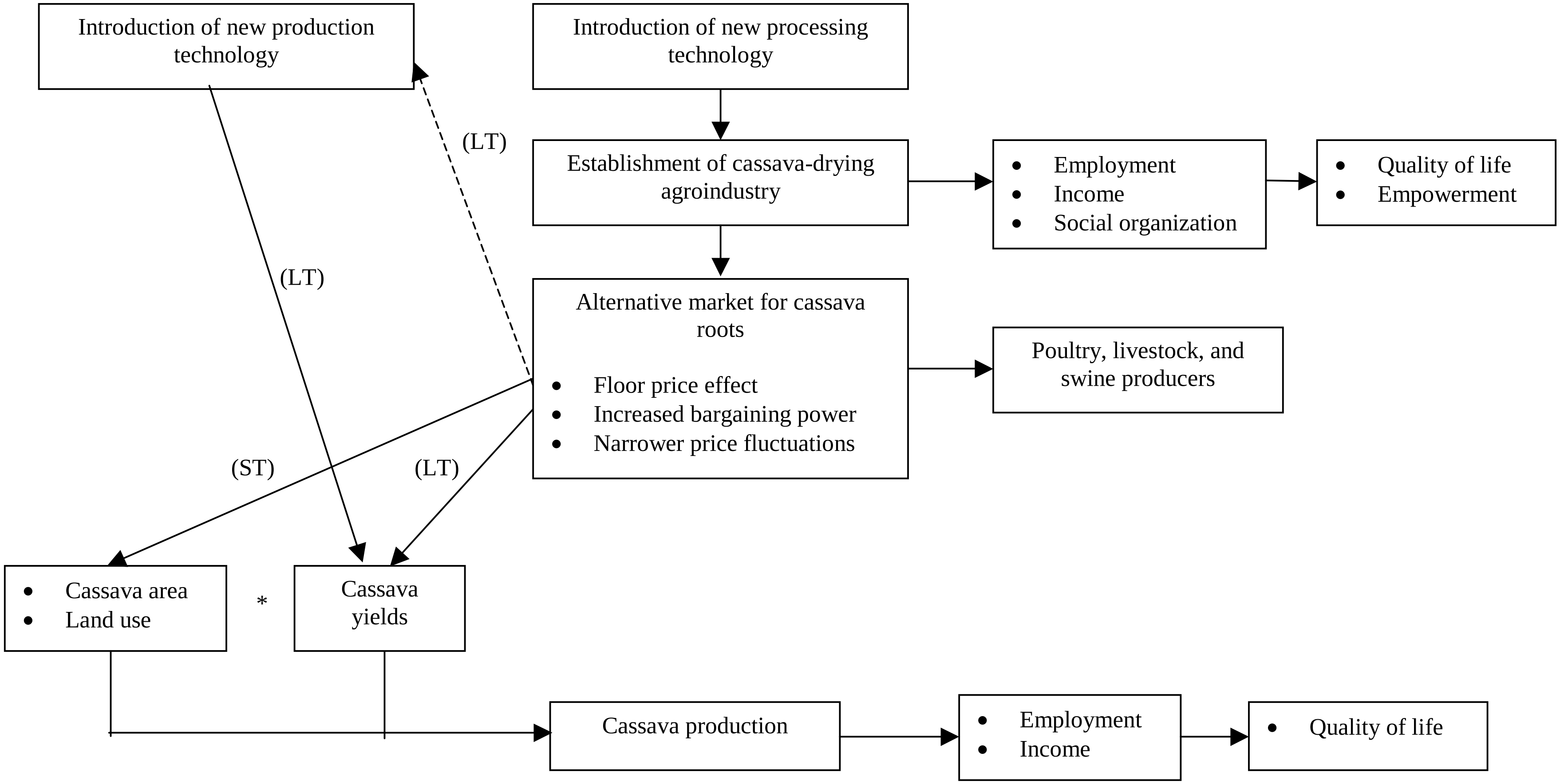


Figure 2. Conceptual framework for the expected impact of the Integrated Cassava Research and Development (ICRD) Project, North Coast, Colombia. (ST, LT = short-term and long-term effect on cassava production, respectively)

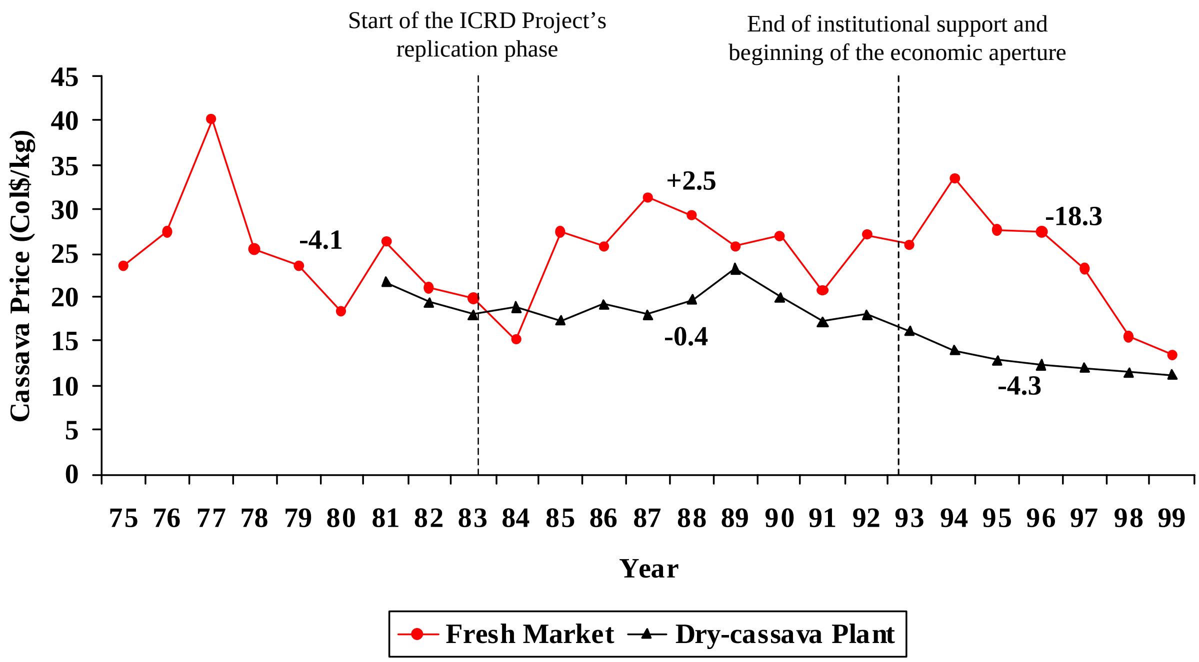


Figure 3. Trends in cassava prices to small farmers in the North Coast of Colombia, 1975-1999, showing the impact of the Integrated Cassava Research and Development (ICRD) Project (1981-1989). Prices are based on the 1990 Colombian peso. Data were obtained from the ICRD Project monitoring and evaluation system. Values in the field indicate price trends in percentages.

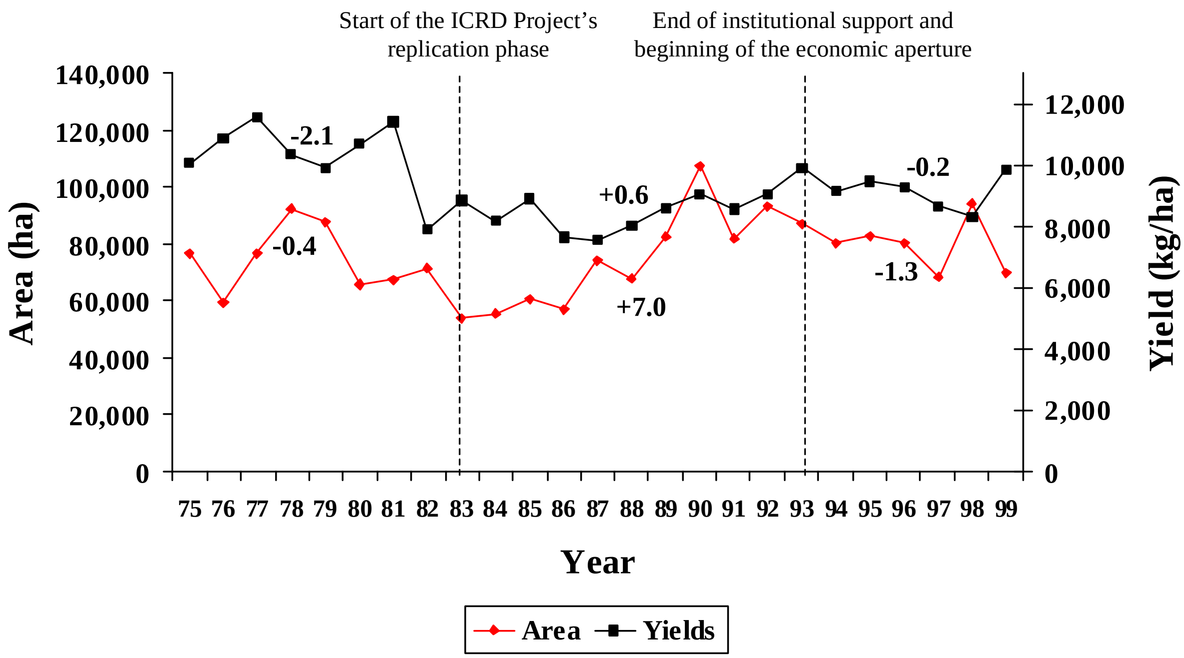


Figure 4. Trends in cassava area and yields in the North Coast of Colombia, 1975-1999, showing the impact of the Integrated Cassava Research and Development (ICRD) Project (1981-1989). Data were obtained from the Colombian Ministry of Agriculture. Values in the field indicate trends in percentages.

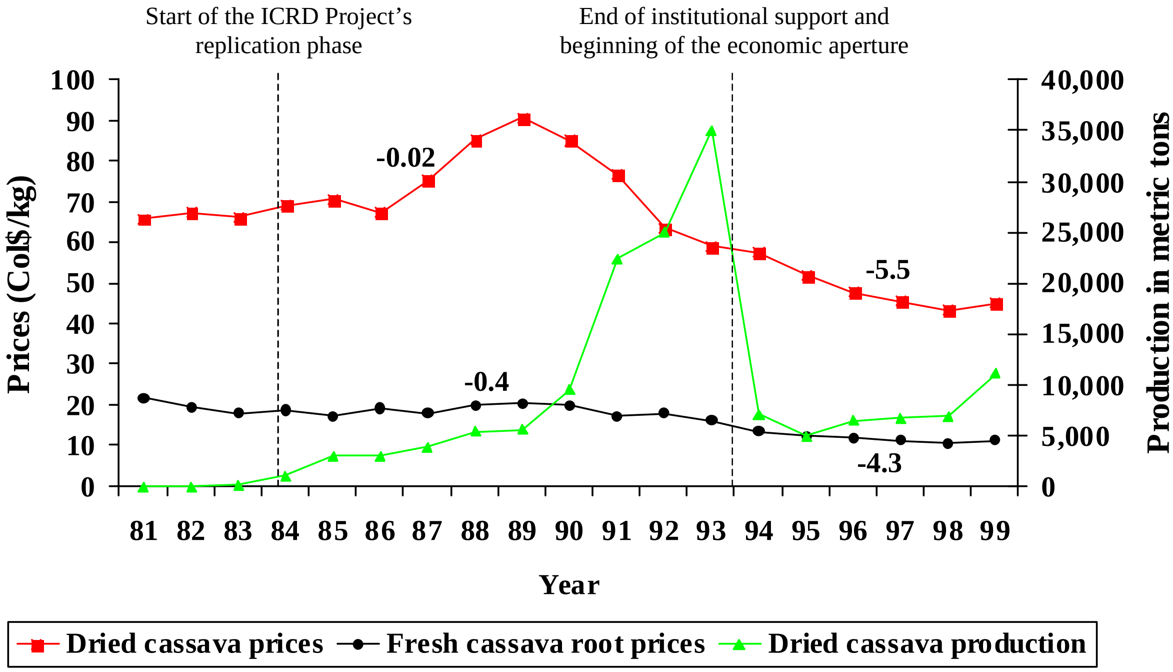


Figure 5. Trends in cassava prices and dried cassava production in the North Coast of Colombia, 1981-1999, showing the impact of opening up the country's economy to international competition (economic aperture). Prices are based on the 1990 Colombian peso.