CHAPTER 7

Twenty Years of Cassava Innovation in Colombia: Scaling Up under Different Political, Economic, and Social Environments

*María Verónica Gottret** and *Bernardo Ospina Patiño***

Introduction

Cassava (*Manihot esculenta* Crantz) is an important crop throughout the tropical world for small-scale farmers with access to marginal lands. Its high tolerance to seasonal low rainfall, high temperatures, and low to intermediate fertile soils makes it an essential source of food security and cash income in areas where few alternatives exist. This chapter analyzes 2 decades of a commodity-based innovation process that includes technological, social, and market innovations. The timely combination of this set of innovations was perhaps one of the key factors for the relative success of this process in making the cassava agri-food chain in Colombia more competitive as well as to contributing to poverty alleviation.

The analysis has been divided into three time periods:

(1) The 1980s, where an innovation process initiated by the public sector is analyzed. This period of the innovation process is called the Integrated Cassava Research and Development (ICRD) Period.
(2) The 1990s, where public support was limited to a minimum, and which has been called the Latent Period.
(3) 2000 to date, where a public-private partnership innovation process started as a response to a real demand of the private sector, and has been called the CLAYUCA Period. (CLAYUCA is the Spanish acronym for the Latin American and Caribbean Consortium to Support Cassava Research and Development.)

For each period, the political, economic, and social environment is described briefly, the problematic is defined, the proposed best-bet

* Visiting Researcher, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, and PhD Candidate, Institute of Social Sciences, The Hague, The Netherlands.
** Senior Research Fellow, CIAT, Cali, Colombia, and Executive Director, Consorcio Latinoamericano y del Caribe de Apoyo a la Investigación y Desarrollo de la Yuca (CLAYUCA), Cali, Colombia.

solutions are explained, and the roles of differentiated social actors are analyzed. This leads to determining the factors that have influenced the successes (and failures) of the intervention process in each period as well as its outcomes in terms of adoption, effect on prices and productivity, and, to the extent that is possible, its effect on income generation and its contribution to poverty alleviation.

The chapter concludes with some reflections on enabling innovation as well as on scaling out and up aimed at making a contribution to ongoing discussions on this topic.

The ICRD Period (1981-1993)

During the 1970s and 1980s, small-scale farmers of the North Coast of Colombia obtained 40% of their cropping income by marketing cassava (Janssen, 1986). The crop represented an important food source for the farmers and their families as well as an employment generator, creating about 7.3 million wage-days per year. Despite cassava's socioeconomic significance, the quick deterioration of cassava roots rendered its marketing difficult. Farmers across Latin America had limited marketing outlets for their cassava production, most of which was for on-farm consumption and sold on fresh markets. A marketing channel made up of several intermediaries ensured the supply of roots from the farm gate to the urban consumers. The short shelf life of harvested fresh roots made marketing cassava a risky business; losses were high, and fluctuations of daily price were large.

The political, economic, and social environment in the 1980s

During the 1980s, the Colombian government followed an import-substitution economic model. Production was highly protected by import taxes, making imports expensive. Thus, the market alternative identified for cassava in the early 1980s, as a feed ingredient, was dependent on this policy scheme that made cereal imports for the animal feed industry unattractive. During this period also an Integrated Rural Development Program (DRI, the Spanish acronym) was in place, with a strong public sector presence in rural areas and provided an integral support package to farmers including research, technical assistance, marketing, organization, and credit, among others. Moreover, this Colombian rural development initiative was completed with strong external donor support.

Additionally, organizational processes were already in place as a result of social struggles to secure access to land.

The challenge

In the early 1980s, the Colombian cassava market experienced particularly depressed prices, partly as a result of an intensification of

cassava production. Taking advantage of improved access to land as a result of the Land Reform Program during the 1970s, and the credit program offered through the DRI Program, cassava farmers increased their production in the late 1970s (Janssen, 1986). By 1981, cassava production was extremely high and farmers were 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 Program's basic premise that production increases would improve the income of small-scale farmers. 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 Program therefore began searching for alternative markets for cassava.

CIAT and the Cassava Program in the 1980s

During the 1980s, the International Center for Tropical Agriculture (CIAT, the Spanish acronym) had a commodity-based Cassava Program with a multidisciplinary research team. However, there was concern that, constrained by lack of markets, cassava farmers in Latin America were not adopting improved production technologies developed during the 1970s. The Center 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 mainly to European markets. After conducting economic studies, and based on an internal planning exercise, CIAT initiated an integrated approach to cassava research and development (R&D), leading to a change in approach from research only to R&D, and from research on primary production to research along the agri-food chain (Cock, 1985; Lynam and Janssen, 1988).

This new R&D approach was implemented through an ICRD methodology based on a planning process, both at the macro and micro levels, that led to a set of activities requiring a pilot phase (Best et al., 1991). In new words, this methodology aimed to facilitate a "learning selection" process (Douthwaite, 2002), leading to a commercial phase that helps scale out or promote a horizontal spread of the innovation.

The intervention: Best-bet solutions and participating social actors

For the DRI Program, also facing the challenge of finding alternative markets for cassava, CIAT was a natural partner. Thus, in 1981, an ICRD Project was started in the North Coast of Colombia that aimed to implement an integrated set of institutional, organizational, and

technological best-bet solutions designed to link small-scale cassava farmers to expanding markets, stimulate their demand for improved production technology, and improve their income and welfare.

The first best-bet solution was the establishment of an agro-industry based on drying and chipping cassava roots by adapting the processing technology that was already available in Thailand, based on previous processing technology research in Asia. This required the construction and operation of small-scale processing enterprises, owned and managed by small farmer associations. The technology brought from Asia was tested, adjusted, and diffused with small-scale farmers' participation. This low-cost and appropriate technology consisted of chipping cassava roots, which were then spread on cement floors and sun dried. The North Coast region of Colombia was chosen to elaborate the project because of the importance of the cassava crop to the region. In the early 1980s, the region grew 35% of the country's total cassava production. Moreover, the region had a high proportion of small-scale farmers, with 80% of farms of 20 ha or less representing less than 10% of the total farmland (DANE, 1974). The North Coast region featured all the characteristics desirable to develop and implement the ICRD approach.

To implement the ICRD Project, each participating institution assumed an agreed set of responsibilities in accordance with its own mandates and capacity. However, although the project was coordinated by the DRI Program, CIAT's cassava R&D team became the "product champion", and was responsible for defining the research agenda, providing the set of best-bet solutions, and inducing the innovation process.

The pilot phase. This phase was implemented during the first 3 years (1981-83) of the project, and began with a group of 15 farmers, selected from the municipality of San Juan de Betulia, Department of Sucre. A technological prototype was developed, based on the technology brought from Thailand, and adjusted to Colombian conditions. Based on this, a pilot plant was built, the processing technology was evaluated and adapted, and an operational scheme was developed for local conditions. Seven tons of dried cassava chips were produced and during the first year distributed to several animal feed industries to obtain feedback on their potential interest in buying the product, and the price they were prepared to pay. As a result, one firm committed to buy the entire production of the next cassava season.

In 1982, the pilot plant became semi-commercial, with the farmers taking full responsibility for its management. The 1982-83 period provided reliable data on the plant's operation, and consolidated the market for the product. A technological and economic feasibility study was conducted, and its positive results prompted the DRI Program to create a line of promotional credit for establishing additional drying plants. The pilot plant expanded its capacity, and was used as a demonstration and training

model for other farmer groups interested in building drying plants in their communities.

During this initial period of the project, small-scale cassava producers not only were the target group, but also participated actively as co-developers. The public sector had a strong role in planning, priority setting, funding, and on leading and controlling the project. The private sector acted as end-user of the product, provided feedback on the product quality requirements, and set up the price for the product that was pegged to the internal price of grains. Key success factors of this initial innovation process were:

(1) A pilot site that permitted an intensive involvement of farmers as co-developers, adaptors, and adopters;
(2) The pilot site was selected based on a felt need and interest, and by demand of farmers;
(3) The innovation process went through a pilot phase that gave enough time to test, learn, and adapt the set of best-bet solutions before a broader release; and
(4) Access to the technological innovation was free.

The scaling-out phase. To replicate the pilot plant to other sites in the North Coast of Colombia, an organizational prototype was developed to target small-scale farmers. For that purpose, the organization of cooperatives was proposed with an average of 25-30 members to build and operate small-scale processing enterprises owned and managed by them. At the same time, the development and validation of production technologies were intensified, and a methodology of farmer participation was incorporated into technology development. By 1989, small farmer cooperatives were managing 39 drying plants, and five plants were privately operated. As dried cassava chips production reached 5600 tons, the product had to be promoted among a larger number of buyers. The National Association of Cassava Producers and Processors (ANPPY, the Spanish acronym), an association of small-farmer cooperatives, was created and took responsibility for marketing the dried cassava chips. In 1989, the ICRD Project ended as a formal interinstitutional activity.

One hundred and thirty-eight processing plants for drying cassava were operating by 1993. 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). The rapid growth in private investment occurred between 1990 and 1993, when the technology was completely adapted to local conditions, the market already established, and the economic feasibility of the investment proved. The private entrepreneurs therefore assumed a lower risk. 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. An estimated 36% of small-scale cassava farmers in the region were selling cassava roots to the dried cassava agro-industry, and 15% of all small-scale farmers were members of a cooperative.

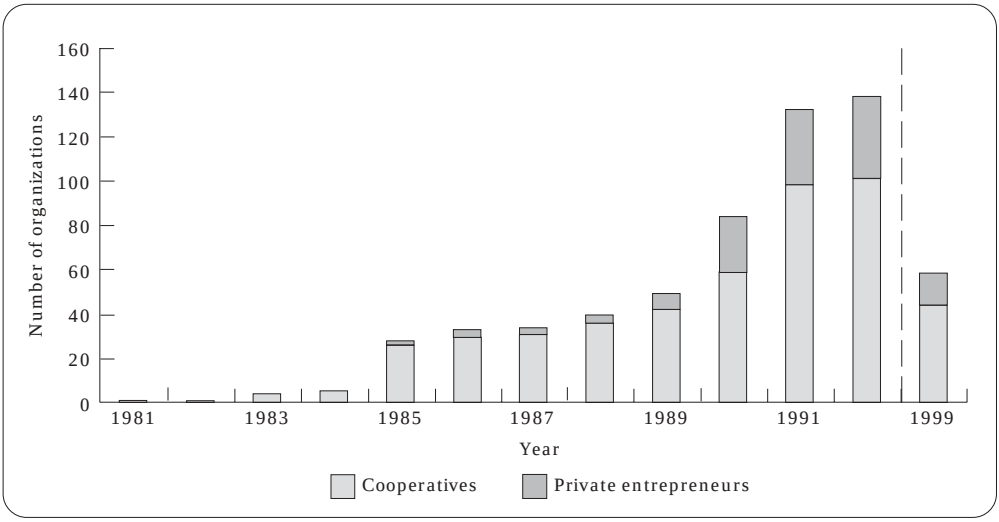

Figure 1. Emergence of the cassava-drying agro-industry in the North Coast of Colombia, 1981-1993. Data were obtained from the Integrated Cassava Research and Development [ICRD] Project monitoring and evaluation system.

Reaching the poor: Cooperative emergence analysis

Based on an econometric model developed and estimated, Gottret and Raymond (2003) concluded that cooperatives emerged in communities with higher potential production surplus, and higher social and human capital. With respect to cassava supply conditions, cassava-drying plants tended to emerge in municipalities with cassava cropping land of higher potential, and with more productive farmers. Existing local demand for cassava also had a negative impact on the establishment of cassava-drying plants. Hence, these results indicate that dry cassava agro-industries did tend to emerge in communities with higher potential cassava production and lower fresh market demand.

Human capital played an important role in the emergence of cooperatives as captured by the average education of farmers in the community. Human capital influenced the capacity that the community had for becoming organized and for asking institutional support to build a processing enterprise. Although the number of public and community associations did not influence the cooperative emergence individually, their interaction and cooperation stimulated the creation of the drying plants. Through cooperation with local associations, research and public institutions reached the targeted population more effectively by taking

advantage of the infrastructure already in place. Local associations served as intermediary for diffusion purposes of new technologies or for provision of complementary technical assistance and other types of services.

The project's target of reaching small-scale 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.

Short-term effect of the new alternative market for cassava

The development of the dried-cassava agro-industry in the Colombian North Coast 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 2, prices for fresh roots rose between 1983 and 1990 at an annual rate of 3.5%. 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, farmers had the option of selling their product to a cassava-drying plant. By linking farmers to expanding markets, the cassava market situation was improved (see Box 1).

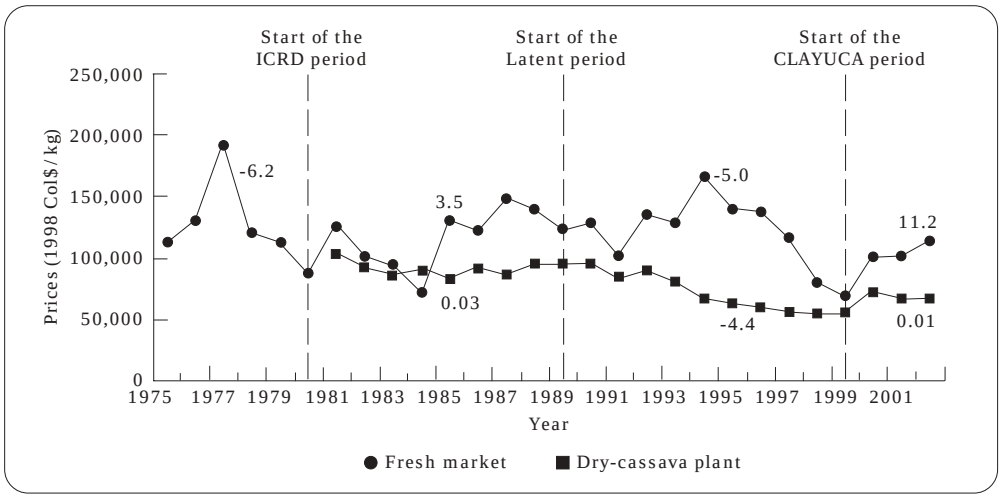

Figure 2. Trends in cassava prices in the North Coast of Colombia, 1975-2001. Prices are based on the 1990 Colombian peso. Data were obtained from the Integrated Cassava Research and Development (ICRD) project monitoring and evaluation system. Values in the field indicate price trends in percentages. (CLAYUCA = Latin American and Caribbean Consortium to Support Cassava Research and Development.)

Box 1

Comments by cassava farmers in San Juan de Betulia, Sucre, 1999

"I remember when I was child, some producers were left with their cassava...there were no markets for the product." And "... of course, it's the cooperative that has practically given life to cassava cropping in this region. Before, some years nobody would buy the cassava, there was no market, and the roots were completely lost. ...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 sell their crop to the drying plant".

Over the short term, this new market alternative created an incentive to increase the area planted to cassava. As shown in Figure 3, the area under cassava in the Colombian North Coast increased at an annual rate of 7% between 1983 and 1993. Results from a 1991 cassava-farmer survey show that about 43% of cassava farmers increased their area planted to cassava between 1983 and 1991. Of 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 cassava for yam (*Dioscorea* sp.) because of the incidence of a serious yam disease, and 5% received credit for cassava cropping (see Box 2).

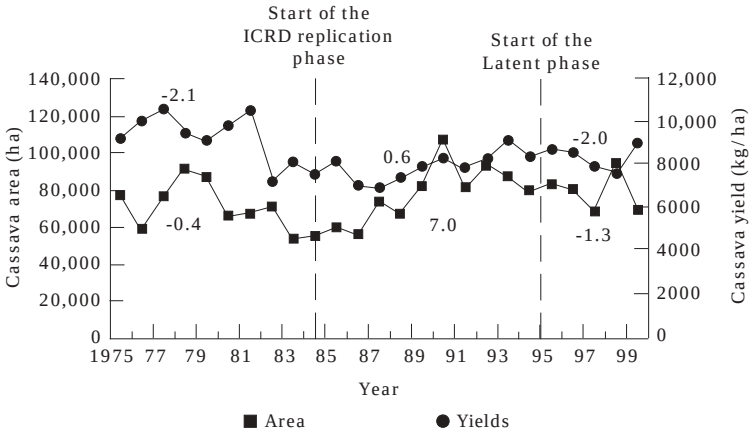

Figure 3. Trends in cassava area and yields in the North Coast of Colombia, 1975-1999. Data were obtained from the Colombian Ministry of Agriculture. Values in the field indicate trends in percentages. (ICRD = Integrated Cassava Research and Development.)

Box 2

Comment of a cassava farmer in Los Palmitos

"The construction of the drying plant was a major achievement 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 a hectare with cassava, mainly for home consumption. Now, farmers plant 2 to 3 hectares of cassava because they have a secure market. The drying plant pays members and nonmembers in cash, therefore they increase their cassava cropping area, and this means a higher income."

(Alvaro Meza, cassava farmer and cooperative associate of Sabanas de Beltrán, Los Palmitos, Sucre, 1999)

Cooperative impact on adoption

Results from Gottret and Raymond (2003) showed that, in the long term, the new agro-industry fostered the adoption of improved production technology, such as new varieties to increase cassava yields. About 77% of cassava farmers in the region adopted the variety Venezolana, and 5% the variety MP-12. On the average, cassava farmers also planted 82% of their cassava area to modern varieties. Gottret and Raymond (2003) concluded that the existence of a drying plant in the community, but more importantly, the proximity of 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 that, as discussed previously, gave farmers an incentive to increase their production by either increasing the area planted, or adopting new technology to increase yields. The other effect of the drying plant was to enhance technology diffusion in three ways. First, technological development programs found cassava-drying cooperatives to be natural partners for technology diffusion by allowing them to reach more farmers. Cassava farmer associations also fostered farmer-to-farmer networking, which was found in previous adoption studies to be a major source of technology diffusion (Henry et al., 1994). Further, a major constraint to adoption—availability of planting material—was partially overcome by the cooperatives that established seed multiplication plots.

The presence of technology development projects implemented by cassava research institutions in their municipality also influenced the adoption decision. The percentage of cassava area planted to modern varieties was therefore higher when at least one of these projects was active in the municipality.

Finally, the opportunity costs that farmers faced of working off-farm 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 for the farmer and, consequently, farmers who grew cassava mainly for on-farm consumption had fewer incentives to increase cassava yields by adopting modern varieties.

This analysis allows us to conclude that the cassava-drying agro-industry influenced the adoption of modern varieties both directly and indirectly. 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 and development projects in the communities. Therefore, the presence of institutions, and the presence of and access to drying plants, each played an important role in the adoption of modern varieties.

Making a difference for the poor

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 compared with 64% at the national level, and 55% were living in absolute poverty compared with 36% at the national level (DANE, 1985). The small-scale farmers targeted by the ICRD Project were therefore among the poorest populations of the region, already poor by national standards. Can a project like the ICRD help alleviate poverty?

Results from Gottret and Raymond (2003) showed that the ICRD Project contributed to poverty reduction. It did so, not directly through the emergence of cassava-drying cooperatives, but through the provision of new production technology and its diffusion as captured by its adoption. The higher the percentage of cassava area planted to modern varieties in a municipality, the greater was the reduction in poverty.

An economic surplus model, applied to the ICRD Project by Gottret et al (1994), which 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 US$1.6 million during the 1984-91 period (8.5% of total benefits). However, it was the indirect impact of the agro-industry on the adoption of improved cassava production technology that generated most of the economic surplus, estimated at US$18.6 million.

Beyond what these results can explain, the project had other direct impacts on poverty in the communities that built drying plants. It created employment, stabilized incomes, and the plants provided informal credit, with which farmers could buy durable goods or face health needs, and permitted the accumulation of capital goods such as cattle, which most farmers aim to own (see Box 3).

Box 3

Further comments by cassava farmers in San Juan de Betulia, Sucre, 1999

"There's been a big 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! A farmer 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..."

"... a few years ago, in my house there was no television, no 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."

Moreover, income generated from cassava cropping improved the well being of rural households (see Box 4).

Box 4

Comments of Don Carlos, cassava farmer and cooperative member of Segovia, Sampués, Sucre, 1999

"Before, our situation was critical. We only had one pair of pants each; we were all day workers. For example, we didn't eat three meals a 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 the village has a sewage system, and all of this we got with the little we earned. 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..."

In conclusion, the ICRD Project directly and indirectly reduced 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.

The Latent Period (1994-2000)

Four years after the ICRD Project officially ended, some institutional support for cassava continued in the region, but was terminated after 1993. During the 1990s, the Colombian government moved toward a neo-liberal economic system, opening the economy to international competition at the same time that developed countries maintained and even increased their subsidies to agricultural production, generating export surpluses. As a result, the Colombian government permitted massive imports of grains to attend the growing demand for raw materials for its feed industry, reaching levels of 1 million tons per year. Thus, the price of dry cassava chips that was pegged to the price of grains decreased at an annual rate of 5.5% between 1993 and 1999 (Figure 4). This situation made the cassava drying agro-industry noncompetitive. Prices of cassava roots paid by the agro-industry decreased at annual rates of 4.4%, and by the fresh market at 5.0%, between 1990 and 1999 (Figure 2). Producers responded by decreasing the area planted to cassava, and by not making any further investments to increase yields, Area planted to cassava decreased between 1993-2000 at an annual rate of 1.3%, and yields remained unchanged (Figure 3).

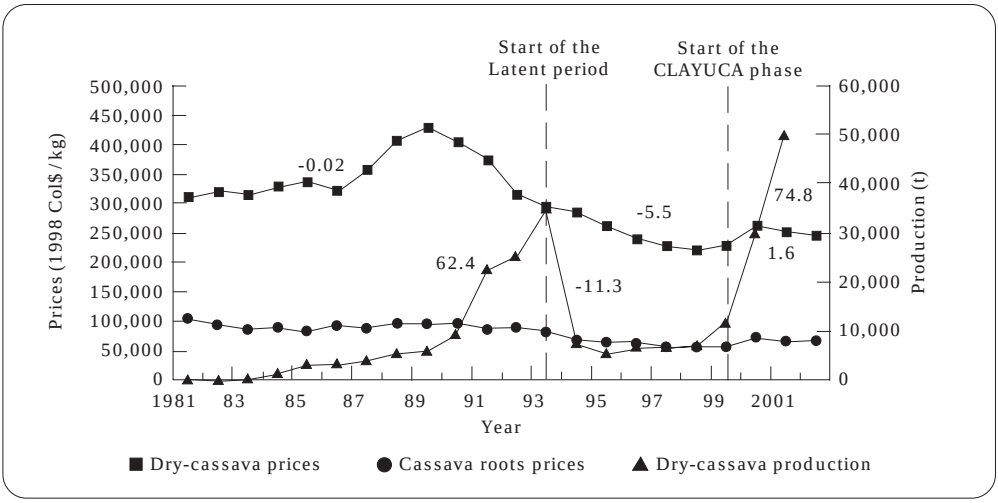

Figure 4. Trends in cassava prices and dried cassava production in the North Coast of Colombia, 1981-1999. Prices are based on the 1990 Colombian peso. (CLAYUCA is the Spanish acronym for the Latin American and Caribbean Consortium to Support Cassava Research and Development.)

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 political violence in their communities. Hence, dried cassava production dropped from 35,000 tons in 1993 to only 7,000 tons in 1994 (Figure 4).

Despite the drastic reduction in external support, some farmer groups and small entrepreneurs continued making innovations. Processing technology was kept simple, small-scale, and low investment, but simple innovations were made to reduce labor needs and decrease processing costs. The organizational innovation continued to shift from farmer cooperatives to small-scale, entrepreneur-owned agro-industries, reducing administrative costs. Also, a new market outlet was developed that targeted local poultry and pig producers with substantial reduction in transaction and transportation costs.

In 1999, even though cassava farmers had faced major shocks to the dry cassava agro-industry, 56 cassava-drying plants were still operating. Of these, 43 belong to small farmer cooperatives, although 15 rented their plant to individual entrepreneurs. Figure 5 also shows that dry cassava production increased again in the late 1990s as grain imports became more expensive because of the 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.

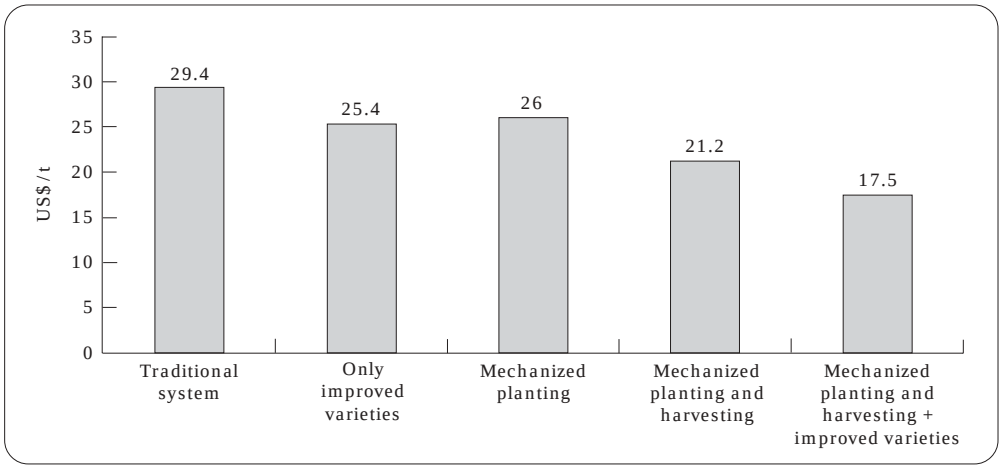

Figure 5. Cost reduction effect with different technology adoption scenarios, North Coast of Colombia, 2002 (taken from Pachico et al., 2001).

The CLAYUCA Period (2000 to date)

In the late 1990s and the beginning of the twenty first century, a new approach to cassava R&D was proposed by CIAT and collaborating institutions, in order to confront the urgent need to achieve a greater level of competitiveness in the cassava sector, without marginalizing the small-scale cassava producer from the process. This new approach, identified in this chapter as the "CLAYUCA model", has been based in the establishment of strategic alliances and partnerships between cassava farmer groups, and the private and public sectors. In 1999, CLAYUCA was formed as a regional planning and coordination mechanism for the cassava sector in the region.

Political and economic environment of Colombia from 2000 to date

During the period of establishment of CLAYUCA, some important changes had occurred in the economic environment of Colombia. With the help of massive amounts of subsidies in developed countries, prices of imported cereals were very favorable compared with prices of locally produced products. However, because of the devaluation of the Colombian currency, it became more expensive to import agricultural products, and policies to support local production of raw materials became a feasible strategy to reduce costs. The Colombian poultry industry is a good example to illustrate this situation. Despite the impressive growth rates that this sector has experienced during the last decade, with annual growth rates near 8% average, its dependency on imported cereals to be used as raw materials in the preparation of balanced feeds has increased dramatically, reaching levels of around 2 million tons per year in 2002. This increasing dependency was considered a threat for the sustainable development of the sector, and they decided to support the search for alternatives. One of the options considered was the cassava crop, a potential carbohydrate source that can be used competitively as a partial energetic substitute of cereals.

The interest of the private sector in the cassava crop was seconded by the public sector, which through the Ministry of Agriculture and Rural Development (MADR, the Spanish acronym) supported the formulation and implementation of strategic alliances with the private sector and with the participation of farmer groups. Thus, the public sector regained its importance with a new role as facilitator and co-founder of these alliances. Colombia became the original ground on which the CLAYUCA model started to form.

The public sector was seeking at the same time a more active participation in regional and bilateral trade agreements, fully convinced of the need to strengthen the competitiveness of the agricultural sector.

Cassava in Colombia from 2000 to date

At the start of the CLAYUCA period, with the renewed importance gained by the cassava crop as a multiple-uses carbohydrate source, the prices of the crop in both the fresh consumption and the industrial markets started to react positively. During the period 1999-2002, cassava prices in the fresh market in Colombia were growing at a rate of 11.2% per year, a significant increase after a decade of negative growth. Conversely, prices in the industrial market (dry cassava chips) were almost static, but were not decreasing.

The production of dry cassava chips during this period also presented a dramatic increase, with many small-scale agro-industries operating, located especially in the Atlantic Coast of Colombia, motivated by the growing demand and the increased prices. The volume of dry cassava chips produced in 2001 was estimated at 50,000 tons, an increase of 74.8% in comparison with previous years. Prices for dry cassava chips also presented a positive increase, growing at a rate of 1.6% during this period, after previous years presenting negative growth rates (Figure 4).

CIAT from 2000 to date

The changes that occurred in the macro environment and context in which CLAYUCA was formed also affected CIAT. During the late 1990s, the Center implemented a shift from its commodity-based programs to agro-ecosystem-based programs that were afterwards accompanied by an organizational restructuring from programs to a project portfolio, which in the case of the cassava crop affected the synergies and close relationships that CIAT had built with cassava-producing countries in the region. These changes meant a scattering around projects of the former multidisciplinary cassava research team as well as of their activities.

The model for cassava research used by CIAT and collaborating institutions in the region during the decades of the 1970s to 1990s was financed mainly with public sector funds. During the early 2000s, many public-sector institutions went through radical changes. Also, in the international donor community, competition for funding was stronger and among an increased number of players. Countries and institutions interested in cassava in the region felt the need to organize and form strategic alliances that could lead to the establishment of new models for financing and supporting cassava R&D activities. Catalyzing upon this felt need, CIAT proposed to cassava-producing countries in the region the formation of the CLAYUCA Consortium in April 1999.

Justification and rationale for the new model

The establishment of joint effort mechanisms between the public and the private sector to support cassava R&D activities is justified on the grounds

that it allows countries to have more control of the research agendas and the benefits obtained. The investors gain control and assume responsibilities on the agenda, which becomes a regional agenda. The Consortium acts as a mechanism that facilitates access to technology according to user demands, common interests, and prioritized problems.

CIAT does not control the definition of the agenda, but has a new role as an active participant in its definition and implementation. The public and private sector also have new roles as co-funders and co-innovators in early stages of the innovation process.

The work of the Consortium goes beyond the traditional research domain and becomes a regional forum.

The CLAYUCA institutional model

The principles upon which the CLAYUCA institutional model has been established are:

- A regional, multi-country effort: The Consortium is working as a network that promotes integration of efforts among cassava producing countries in the region.
- Organized participation of public and private sector institutions, including universities, nongovernmental organizations, and farmer groups: Opposed to the traditional model of the public sector controlling research activities at country level, the CLAYUCA approach promotes active participation of the private sector, assuming leading and coordination roles.
- Common agenda based on prioritized problems: All participants in the Consortium are allowed to include their own needs and problems. Stakeholders own the agenda.
- Collaborative, participatory planning and implementation of the agenda in each country member: Planning of activities of the Consortium in each country is autonomous; everyone participates.
- Self-financed, autonomous operation: Each country and each member has to contribute for the financial operation of the Consortium.
- Competitiveness: The cassava crop faces tremendous challenges to establish and strengthen new markets. These new market opportunities demand that crop production and processing systems be competitive.

The cassava market situation from 2000 to date

New, increasing market opportunities for the cassava crop have appeared in 2000. The poultry sector, and in general the animal production and balanced feeds sectors, have been experiencing very high growth rates throughout the 1990s. Local production of cereals and other raw materials has been insufficient to meet this market expansion, thus creating an unsatisfied demand.

The import of cereals for use in animal balanced feed has increased constantly during the last decade. In 2001, an estimated 2 million tons of maize (*Zea mays* L.) were imported into Colombia, for use in the animal balanced feeds industry. Additionally, new market opportunities were developing and strengthening for the cassava crop, around new, higher value products, especially in the fresh market, starches, and other industrial uses. When the technological innovation (dry cassava chips) was first introduced in Colombia back in the 1980s, the volume of imported cereals in the country was around 200,000 tons per year. Two decades later, this volume has increased tenfold, yet the supply of the dry cassava sector has remained almost the same. To meet these new growing demands, technological as well as organizational and institutional changes were needed. A second generation of best-bet innovations has to be put in place.

Second best-bet technological prototype: Processing

Different from the technology introduced from Thailand during the 1980s, based on large cement floors and natural solar drying technology, the option that CLAYUCA is following in Latin America and the Caribbean is based on the development of an artificial drying system, a medium-scale processing capacity of around 50 to 70 tons of fresh cassava roots per day. This technology implies a higher level of complexity, allows getting a better nutritional quality of the final product (cassava dry chips or flour), and the yearly output is also higher—5500 to 8000 tons per year depending on whether the processing plants operate under two or three shifts schemes (16 or 24 hours per day). Another very important parameter for efficiency of the processing units is the availability of supply of cassava roots on an all-year-round basis.

The difference also occurs in the size of the investment. The relation of prices needed to build one processing plant based on artificial drying technology, and one based on solar natural drying, is of around 5 to 1. For example, to produce 40,000 of dry cassava chips, 128,000 m^2 of cement floor are needed, and the total investment would be about US$3.2 million. To produce the same volume, four drying plants based on artificial technology will be needed, and the total investment would be about US$600,000.

Second best-bet technological prototype: Mechanization

Important advances have been made during the last decade on the adaptation and validation of mechanized planting and harvesting systems for cassava. In the case of planting, prototypes that allow planting efficiencies of around 1 ha per hour with three workers are now available in the market. In traditional cassava production systems, with manual planting, a total of 12 workers are needed.

In the case of harvesting, one of the activities that demands more labor force in cassava production—the use of prototypes available for semi-mechanized harvesting of the roots—greatly improves the performance of the labor force. The use of the harvesters allows efficiencies of about 800 to 1000 kg harvested per day per person, whereas in the traditional system with manual harvesting the efficiencies obtained rarely exceed 400 kg harvested per person per day.

Second best-bet technological prototype: Germplasm

CIAT has been implementing some changes in its cassava scheme aimed at generating clones specifically adapted to agro-industrial uses and to the edapho-climatic conditions of the most important cassava growing regions of Colombia. As a result, new cultivars are available with higher yielding potential. Productivities of around 20 to 30 tons per hectare are an achievable target. These improved cassava varieties are obtained more easily by farmers through projects that CIAT is implementing with financial support from MADR, and active collaboration of public institutions and private industries.

Despite the strong emphasis in the development of industrial varieties suited for new uses and processes, the efforts at CIAT for developing varieties suited to the traditional fresh markets have been maintained.

The combination of the second generation of best-bet technological prototypes and innovations has the potential to facilitate the development of lower cost, more productive, and more competitive cassava systems that could generate additional employment and income opportunities for cassava farmers.

Studies made at CIAT and CLAYUCA (Pachico et al., 2001) to estimate the cost reduction effect of using different technology adoption scenarios indicate that the costs of the traditional cassava production systems can be lowered 13.6% by the introduction of improved varieties, 11.6% by introducing mechanized sowing, and 27.9% by introducing mechanized sowing and harvesting. The net effect of the three technologies combined, could give a total reduction in cassava production costs of 40.5% (Figure 5).

Second best-bet organizational innovation

Additional to the need for a second generation of best-bet technological innovations, the new development scenarios for the cassava crop demanded innovations in the roles and the organizational scheme for the different actors of the cassava agri-food chain.

These new scenarios are based on the promotion of joint ventures between public and private sector institutions and enterprises with the

common objective of supporting cassava-based R&D activities. These partnerships do not occur overnight. A good solid initial thrust needs to be developed.

The private sector recognizes the importance of sharing responsibilities and risks in supporting and financing research activities, but at the same time, it clearly recognizes the benefits it will receive. It is also very important in securing the market.

The presence and active participation of the public sector is a very important component of these partnerships. It has a strong capillarity, and a wealth of knowledge and information about the appropriateness and adaptation of the technologies. It also plays an important role as supplier of risk funds and facilitator of the process.

Farmer groups participate as in-kind investors, contributing with their land and cassava production plots. The new partnerships allow them to gradually become co-owners of the agro-industrial enterprises. In some of the new joint venture enterprises that were being established in Colombia during 2002 (Figure 6), farmers groups were given the opportunity of acquiring shares of the agro-industrial enterprise using their lands as the main bargaining instrument. Through these arrangements, these lands will be used for the enterprise for a given number of years, and farmers will be given a proportion of the revenues. After some years, they will be given the chance to acquire the shares that belong to the public sector. The private sector, for example the poultry sector, was also participating with a percentage of the total investment.

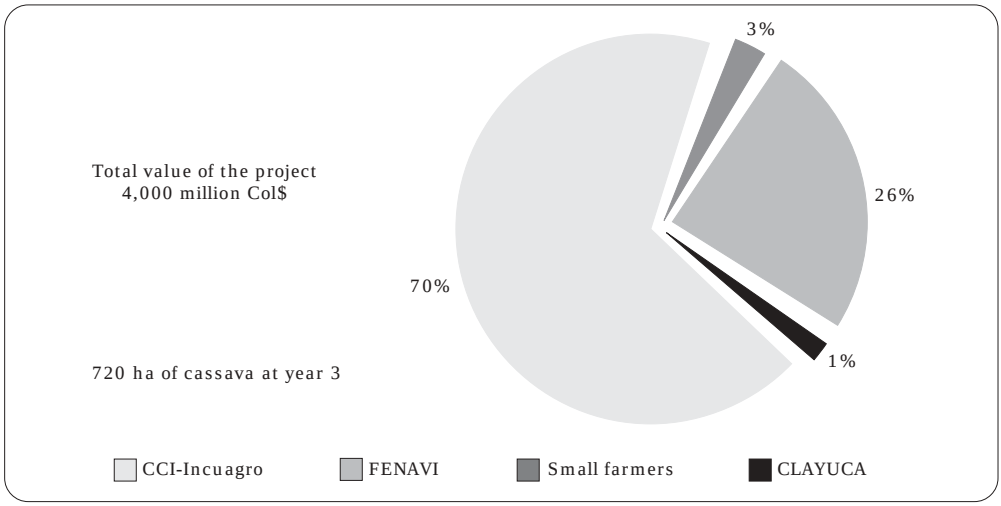

Figure 6. Second best-bet organizational innovation: An example of a joint venture organizational scheme. (From information from the Latin American and Caribbean Consortium to Support Cassava Research and Development [CLAYUCA, Revista Agricultural]; CCI = Corporación Colombia Internacional; FENAVI = Federación Nacional de Avicultores de Colombia.)

Social actors and their roles in the innovation process

The different actors also have had to learn and perform new roles in the development scenarios that have emerged for the cassava crop. The private sector now has a more active role in the definition of the priorities and the agendas. It provides financial support as co-investor, but also acts as co-innovator at early stages of the technology innovation process. One of the more important roles it performs is that of product champion, considering the strong lobbying capacity that it has to attract support from the public sector (see Box 5).

Box 5

Comments of Diego Miguel Sierra, Executive President, Colombian Poultry Growers Federation; President, Executive Committee, CLAYUCA, 2002

"We came to CIAT 5 years ago in search of its work in cassava and started the work with a seed multiplication agreement. One year later, CLAYUCA was created with the support of CIAT. The poultry production business depends highly on animal feed costs, and this year Colombia is importing 1.5 million tons of maize and 400 thousand tons of soybeans. With CIAT, CLAYUCA, and the Ministry of Agriculture, we started constructing two plants with funds from the private sector and cassava farmers. In early 2004, we expect to have dry cassava for the poultry sector. These are our immediate goals... to use tropical raw materials for the poultry sector as a competitive option, and this is becoming feasible thanks to the cooperation with CLAYUCA and CIAT."

The public sector is playing new roles in co-funding and facilitating the innovation process. The formulation and implementation of policies for the agricultural sector, for example the competitive agreements strategy, also helps consolidate public-private partnerships. During the period 1999 to 2002, in Colombia, the Ministry of Agriculture invested nearly US$1.5 million directly in cassava R&D activities. This support helped to consolidate the efforts of the private sector and the farmer groups, and to make it easier to generate the technological innovations that were required.

Farmer groups also perform new roles. Their participation is crucial as co-investors in the joint venture enterprises. They enter in the joint venture with their land, thus guaranteeing the supply of raw material for the new processing enterprises. They also work to strengthen their links with the other actors of the agri-food chain. They act as adapters and adopters of the technological innovations. Gradually, they may become owners and get full control of the processing units. They have direct participation in the Board of the processing enterprises.

For the donor community, the public-private partnerships are an attractive model to support and to mobilize resources. The fact that the model is based on competitiveness, has joint efforts from public and private sectors, and is regional, becomes very important. Also, the active participation of the farmer groups gives the donors a guarantee of addressing the more needed sectors. Finally, the participation of a Consultative Group Center facilitates the design, generation, validation, and transfer of improved, sustainable technologies.

Reflections on Enabling and Scaling Innovation

A key factor for enabling innovation effectively in the case presented has been the proper and timely combination of a set of market, organizational, and technological innovations. As has been shown in the analysis of 2 decades of cassava innovation, the political, economic, and social environment had a strong influence on enabling/disabling innovation processes as well as on the effectiveness of scaling out and up efforts. Thus, innovation-enabling strategies should be contextualized and flexible enough to be adjusted accordingly. A "champion" with a strongly felt need, genuine interest, trustworthiness, and enough lobbying capacity to mobilize resources is key for the effectiveness of the innovation process and its scaling out and up. Despite the downsizing of the public sector in most developing countries, its involvement, active participation, and commitment is key for effective scaling out and up of innovation processes. Through 2 decades of innovation in cassava, networking among farmer groups along the agri-food chain and with support organizations has been an important feature for its relative success even under different institutional models and economic, political, and social environments. Feedback and evaluation mechanisms are key for providing essential information for adjusting and refining innovation-enabling strategies, and for facilitating the establishment of a learning community.

References

Best, R.; Sarria, H.; Ospina, B. 1991. Establishing the dry-cassava agro-industry on the Atlantic Coast of Colombia. *In:* Pérez-Crespo, C.A. (ed.). Integrated cassava projects. Centro Internacional de Agricultura Tropical (CIAT), Cali, CO. p. 112-27. (Working Document no. 78)

Cock, J.H. 1985. Cassava: New potential for a neglected crop. Westview Press, Colorado, USA. 205 p.

DANE (Departamento Administrativo Nacional de Estadística). 1974. Censo Nacional Agropecuario. Santafé de Bogotá, CO.

DANE (Departamento Administrativo Nacional de Estadística). 1985. Censo Nacional. Santafé de Bogotá, CO. 13 p.

Douthwaite, B. 2002. Enabling innovation: A practical guide to understanding and fostering technological change. Zed Books, London, GB. 266 p.

Gottret, M.V.; Raymond, M. 2003. Analysis of a cassava integrated research and development approach: Has it really contributed to poverty alleviation? *In*: Mathur, S.; Pachico, D. (eds.). Agricultural research and poverty reduction: Some issues and evidence. Economics and Impact Series no. 2, Centro Internacional de Agricultura Tropical (CIAT), Cali, CO. p. 205-226.

Gottret, M.V.; Henry, G.; Mullen, J.D. 1994. Returns of the Integrated Cassava Research and Development Project in the Atlantic Coast of Colombia. Centro Internacional de Agricultura Tropical (CIAT), Cali, CO. (Unpublished working paper, available from the authors)

Henry, G.; Izquierdo, D.; Gottret, M.V. 1994. Proyecto Integrado de Yuca en la Costa Atlántica de Colombia: Adoption de tecnología. Centro Internacional de Agricultura Tropical (CIAT), Cali, CO. 79 p. (Working Document no. 139)

Janssen, W.G. 1986. Market impact on cassava's development potential in the Atlantic Coast region of Colombia. Ph.D. Thesis, Agricultural University of Wageningen, NL. 369 p.

Lynam, J.K.; Janssen, W. 1988. Methodology development for the planning and evaluation of integrated cassava development projects. Centro Internacional de Agricultura Tropical (CIAT), Cali, CO. 32 p.

Pachico, D.; Janssen, W.; Lynam, J. 1983. Ex-ante analysis of new technology: A comparison of cassava for feed and fresh markets in Colombia. Agric. Syst. 11:131-142.

Pachico, D.; Escobar, Z.; Rivas, L.; Gottret, M.V.; Pérez, S. 2001. Income and employment effects of transgenic herbicide resistant cassava in Colombia: A preliminary simulation. Paper presented at the International Conference on Agricultural Biotechnology Research, 15-18 June 2001, Ravello, IT.