

INTEGRATED CASSAVA RESEARCH AND DEVELOPMENT PROJECTS IN COLOMBIA, ECUADOR AND BRAZIL. AN OVERVIEW OF CIAT'S EXPERIENCES

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Abstract

Centro Internacional de Agricultura Tropical, CIAT's 12 year experience in developing the Integrated Cassava Research and Development Project (ICRDP) approach and methodology, is discussed in this paper. The origins, justification, methodology, results and lessons learned from this approach are presented using a comparative analysis of CIAT's experiences in Colombia, Ecuador and Brazil. ICRDP's have been an effective vehicle for CIAT's Cassava Program to interact with various national research, rural extension and development institutions. Existing production, processing and marketing technologies have been validated and adapted to specific regional conditions with the ICRDP framework. New technologies have been generated through the synergy of research and development promoted by the ICRDP. The results have demonstrated to research and development institutions, donors, governments and policy makers that cassava is a crop that can play an important role in achieving development goals. Through the integrated approach, traditional cassava markets have diversified, overall cassava demand has increased, reducing price variability while increasing yields, and as a result creating incentives for adoption of improved technologies. Additionally, income and employment opportunities of poor farmers have improved through promotion of small-scale, cassava-based rural agroindustries, with low opportunity costs especially for landless producers.



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INTRODUCTION

In 1973, when CIAT's⁴ Cassava Program became fully operational, there were few, if any, strong agricultural research programs in Latin America that were focussing attention on cassava. Research was well behind in relation to other crops, and mainly emphasized production aspects (Pérez-Crespo, 1991). The objectives of the Cassava Program during its first ten years (1973-1982) emphasized germplasm development and agronomic practices. Research results obtained during this period were encouraging, and demonstrated clearly that it was technically possible to significantly increase cassava production. However, farmers were not especially interested in adopting new cassava production technology in order to raise efficiency nor productivity. With an increasing concentration of Latin America's population in urban centers, preferences shifted away from cassava as a basic dietary staple to more easily transportable, storable and exchangeable foodstuffs. Any expansion in the utilization of cassava in Latin America was therefore dependent on the development of new products that would use or transform cassava from its fresh state to a storable or higher value product and in the development of new markets for these products (Lynam et al., 1987).

In 1979, CIAT took an innovative step by adding the Utilization Section to the Cassava Program, thus extending its responsibilities for crop research beyond development and transfer of germplasm and agronomic practices. CIAT's move was not the first to look at the industrial potential of cassava. Many earlier projects in a wide number of countries especially in Southeast Asia had involved agroindustrial transformation of cassava into meal, flour, starch, alcohol or other derived products. In Latin America, relatively few of these met with anticipated success. Some that tried to improve production ran into marketing problems. Others that invested in processing plants encountered problems with the price or availability of the raw material.

Analysis of these projects highlighted the need for an integrated approach to cassava production, processing and market development. Cassava development could not be appropriately addressed unless all three areas were simultaneously put into action in an integrated fashion. Research and development activities needed to begin at the marketplace, identifying potential markets for cassava and its products. Once identified, then product development, processing, production and commercialization should begin to develop the market effectively.

Initial activities of the Utilization Section concentrated on development of cassava root conservation technology for human fresh consumption and drying technology for the animal feed industry. Research activities on sun-dried cassava chips at CIAT were initiated not so much with the aim of introducing the product in Latin America where it was virtually

⁴ CIAT is part of the Consultative Group on International Agricultural Research and has a world mandate on research of cassava beans and tropical forages. In addition, it has a Latin American mandate for rice research.

unknown, but rather to solve an Asian problem related to poor quality of dry cassava chips and pellets produced in Thailand and Indonesia and exported to the European Economic Community for incorporation into animal feed concentrates. During the seventies world cassava trade expanded from slightly over 1 million tons in 1970 to almost 5 million tons in 1980 (Colpe, 1991), primarily as a result of the expansion and adoption of modern technology for processing, handling and storing, which facilitated the production of cassava feedstuffs that met the needs of consumers at competitive prices and with a steady supply.

Through this work, CIAT gained considerable experience in cassava drying, especially natural drying techniques similar to those utilized in Asian countries. However, it was not until 1980 that this accumulated knowledge could be applied. A series of reviews had cast doubts on the ability of the program to reach farmers with the technologies generated and to attain increased productivity. After a series of internal planning exercises focusing on specific social objectives, a new research and development framework was formulated for the Cassava Program including the need to be directly involved in cassava-based rural development programs, as a *sine qua non* condition for the development of the crop (Cock, 1988).

At the time that the Cassava Program was searching for partners and sites to test this new approach, the Colombian Ministry of Agriculture, through the Integrated Rural Development Program (DRI) was pursuing CIAT's collaboration to solve problems related to increasing production and decreasing demand and prices for cassava in an extensive area of Colombia, the North Coast. The two efforts were joined and the experiences gained in this collaborative exercise, as well as in subsequent similar projects in other countries during the last 12 years, has allowed CIAT to develop the generalized ICRDP methodology discussed in this paper. The first section of the paper analyses the justification, methodology and results obtained with this integrated approach, using examples from projects in Colombia, Ecuador and Brazil. The second section presents a comparative analysis of the case study experiences and draws out lessons learned and implications for CIAT and counterpart national institutions in the implementation of ICRDP's. The paper concludes with a proposition of future activities that are needed to consolidate the ICRDP methodology.

Importance of Cassava in Latin America

Latin American production of cassava is 21% of the world total. Brazil, Paraguay and Colombia are responsible for 92% of cassava production in this region (FAO, 1990). The crop is generally produced in more marginal rainfed areas and is grown by small farmers with limited access to land, inputs and improved technology. In the areas where cassava is grown extensively, farmers often have no alternative crops due to climate and soil limitations.

Marketing channels available for cassava growers are generally limited with one or two traditional markets per region, for products in the form of fresh roots or processed

products such as *Farinha da Mandioca* (toasted cassava flour) in Brazil. While demand for processed products may remain stable or even increase, creating shortages and high prices while societies urbanize, the overall demand for cassava tends to decline, creating price fluctuations and increasing commercialization risks. Lacking additional market opportunities for fresh cassava, farmers have no incentives to adopt improved production technologies.

Fortunately, cassava has several positive characteristics that can allow it to compete as a multiple source of carbohydrates especially when compared with other root crops on the basis of price, yield, nutritional value, quality and availability. Root dry matter content in cassava is higher than in other root crops (35-40%), giving optimum conversion rates of 2.5:1 or better. Over 85% of root dry matter consists of highly digestible starch. Cassava starch has agglutinant properties which make it suitable for pelleting in animal feeds, such as for shrimp or fish, replacing expensive artificial agglutinants (Cock, 1988).

The disadvantages of using fresh cassava roots directly in products such as animal concentrates are their bulk, rapid perishability, low protein content and the presence of cyanogens in all root tissues. By means of simple processing techniques such as *chipping* and natural drying, the disadvantages related to bulk and rapid perishability can be overcome. Sun drying also permits the elimination of most of the cyanogens from root tissues. The disadvantage of cassava's low protein content can be addressed by increasing its price competitiveness with other carbohydrate sources and by differentiating the uses of its high quality carbohydrate structure and composition.

Linkage of small-scale cassava farmers to potential growth markets via new processing technology and new product development is an important option that can help to meet several social policy objectives such as income generation among marginal farmers and landless poor (Lynam, 1987). However, it does not occur spontaneously. Penetration of alternative markets by cassava will generally require competitive farm-level prices, investment in processing capacity and management and a coordinated expansion in production, processing and utilization. All these activities must be phased in a coordinated manner, within an integrated project framework.

During the last 12 years, the Cassava Program of CIAT has been gaining experiences in the development of these project approach methodologies aimed at coordinating changes in farming systems with changes in the marketing system, within the framework of multi-institutional integration. This work has resulted in the formulation of a generalizable methodology (ICRDP).

INTEGRATED CASSAVA RESEARCH AND DEVELOPMENT PROJECTS (ICRDPs).

Definition. The ICRDPs are defined as an institutional, technological, social and organizational intervention designated to link small-scale cassava farmers to new or improved growth markets, thus stimulating demand for production technology with potential to improve small farmers welfare.

Methodology. The ICRDP methodology consists of four stages which should be phased sequentially in order to achieve success (Fig.1). A brief description of each phase follows:

Macroplanning. This planning stage analyzes the overall economic situation of the country or region initially targeted for an ICRDP. Potential demand for cassava and derived products, the ability of the crop to compete with other products and markets as well as the potential for cassava production in different regions is considered. Information gathered in this phase ensures that the correct target region and the most promising markets are selected

Microplanning. In this stage, information is generated to define market characteristics, production practices and constraints, availability of institutional support, existing farmers organizations, cassava processing technologies, and regional government development priorities. The end result of this phase is selection of the target area for implementation of the pilot project.

Pilot phase. During this stage available technologies can be entirely reworked and adapted to local conditions. The institutional and organizational framework of the project is determined and serves as the point of intersection between cassava production, processing, and product development research. Farmer organizations are included from this stage forward and become permanent actors and decision makers of the project. At the end of the pilot stage, sufficient reliable information is available to test the assumptions made during the planning stages. The full-scale commercial phase of the ICRDP is then justified or rejected.

Commercial expansion phase. Replication or expansion of the use of the cassava processing technology and the new or improved products can now be implemented based on experience gained during the pilot project stage. Commercial costs of the new technology and the resources required to promote its adoption on a wider scale can now be calculated including credit lines for crop production, establishment of processing capacity and operational capital, and institutional requirements for training and technical assistance activities for farmers. During the initial activities of the commercial phase a monitoring system should be established, building on the information gathering mechanisms initiated during the pilot stage. Finally, it must be remembered that the project framework is not a permanent mechanism per se and the end result of this stage should be a self-supporting, economically sustainable cassava-based agroindustry.

Anticipated outcomes. The anticipated outcomes of the ICRDPs were:

- **The involvement** of national research, extension and development agencies in a concerted effort to improve small-farmer welfare through activities focused on cassava
- **The development** of cassava processing, and product markets as income-generating activities

● The creation of demand for improved cassava production technology

Experiences and results. CIAT has joined efforts with national counterpart agencies to initiate ICRDPs in nine Latin American countries (Tab.1).

These projects have included different products, markets and processing technologies and have attained different stages of development. In two countries, Mexico and Peru, the projects were not successful. In Mexico, lack of strong farmer commitment and involvement from project onset and lack of coordination between production, processing and commercialization activities were identified as the main reasons behind the failure. In the case of the Peruvian project, long distance of the target area from the markets and strong competition with another more profitable agrochemical enterprise, cocaine processing, made the cassava-based project economically non-viable.

To review the lessons and implications of CIAT's experiences with the cassava integrated projects we will now concentrate the discussion on three countries: Colombia, Ecuador and Brazil. Each country case example or "snapshot" presents the main aspects and results of the ICRDP. This is followed by a comparative analysis across cases. In all three projects, the CIAT Cassava Program, through special funding managed to have staff members directly involved in their implementation.

THE COLOMBIAN INTEGRATED CASSAVA RESEARCH AND DEVELOPMENT PROJECT

The North Coast of Colombia is one of the most important cassava production zones of the country accounting in 1990 for 52% of total cassava production and representing 13% of total land under cultivation and 20% of the total value of agricultural production of the region (Ministerio de Agricultura, 1991). According to Janssen (1986), 40% of the total small-farmer income from agricultural production in this area is derived from cassava cultivation. On-farm consumption and fresh cassava sold to urban markets have been traditionally the two main commercialization outlets for the cassava crop in the region although some typical processed cassava-based products for human consumption also account for a small share of the cassava market. Industrial uses of the cassava market have been virtually non-existent in the region

During the last part of the seventies, the Colombian government sponsored Integrated Rural Development (DRI) program was already promoting the cassava crop as an agricultural policy option in the Atlantic Coast providing credit and technical assistance to increase cassava production. This traditional production oriented approach was relatively successful and cassava production increased rapidly due primarily to the effect that increased credit availability had on intensification of production by farmers beneficiaries of the DRI program. This period of rapid growth in production caused saturation in cassava local markets and prices dropped to such levels that farmers were unable to find buyers for the crop and

recover their costs. To resolve this problem, a post harvest committee was set up by the DRI program which then contacted CIAT for help in finding alternative markets for the cassava production of the region. At the same time, the Cassava Program of CIAT, with studies that were clearly showing the existence of a large and expanding market for animal feed in Colombia was analyzing the possibility of using dried cassava in animal feed rations. The two efforts were then integrated so as to assess the possibilities of entering into these alternative markets.

Among the various possibilities analyzed, the most promising appeared to be the establishment of cassava-based producer organizations to operate cassava drying plants and sell the dried cassava to animal feed factories. CIAT has already accumulated know-how in the cassava chipping and drying technology which was brought from Asia and the approach chosen appeared attractive because firstly, the resource poor farmers in the area could not afford individually to establish cassava processing infrastructures whereas as a farmer organization they could do so. Secondly, the cassava drying process was proposed as an instrument to create an effective floor price for cassava roots, so that if prices in the fresh market were high, farmers could sell into these markets and make enough profits to pay off loans on the cassava drying plants. Additionally, roots unsuitable for the fresh market could be sold to the drying plants, allowing them to operate at low level. Conversely, if the prices for cassava roots dropped farmers could sell the roots to the drying plants and still make a profit. To test the validity of this model through a pilot project the first farmers-operated cassava natural drying plant was established in the municipality of Betulia, State of Sucre, in 1981.

Colombian farmers, in spite of their total lack of experience and tradition in cassava processing activities, quickly adapted and assimilated the technology. Initial promising results were then used as the basis to formulate expansion of the project which underwent two additional phases, the semi-commercial (1981-83) and the replication or commercial (1984 to present). In 1991, approximately 150 cassava drying plants were in operation in the North Coast of Colombia (Fig.2), 105 of which were owned and operated by small-scale, cassava producer associations and/or cooperatives, and the remainder 45 plants were exploited by private entrepreneurs which during the period 1987-91 were greatly increasing their participation in the industry. This data is estimated since it is no longer possible to keep accurate accounts through monitoring activities due to the fast, widespread and diverse types of cassava drying adoption in the region (Henry, 1992) During 1991, these 150 drying plants produced approximately 25,000 MT of dry cassava chips, corresponding to 62,500 MT of cassava roots, a demand that represented 6.6% of total cassava produced in the region in this year and accounted for 5.7% of total cassava area planted. Project activities rapidly lead to penetrating the Colombian animal feed market with dry cassava chips. Throughout the span of the project, cassava producers and processors received important institutional support, especially credit lines, technical assistance and training. Important results were also obtained in the area of improved cassava production technology. The impact of the Colombian integrated research and development project can be best assessed considering the additional monetary value of the annual production of dry cassava,

the savings in foreign exchange due to decreased imports of cereals for animal feeding, the additional employment opportunities generated in rural areas through the expansion of cassava production and processing activities and the enhanced forward and backward linkages with goods sectors and services.

Estimates made by the Economics Section of CIAT's Cassava Program (Gottret and Henry, 1992) calculated that during the period 1984-1991, the cassava sector in Northern Colombia benefitted by almost US\$ 22 million when research to improve cassava crop management was integrated with research on its processing, marketing, and consumer preferences, within the framework of cassava-based development projects with strong farmer participation. In addition, studies (Gottret & Henry, 1992) have shown evidence that cassava production technology components adoption in areas with ICRDP activities are significantly higher than in the areas that were not influenced by the project. For example, cassava variety Venezolana was adopted in 1991 by 93% of cassava producers in areas with cassava drying activities and strong institutional presence, whereas in the areas that were not directly influenced by the ICRDP activities, only 48% of the cassava producers adopted this variety (Gottret & Henry, 1992).

Overall, the main lesson of the Colombian project was the demonstration that farmers, when allowed and facilitated to participate in research and problem-solving concerning their current problems and needs, become important partners for Research and Development institutions and make valuable contributions to the identification, adaptation and evaluation of alternative solutions. Moreover, an original hypothesis of the ICRDP model was validated: that the integrated project approach which creates new markets and better prices for cassava will increase farmers' incentives to adopt improved production technologies. The project demonstrated that small farmer associations are indeed a viable mechanism or vehicle for technology diffusion.

THE ECUADORIAN INTEGRATED CASSAVA RESEARCH AND DEVELOPMENT PROJECT

Initiated in 1985, the Ecuadorian ICRDP, represented from the onset a challenge for CIAT, in the sense that the Colombian project, as successful as it has been, demanded very high institutional costs and there was a need to replicate these experiences at lower institutional costs. The project in Ecuador was conceived as both a social and technical experiment, requiring specific institutional and organizational arrangements and allowing new roles to be played by farmer organizations, farmer promoters and national research and extension staff at field level (CIAT, October 1982).

The project in Ecuador was implemented in a traditional, cassava processing area in the seasonally dry Coastal Manabí Province, a region estimated to account for 20-30% of total national cassava production (MAG, 1990). In Manabí, small farmer households have extracted cassava starch for over 100 years with little change in the processing technology. Despite the fact that early studies had already identified the potential of cassava drying

technologies as a viable alternative for promoting alternative users and markets for the crop, it was not until 1985 that conditions became economically favorable to launch the integrated cassava project in Manabí.

Climatic conditions favorable for cassava processing and sun-drying, excess cassava production and the predominance of small farm population characterized the region as "optimal" for the project. Farmers were organized into small producer-processor associations called APPYs (Asociaciones de Productores y Procesadores de Yuca) and from the start, these associations were joined in a 2nd order farmer organization called a Union or UAPPY (Union de Asociaciones de Productores y Procesadores de Yuca). The UAPPY changed to UATAPPY in 1992 when it changed its legal status to admit associations of rural workers or ATAPYs. This change allowed legal participation by small farmers lacking title to their lands and by landless rural workers such as women who could easily benefit from processing-generated jobs. Begun as a marketing committee, the Union now includes 17 associations and performs a variety of functions including technical assistance, credit, marketing, accounting, training, product development and monitoring. Farmers meet annually as stockholders to evaluate their progress and make recommendations to UATAPPY leaders and other project collaborators.

A participatory approach to technology generation, adaptation and dissemination was adopted from the beginning. Colombian farmer-processors were brought to Ecuador to teach Manabí farmers the new chipping and drying technology. These farmer-to-farmer contacts were later reinforced with visits to Colombia from Manabí farmers who were able to see in action technical, organizational and operational features of the Colombian cassava processing plants. From the start, farmer processors played an important role as promoters, technology transfer agents, teachers and leaders of the project. CIAT and local agencies staff joined and supported farmers efforts as partners and collaborators. Basic chipping technology was the same as in Colombia. Drying trays, a technology suggested by CIAT, was quickly adopted as an intermediate step towards building a cement drying floor. Trays allowed poorer farmer groups to get started quickly with less initial investment costs. Later on, profits earned could be used to build the concrete drying infrastructure.

Project leaders and CIAT researchers assumed that the end market for dried cassava in Ecuador would be the same as that in Colombia- the balanced feeds industry for poultry and livestock. Early in the project, serendipitously, it was discovered that cassava was an ideal substitute for imported chemical agglutinants for the feed pellets used by the Ecuadorian shrimp industry. The scale of this industry in Ecuador was such that demand for cassava flour could be of over 8,000 MT/year. This market was very attractive for farmers and expansion of processing associations was stimulated growing rapidly from 2 to 16 during the period 1985 to 1988.

Transforming dried cassava chips to flour for shrimp feed required new steps in the processing technology, because the roots had to be peeled before drying, as well as a different management system in which the associations produced dried chips and sold then

to the Union. Peeling soon became an important source of additional income for member and nonmember families, mostly poor women, children and elderly people, usually without additional sources of income during the dry season. The Union was forced to develop milling capacity and management utilizing portable hammer mills to grind the dried chips into flour. This process catalyzed the idea of developing a Union-owned and administrated "Demonstration Center" where new cassava processing technologies could be designed, adapted and tested, and training and demonstration events for farmers could be held. In 1993 the Demonstration Center name was changed to "Planta Central", due to increasing transformation, storage and transshipment activities. Training and research activities were shifted to some extent to specific farmer associations enhancing more participation.

In 1989, the shrimp industry in Ecuador slumped and the bottom fell out of this market for the Union. Strong competition from Asian producers and problems with a shortage of larvae ponds cut shrimp production overnight eliminating 95% of the demand for cassava flour. The Union reacted quickly launching an all-out campaign to identify other markets for cassava flour. The demonstration center allowed farmers to rapidly adapt existing products for new markets. For example, the whole-root cassava flour was refined by passing it through a mechanical vibrating sifter, a process yielding a flour of the same granular size as wheat flour. This refined cassava flour started to be used as a substitute for wheat in the fillers for resins used for making plywood, thus capturing an important share of this market. Additionally, bran, a by-product from sifting, was sold as a source of fiber to the livestock feed industries. In 1989, farmers, collaborating institutions and CIAT learned a valuable lesson about the importance of diversifying products and markets. Since then, the Union markets and products portfolio continued to diversify. Today, seven different primary products and 4 byproducts are produced and sold to seven different market sectors (Table 2) reaching over 40 different buyers.

The growth of the Ecuadorian cassava project has not been in the number of processing organizations but rather in size operation. Initially fueled by the existence of strong market demand and reasonable funding for construction and operational credit, expansion of the processing associations was very rapid growing from 2 to 16 during the period 1985 to 1988. By the end of 1988, a combination of scarcity of donor funds for construction and a rapidly increasing inflation made it much more difficult for the Union to promote the formation of new associations. In 1992, there were 17 associations in Manabí with a total of 320 members (Fig 3).

A major difference of the Ecuadorian ICRDP compared to other ICRDPs has been the role of the UATAPPY as an agent of its members growth and development. Project functions normally assigned to supporting state institutions or NGOs have been managed and often carried out by the UATAPPY, including the handling of development funds. This has served to strengthen and promote sustainability in a type of project where state institutions and NGOs terminate their support when project funds run out.

Another unique characteristic of the Ecuadorian project as compared with Colombian experience has been the more direct and active participation of women, from the start, in the Union and in all project activities, as producers, processors and managers. Today, there are three kinds of processing associations, all men, mixed and women's groups. Women comprises nearly 33% of total membership.

The UAPPY experience with the integrated cassava project over the past years has fully validated three guiding principles which can be considered as the culture of project participants and the criteria for good collaboration among participants:

- The transfer of technical and social technology is more rapid, efficient and effective when end-users are directly involved and responsible.
- Farmers organizations are effective intermediary agents between farmers and institutions and can be used as an efficient channel for project services, credit and information dissemination. Experiences and learning accumulated by the farmer organization in this process contribute to the growth, maturity and ultimate sustainability of the farmer group.
- Farmer organizations—not merely as recipients of project benefits but as active participants with farmers "owning" their research agenda— should be part of the institutional strategy of an ICRDP. Collaboration between farmer organizations and supporting institutions in an ICRDP should be encouraged without creating relations of dependence among them.

THE INTEGRATED CASSAVA RESEARCH AND DEVELOPMENT PROJECT IN THE STATE OF CEARA, NORTHEAST BRAZIL

In 1989, after considerable planning and negotiation, the W.K.Kellogg Foundation finally approved a three-year grant (1989-1992) to CIAT and collaborating Brazilian agricultural research and technical assistance institutions, and farmer organizations. The overall objective of the grant was to support the introduction of improved cassava production and processing technologies and appropriate organizational schemes, for institutions and farmer groups, throughout the main cassava growing areas of the State of Ceara, Northeast Brazil.

In this region, an estimated 110,000 ha of cassava are harvested yearly with a total output of near 1.2 million MT of cassava roots. For centuries, the main commercialization outlet for this production has been the *casas de farinha*, a communal-type, small-scale processing unit utilized to process cassava roots into a flour or meal called *farinha de mandioca*, a basic staple product, especially in the rural sectors of Northeast Brazil. In the Brazilian state of Ceara, it has been estimated that there are more than 14,000 *casas de*

contrast with the situation before the project, when processing of cassava roots into cassava flour was the main commercialization outlet. Farmers participating in the project are now starting to adopt the new processing technology and the new market has stimulated them to transform their cassava utilization patterns, becoming more market oriented. Additionally, qualitative information available regarding direct impact on community welfare, institutional support and the general environment indicate that the pilot project served as a vehicle to increase community development in general (organization, knowledge, employment opportunities, incomes), and to strengthen local institutional support (technical assistance, working capital). It was also observed that project impacts on cassava production and productivity were affected adversely due to lack of opportunities for farmers to purchase or rent additional land and that the adoption of improved production technology was taking place slowly among project beneficiaries.

The Ceara ICRDP proved that the promotion of small-scale, cassava-based farmer organization is an attractive proposal for cassava producers, who rapidly started building their organization. The initial task of these groups was to improve their commercialization schemes, and early success indicates that there is potential for consolidating their organizations through stronger institutional commitment to support farmer organizational efforts. The cassava-based agroindustries that were able to operate during the project contributed to create additional employment opportunities, opened alternative markets, stimulated local industry, raised farmer incomes, and encouraged overall community development. A second phase has now been proposed (and funds are being identified) to try to consolidate the results obtained during the pilot project as well as to demonstrate these technologies and results to other regions and farmer groups.

BENEFITS AND BENEFICIARIES OF THE ICRDPs

Benefits generated by the ICRDPs are captured principally by farmers members of the cassava-based agroindustries (Gottret & Henry, 1993). Members have the possibility of receiving four types of benefits from: (a) the availability of a new market for their cassava roots at a more stable price, (b) additional employment (and training) opportunities in the cassava processing agroindustries, (c) value-adding second rate cassava roots that before introduction of cassava processing, didn't have any market value and were basically written off, and (d) the annual share of profits generated by the cassava-based farmer organizations. This last type of benefit is only available to organization members whereas benefits (a), (b) and (c) apply to any member of the larger community within which the agroindustry operates.

During the three years covered by the project in the State of Ceara, Brazil, the total incomes gained by farmers members of the cassava processing groups reached US\$ 163,689 of which 37.3% corresponded to sales of cassava roots, 10% to processing wages and 52.7% came from sharing of annual profits (Fig 5). An additional source of benefits generated by the project was captured by non-members of the agroindustries who were

responsible for selling 61.6% of the 7,080 MT of cassava roots that were processed during the project. In the case of the Ecuadorian project, annual average income earned by farmers members of the cassava-based agroindustries during a six-years period was US\$ 225 whereas non-members gained US\$ 89 (Fig 6).

Regarding direct economic benefits, for the Colombian ICRDP it was estimated (Gottret & Henry, 1993) that near three-quarters (US\$ 16.2 million) of total project benefits accrued to cassava farmers (producers and processors). However, considerable indirect benefits have also been generated. Backward linkages to several small industries supplying materials for the construction and operation of the drying plants. Forward linkages include especially the income generating effect from increased rural incomes. This will have a multiplier effect to the extent that increased rural demand for goods and services will boost urban manufacturing. As such, rural agro-industries have an important positive effect on overall economic development.

ICRDPs also represent an important source of benefits for groups such as women and landless farmers who usually tend to be marginalized from the main benefits of the projects. For example, in the case of the Ecuadorian project, US\$ 15,000 was paid in 1990-91 for peeling cassava roots and 80% of this sum went to poor, non-member women and children who peel cassava as their sole off-farm income. In the 1991-92 processing season this even increased to 90%. In Brazil, distribution of total incomes gained by farmers during the 3-years pilot project in Ceara indicates that 58.9% was gained by smallholders, 32.4% by renters and that sharecroppers received 8.7%. Besides the economic benefits received by farmers (members and non-members) participating in the ICRDPs, there are other important benefits that are obtained by the larger community within which the cassava-based agroindustries operate. Among these it could be mentioned: easier access to credit programs and training opportunities, integration of institutional presence and strengthening of community spirit. Increases in local income during the dry season have resulted in increased purchases of food stuffs and other items from local shops in rural communities, stimulating local economic growth. In some Manabí communities, the cassava processing activity has decreased out migration of men to other coastal regions to work in the banana industry. Additionally, the cassava processing infrastructure can be used for other commercial and cultural activities. For example, in Ecuador, cassava drying patios are rented to dry other products (maize, castor beans, cacao, rice). Associations hold community "fiestas", charging entry to earn money. The drying patios make excellent dance floors! In several communities, the cassava-based associations have motivated the creation of day-care centers, and road/bridge building sponsored with government funds. In Ceara, the wives of ICRDP members have started small poultry fattening operations next to cassava drying floors as their own activity to generate complimentary income.

TYPES OF INSTITUTIONS AND FUNCTIONS IN ICRDPs

The integrated nature of the ICRDPs, in which different activities have to be developed simultaneously (production, processing, marketing, organization, training, monitoring, etc.) as well as the fact that the projects are based on farmer organizations, generates demand for substantial institutional resources and coordinating mechanisms between the different institutions involved. The organization structure of any ICRDP must include enough flexibility and adaptability so as to incorporate different farmer organization schemes and different institutional configurations. Table 3 shows the range of institutions that are currently participating in the projects in Colombia, Ecuador and Brazil and the different functions performed by each.

It is important to note that in the Brazilian case, state level public institutions played leading roles, while farmer second-order organizations have been slow to form. In Colombia, the second-order organization leads commercialisation activities and some large-scale input buying. However, few further activities are coordinated (like research). In Ecuador, a wide range of institutions have played a multitude of roles, but the UATAPPY has been a key player for virtually all ICRDP functions. This demonstrates the different institutional roles that different ICRDPs have played.

RECOMMENDATIONS FOR SUCCESSFUL IMPLEMENTATION OF ICRDPs (LESSONS LEARNED)

The ICRDPs that are now underway in several countries of Latin America have provided a dynamic framework within which CIAT's Cassava Program has been interacting with various national institutions, be they research or development oriented, as well as with farmer groups. This interaction has facilitated the validation and adaptation of existing production and post-harvest technology together with the techniques that have been developed for market analysis. It is hoped that these generalized methodologies for implementation of ICRDPs will be adaptable to different economic conditions, farming systems, institutional capacities and markets. Based on the experiences that CIAT's Cassava Program has built up over the past years, some critical factors have been identified which need to be addressed if successful implementation of ICRDPs is to be achieved. These critical factors could be summarized as follows:

- **PRODUCT AND MARKET DEVELOPMENT.** Up to now, the ICRDPs have depended on a reduced number of market outlets for cassava which include the traditional market (human consumption) and a new market (animal feed). Recently, the ICRDPs have begun to diversify considerably, based on both the consolidation of the markets for existing cassava products and the creation of new products for new markets. New industrial markets have been identified and new products have been developed. This in turn has forced to increase attention to improve market financial management and quality control. The long term viability of the model will depend on the ability of the farmer processing

organizations to move their products into a wider range of markets or to develop a broader range of end uses for the product, especially those that can offer a high margin of profitability (added value). This not only applies to cassava but to other commodities produced by farmer organizations.

● **CROP PRODUCTION TECHNOLOGY RESEARCH.** The development and adoption of cassava production systems that will sustain or increase productivity and reduce cost is critical for the success of the ICRDPs. To maintain the competitiveness of cassava may require the introduction of more intensive farm practices which could place greater pressure on the natural resource base. Research and development on suitable production systems needs to be initiated, continued and strengthened. This will require the introduction of adapted genetic materials and a careful exploration of additional alternatives for soil fertility maintenance and enhancement and the adaptation of ecologically sound crop protection practices. These activities will improve the farmers' chance to increase the productivity of their cassava-based farming systems through better, sustainable and appropriate land management systems. Sufficient evidence now exists proving that small-scale cassava-based farmer organizations can function as efficient and effective enterprises and, as a result, as vehicles for production technology adaptation and transfer. The challenge is to make them as efficient and dynamic as private sector enterprises.

● **INTERINSTITUTIONAL ORGANIZATION**

Institutions. Interinstitutional organization is important to bring together the expertise required to support the farmer organizations in the different areas and activities included in the ICRDPs. At their inception, these projects involve diverse activities, beyond the scope of any single institution. The inter-institutional coordination mechanisms required by an ICRDP are usually new to local implementing organizations and will require a period of adjustment until they can function appropriately and efficiently. It is wise and important to designate one institution as "coordinator" among the rest and to allocate sufficient funds for conducting coordinating activities. In summary, inter-institutional organization, in order to be successful must include at least three components: (1) identification of a coordinating institution, (2) agreement on the necessary functions of each participating institution, and (3) development of coordinating mechanisms at project, regional and national levels.

Farmer groups vs organizations vs enterprises. The promotion of small-scale, cassava-based organizations has shown to be an attractive proposal for cassava producers who rapidly start to build their organizations. However, first order farmer organizations have been shown to be exceptionally weak in the areas of business management and administration. Suitable instruments and methodologies for improving these skills are not always available, and if they are available their use is often hindered by the very low levels of education. The formation of second order farmer organizations that can (a) support their members with a wide range of services, from marketing through technical assistance to applied research, and (b) represent their members in dialogues with other collaborating institutes or with government policy makers (creation of lobbying power), is considered

essential if autonomy is to be achieved by the ICRDPs in the medium term. In Ecuador and to a lesser extent in Colombia, farmer second-order organizations are playing these roles and giving authority and autonomy. There is also the need to reconcile the interests of farmer cooperative-based agroindustries with the interests of small or medium-scale entrepreneurially run agroindustries. In the Colombian project, conflicts regarding this aspect have already arisen.

To be successful commercially the organizations need to be efficient and dynamic enterprises i.e. commercial management. Cooperatives or associations need to allow "enterprise" freedom to act commercially. The social objectives of these groups appears principally in the way profits are distributed. Long term sustainability to the greatest extent depends on commercial survival.

● **HUMAN RESOURCE DEVELOPMENT.** Human resources development is a well-recognized constraint that affects implementation of any rural development program. Training and Networking are two important strategies to alleviate this constraint.

Training. The establishment of ICRDPs in several countries of Latin America has highlighted the deficiency in the region of institutions and personnel specialized in post-harvest research and development, including marketing. Therefore, there is a great demand for training opportunities for research and extension personnel and for farmers, in areas such as cassava processing, crop management, basic accounting, production technology, human & financial resource management, marketing, market analysis, monitoring and evaluation, etc.

Experiences accumulated in various countries where the ICRDPs have been implemented indicate that training activities have been mainly orientated toward building capacity among local agency staff rather than toward farmers, given the class structure and organizational profile of the institutional environment in which these projects are being currently implemented. Training strategies for technicians should try to link training and work, using current and real work-related problems as the training issues and work groups as the basic training unit.

While the above applies to Brazil and Colombia, Ecuador has been an exception to this tendency. Farmer training has been carried out by UATAPPY and collaborating institutions. The sharing of training, management, delivery and participation has resulted in greater collaboration among partner institutions.

Educational and organizational needs of cassava producers are much greater than those of project staff. High rates of illiteracy and lack of organizational skills-particularly those related to handling funds, keeping records, organizing meetings- are cited among the major constraints affecting greater farmer participation in ICRDPs and preventing a more efficient two-way information flow between them and the project staff.

Current farmer training strategies used by local agencies and technicians in most ICRDPs tend to include mainly formal training and mass communication activities centered upon the extension of technological services rather than upon training and education. As such, these training methodologies tend to be useful only for those farmers with the needed skills and end up segregating the rest of the community making it more difficult to develop a broader leadership base at the community level. The Ecuador ICRDP however, has tried to improve this by having an explicit UATAPPY training function, designating an UATAPPY member (farmer) manage this function and training this person to carry out the function in a highly professional manner.

Networking. Forging links within and between regions and countries is one of the most important aspects in the implementation of ICRDPs. The interinstitutional and interdisciplinary approach that is required to translate new or improved production and post-harvest technologies into commercially viable activities is sometimes difficult to achieve at a regional or national level. The project framework within which ICRDPs are usually implemented, facilitates the integration of several national institutions into a network type of structure providing a forum for inter-change of experiences and methodologies and for the resolution of problems that are common across regions and projects. The methodologies that CIAT's Cassava Program and its partners in many national institutions have developed over the last 12 years have shown to be operationally, economically and technically viable, and networking, at the regional and country level, seems to be the best means of ensuring that the experiences and knowledge accumulated can be placed at the disposition of other regions and countries who are facing similar problems and opportunities.

● **MONITORING AND EVALUATION.** Project monitoring and evaluation (M&E), from the start has been an integral part of the ICRDPs methodology. Besides its use in defining potential products, markets, research priorities and sites, beneficiaries, etc, M&E has proven to essential for short run decision making in refining specific objectives, and the subsequent undertaking of appropriate actions.

During the early 1980's a M&E system was designed for the ICRDP model that was carried out at three levels, using different methodologies. The first level consisted of a data bank with continuously updated information from the farmers organizations. The second level involved an annual survey of a large sample of collaborating farmers. The third level consisted of an intensive monitoring of a sub-sample of farmers (Bode, 1991).

During the initial stages of the first ICRDP in Colombia, monitoring activities like the data bank served its purpose well in most aspects. However, as the project progressed and matured in time, data bank updating and subsequent annual reports based on this data, became the only activity and output of M&E and a large part of the data was under utilized. Moreover, the larger part of the output, in the form of annual report, was only circulated to a few collaborating institutions, and there was not sufficient feedback to the farmer organizations themselves. It was then concluded, that the monitoring model was basically designed for the first or pilot phase of a cassava-based development project, and was much

less suitable for other phases. It was viewed as a static model that didn't allow to evolve with the project's progress in time, since different levels of project maturity require different emphases and aspects from M&E.

Based on this valuable lesson learned during the Colombian ICRDP, an M&E improved model was adapted to better serve the needs of the Ecuadorian and Brazilian projects. First of all, key to several of the M&E limitations was the organizational structure and execution. It was found that the main organization and execution has to be based "in house". In other words, the second order farmer organization had to internally analyze the system and coordinate its operation. Collaborating institutions should only adopt technical assistance roles. This will ensure that an effective feed back of appropriate information is delivered in a timely fashion to the relevant audiences.

Secondly, the M&E system should allow for the dynamics of the project itself. Parameters of interest during early stages of the project may not be relevant for the expansion phases. In addition, adoption and impact studies need to be included, but only at a longer horizon. Table 4 shows a schematic representation of how different M&E activities become important as the project matures (Henry, 1994). Most important is that it introduces different aspects of monitoring activities at different stages of project progress or evolution. For example, market studies need to be conducted at the experimental phase in order to suggest viable potential new markets for the project. However, markets are dynamic, and hence these kind of market studies need to be repeated at a longer horizon to ensure a sustainable market potential, or as in the case of the Ecuadorian experience, to look for product and market diversification opportunities (CENDES, 1993; Brouwer, 1992). Another feature of the new M&E model is that the intensiveness of data collection diminishes as the speed of adoption increases.

The new M&E model has already proven to be superior in that it is both more effective and useful and has increased the efficiency in the use of resources and the sustainability of the projects. In Colombia, for example, adoption and impact study results have been fed back to research managers, scientists, second order farmer organizations, policy makers and donors for different specific uses. In the case of Ecuador, additional market studies have been conducted recently, that generated evidence of potential demand for alternative cassava flour uses in non-conventional industrial products (CENDES, 1993). In Brazil, coop-level processed data is been fed back to farmers' organizations within a month allowing them to assess their own performance and relate it with that of other farmers groups.

● **POLICY SUPPORT AND DECISIONS.** ICRDPs from their very inception have been closely related to and affected by policy decisions and support. For example, all countries in tropical Latin America are net importers of cereals and most governments in the region have tried to supply this increasing demand for carbohydrates through policy interventions and subsidized production credit. This has meant that traditional starchy staples such as cassava have to compete with grains at a substantial disadvantage. Exploitation of the post-

harvest opportunities for root and tuber crops is currently less of a technological problem given the extensive know-how available. The central issue in the development of cassava-based markets and products is the economics of the whole production and market process which is directly affected by policy interventions oriented toward strengthening the bargaining power and the organizational levels of cassava producers.

In the case of the Colombian project, policy issues were from the very beginning present since the pilot project was initiated in an area where there was an on-going land reform program within which farmers were already receiving credit and technical assistance aimed at increasing cassava production in the region. Moreover, all throughout the project, farmers organizations had access to credit lines for cassava production and processing and for construction of processing infrastructure. Additional areas in which policy interventions were important are the importation of cereals into the country which is controlled by the government and the inclusion of dry cassava in the political of minimum prices for agricultural products established twice a year by the Ministry of Agriculture during the beginning of the project. Policy issues became even more important during 1993-94 when decreased import duties (as a result from Colombia's "Apertura") allowed the importation of high-quality cassava pellets from Indonesia at "dumping" prices. This act set of a series of high level discussions that has lead to the coming together of representatives of government research and extension institutes, private sector, second-order cassava processing organization and CIAT, to discuss the framework, individual responsibilities and action plan for a collaborative long term effort to optimize the economic sustainability of the cassava sector (in the North coast) in general and the ICRDP, in particular.

In the case of the Ecuadorian project, lack of government intervention for providing small-scale credit has been important in impeding the establishment of cassava-based agroindustries, preventing the expansion of project activities to other potential regions and cassava producing areas.

In the case of the Brazilian project, cassava farmers have benefitted from policy decisions in the form of (1) several programs of grant-type financial resources, which have been mainly used for setting up the cassava processing plants and (2) credit programs for cassava production and processing, based on price variation of cassava products, which given the very unstable economical situation of this country with very high inflation rates (25-30% monthly), represent a less risky credit scheme for farmers.

CONCLUSIONS

The comparative analysis of three ICRDPs—Atlantic Coast-Colombia, Manabi-Ecuador and Ceara-Brazil—leads to three key conclusions:

First, the ICRDPs clearly demonstrate the critical need to integrate production, processing, and marketing research and development activities in order to effectively realize

the full potential of the cassava crop. The intertwined relationships and dependencies of these three activities makes it inefficient and illogical for institutions in either national or international contexts to work exclusively on any type of cassava activity in isolation from the others. The ICRDPs provide an appropriate mechanism for bringing together these activities in a context where multiple types of institutions—including farmers organizations—can collaborate effectively. For CIAT, as an international research center, the ICRDPs have provided a crucial testing ground for linking production and processing technologies, and for developing appropriate socioeconomic tools for market and monitoring research. The feedback from these results has served to shape the priorities for future CIAT research directions. In order to keep relevance to cassava farmers and processor needs, CIAT must try to maintain strong links to ICRDPs activities as well as maintain equally strong human and technical resource capacity in the production, postharvest and socioeconomic areas. Partnerships and collaborative arrangements between CIAT and national entities are a requirement for the future. ICRDPs offer both international and national institutions a framework to build collaborative working arrangements with farmers through their organizations. Strengthening farmer organizations and their links to research and development are critical objectives for the future. ICRDPs will help achieve these goals.

Second, ICRDPs provide important social and economic benefits to small and medium-sized farmers and landless rural workers in more marginal farming sectors. Cassava's exceptional adaptability to such marginal areas makes it a natural indicator for poorer households and an appropriate vehicle for organizing farm-level, income generating productive activities in regions with few other alternatives. ICRDPs act as "magnets" for other types of development efforts and can provide a base to anchor and *integrate* these in order to create general movement towards increased social stability and greater economic growth.

Third, the ICRDPs have clearly proven that when increased value for the cassava crop is created through the identification of new markets and the development of new products to suit these markets, farmers will invest in improved production technologies. Providing and appropriate incentive for farmer to invest in their cassava production systems has profound implications for the use of new technologies to increase productivity and to induce resource sustainability.

FUTURE STEPS

Looking beyond the immediate conclusions drawn from the ICRDPs current experiences, there are several important tasks yet to be accomplished.

First, despite the many years of collaboration between national programs in ICRDPs, there is relatively little consolidation of the experiences and lessons learned from the individual projects, and what has been written is not yet widely available for public use. Most of the experience remains lodged in the minds of practitioners who dedicated

considerable portions of their professional careers to these projects. CIAT must make a concerted effort to document these experiences, analyze the results, and make them available for wider consumption.

Second, there is a crucial need to couple these consolidated experiences and lessons learned with training programs. These will require the distillation of the ICRDP methodology from case experiences and the transformation of the methodologies into appropriate training materials. These in turn will provide the vehicles to allow others to learn how to plan and implement ICRDPs in other cassava producing regions in Latin America, Africa and Asia. Concomitantly, such materials need to be very dynamic, created in a format that allows new lessons and experiences from more recent projects to be assessed and incorporated. It is expected that there are equal amounts of learning to be achieved across continents.

Third, the ICRDPs are able to gain time and reduce duplication of negative experiences through networking and exchange visits between projects and through horizontal training and technical assistance between technicians and farmers. However, there is no structure to continue this horizontal exchange and collaboration. Funding and leadership need to be put in place to create a more permanent structure to facilitate such exchange. Likewise, CIAT has an important role to play in setting some "rules of the game" for such interactions to take place. Technology generation by public funds and agencies *must remain freely accessible* in the public domain. At the same time, private sector participation must be encouraged and their interests must be understood and accommodated in an equitable fashion. This will require large amounts of international "tact" and negotiation. Placing such a structure within an existing agro-industrial regional networking program (such as the case of PRODAR in Latin America and the Caribbean) would reduce administrative costs and prevent duplications of efforts with multiple but similar networks. It would also allow the ICRDP experience to cross over to other productive sectors or commodities that could benefit from this integrated approach. Likewise, ICRDPs could benefit from connections to other possible agroindustrial technologies that could diversify current farmer organizations outputs. Linking a collaborative ICRDP program from the Latin American and the Caribbean region with similar interests in Africa and Asia might create further possibilities for internal growth, reduce duplication efforts and technology development lag time, and can create greater horizontal exchange across regions where similar cassava problems and opportunities exist. These efforts could provide a means to farmer-to-farmer communication and assistance across large distances and perhaps enable cassava development to occur in areas where other more costly institutional efforts have failed.

Finally, since cassava is often grown in marginal environments where degradation to the resource base is in rapid advancement, ICRDPS offer an ideal ground to explore with farmers the questions and problems of the long term sustainability for cassava integrated systems. Farmer producer/processors who have learned and earned the value that new markets can give their cassava crops have an incentive to conserve their resource base and

ensure that its productivity will endure. Such farmers and their organizations can become willing collaborators in expanding the focus of the ICRDP to a landscape perspective where the longer term management of cassava is but one part of a complex resource management system. Mature ICRDPs must now turn towards these more complex problems and begin to focus attention on longer term sustainability. Explicit attention must now be directed to the system impacts of cassava production and processing, including work on productive capability, water and waste management, and relations with complementary and competing systems. If ICRDPs can indeed augment their horizons and incorporate these issues and problems, then there will be a greater chance for long term viability for the rural people who depend on cassava for their livelihoods.

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Table 1. Integrated Cassava Research and Development Projects in Latin America

Products and Markets →	Dry Cassava Chips	Cassava Flour		Starch		Fresh Roots	Cassava Leaves
	Animal feeding	Human uses	Industrial uses	Human uses	Industrial uses	Human uses	Animal feeding
Colombia	Commercial	Pilot		Pilot	Pilot	Commercial	
Ecuador	Commercial	Commercial	Commercial	Commercial	Commercial		
Brazil	Commercial					Pilot	Pilot
Paraguay	Pilot			Pilot		Pilot	
Panama	Commercial						
Bolivia	Pilot						
Argentina				Pilot			
Mexico	↓ ↓ ↓ ↓ ↓						
Peru						↓ ↓ ↓ ↓ ↓	

Table 2. Market sections and products in the Ecuador Cassava Project. 1989-1992.

Market Sectors	Products	TOTAL ANNUAL OUTPUT (t)				
		1988-89	1989-90	1990-91	1991-92	1992-93
Shrimp Feeds and Exports to Colombia	White industrial flour		574	982	304	631
Shrimp Feeds*	Whole industrial flour	1100	304	258	464	127
Plywood Industry	Refined whole industrial flour			200	170	292
Ice cream cone factories	Refined white food flour		33	6		33
Carboard box Industry (Ecuador and Colombia)	Industrial starch		70	188**	57**	256**
Bakeries Traditional large scale	Food starch	5	10	6**	9**	17
Livestock Feeds	Starch bagasse and flour bran		24	103	29	166**
TOTAL		1105	1015	1743	1033	1522

* After 1990-91 most of whole industrial flour was used for other livestock feeds, not shrimp pellets.

** Includes starches or bagasse purchased by the UATAPPY from private starch processor

Table 3. Types of Institutions and Functions in ICRDPs

Countries/Regions Institutions and Functions	Colombia (North Coast)	Ecuador (Manabi)	Brazil (Ceara)
Agricultural Research	ICA	INIAP	EMBRAPA EPACE
Technical Assistance	ICA		EMATERCE
Rural Development	DRI	FODERUMA	SUDENE
Credit	CAja Agraria		Banco Nordeste
Farmer Organizations 1st order 2nd order	180 groups ASOCOSTA ANPPY	18 groups UATAPPY	165 groups COPEMABA COPROMA
NGO's	Fundiagro		Esplar
International	CIAT ACDI	USAID	CIAT BIRD F. KELLOGG
Government National level Regional level	Min. Agric. Sec. Agric.	Min.AgricSec.Agric	Min. Agric. Sec. Agric. Sec. Ind & Com.

Table 4. A Modified ICRDP Monitoring and Evaluation Model

Activity	Source	Pilot Stage		Commercial Stage
		Experimental	Semi-commercial	
Monitoring (short run) - Technical - Financial - Social - Commercial - Institutional	1,2 1,2 2 2 2	■ ■ ■ ■ ■	■ ■ ■ ■ ■	■ ■ ■ ■ ■
Monitoring (long run) - Markets - Models	2,c 2,c	■ ■		■ ■
Adoption - Processing plants - Production technology - Other technologies	2 2,c 2,c		■ ■ ■	■ ■ ■
Impact - On-farm/processing plant - Community - Aggregate	2,c c c	■ ■ ■		■ ■ ■

c = Collaborators (Institutions, Universities, NGO's, etc.)
 1,2 = First and second order farmer organizations

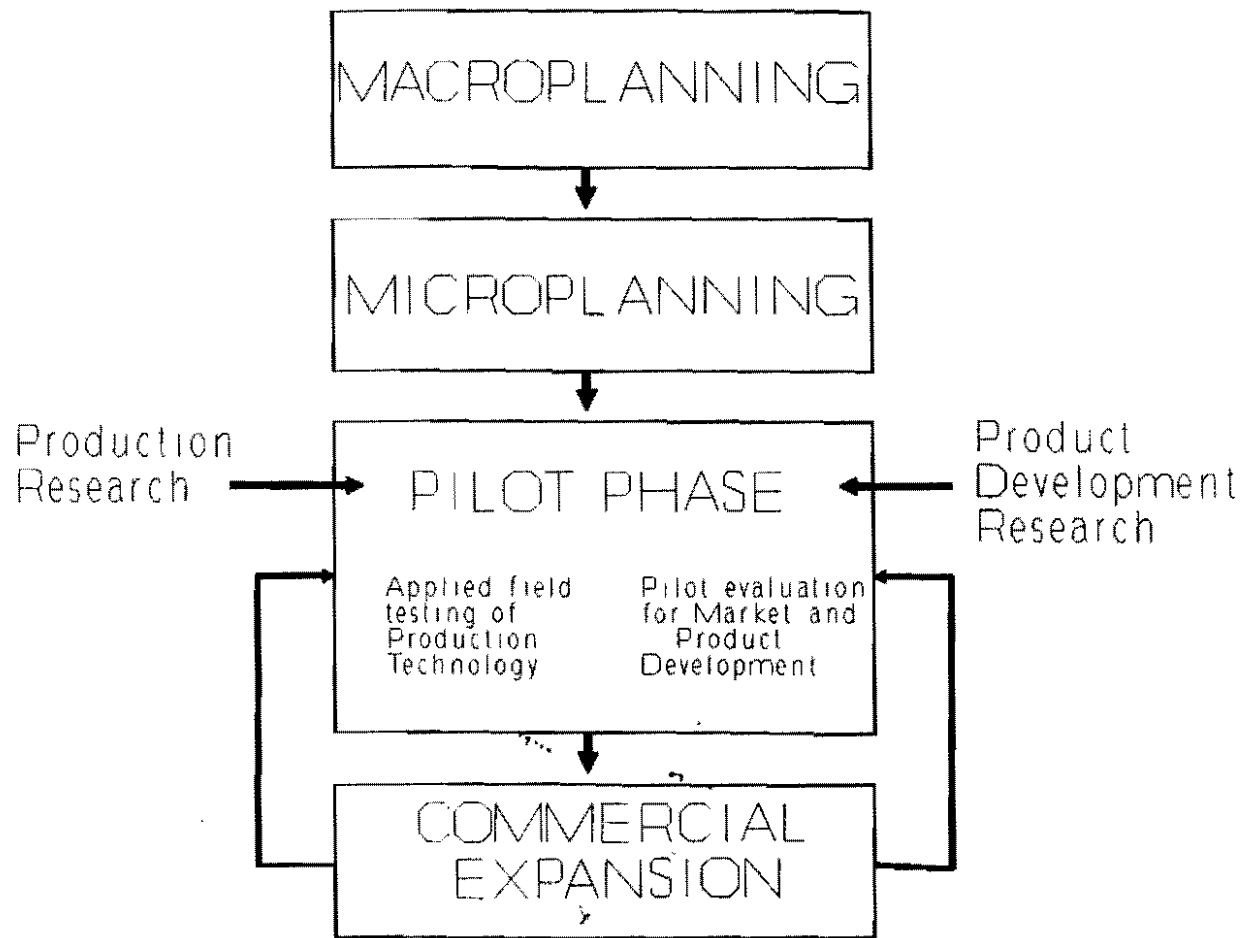


FIG. 1. Flow Chart of ICRDP Projects

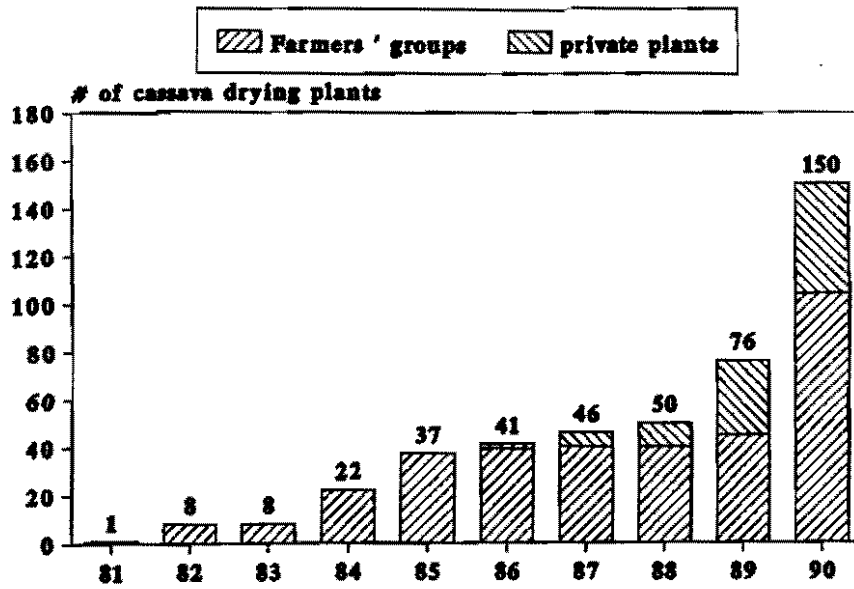


Fig 2. Adoption of cassava drying plants in Colombia. 1981-91.
Source: Henry, 1992

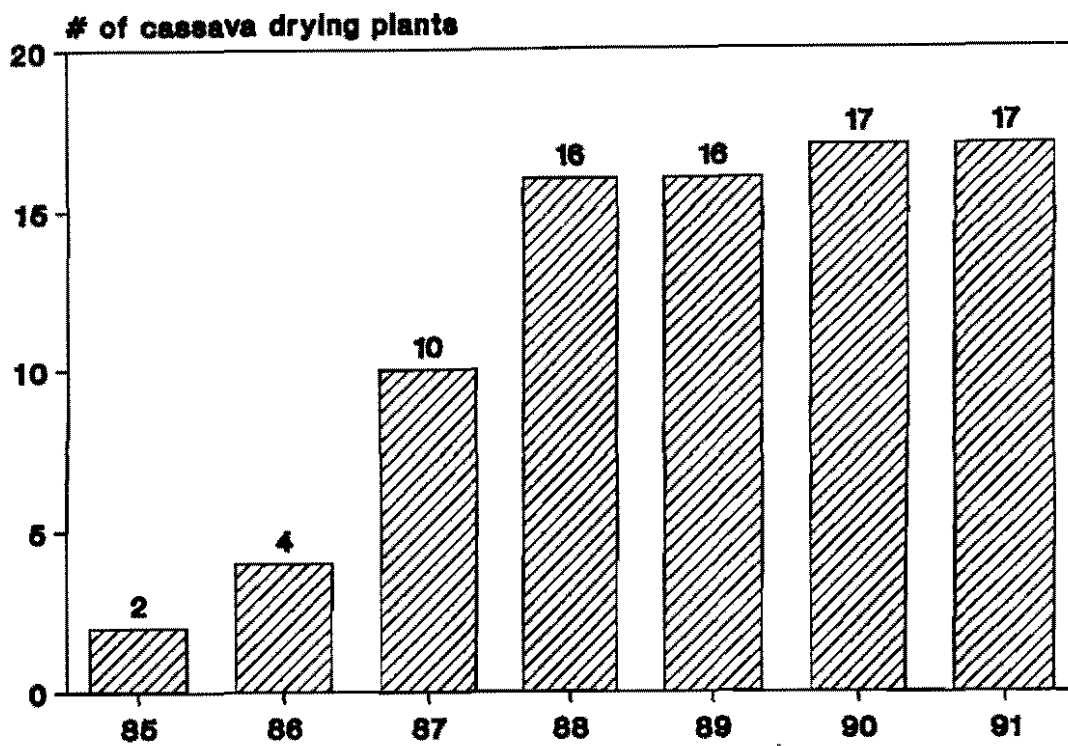


Fig 3. Expansion of cassava drying agroindustries in Ecuador. 1985-91

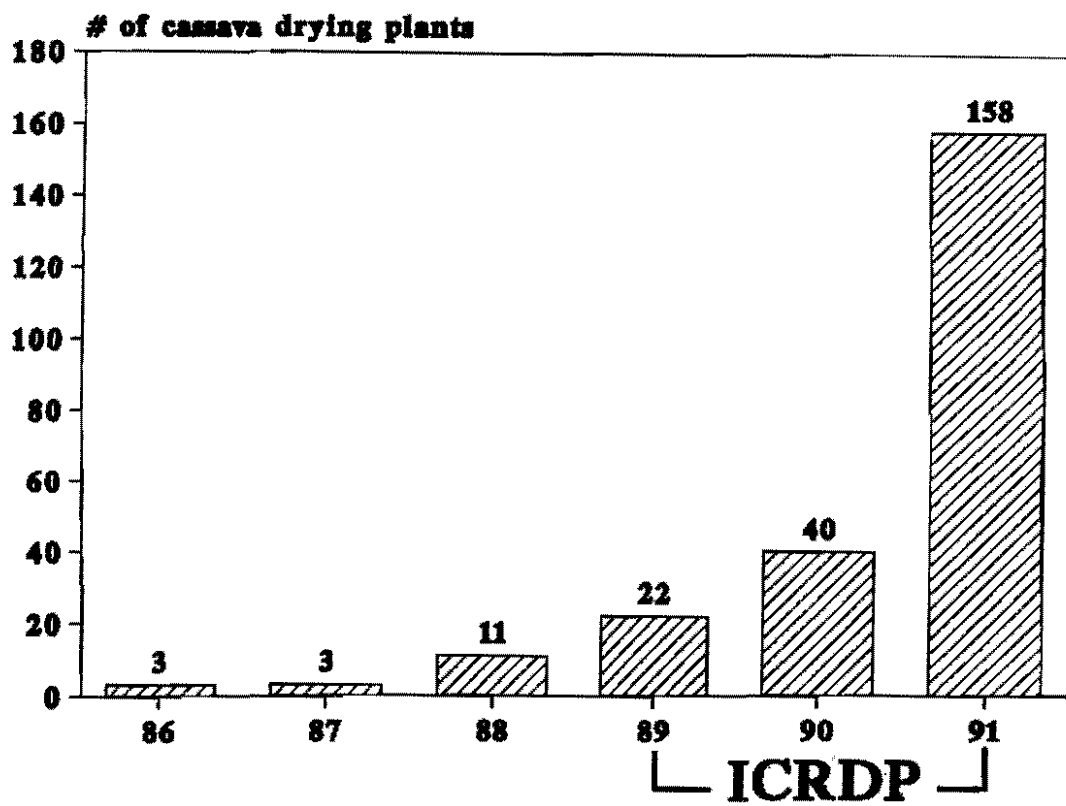


Fig 4. Expansion of cassava drying agroindustries in Ceara, Brazil. 1986-91

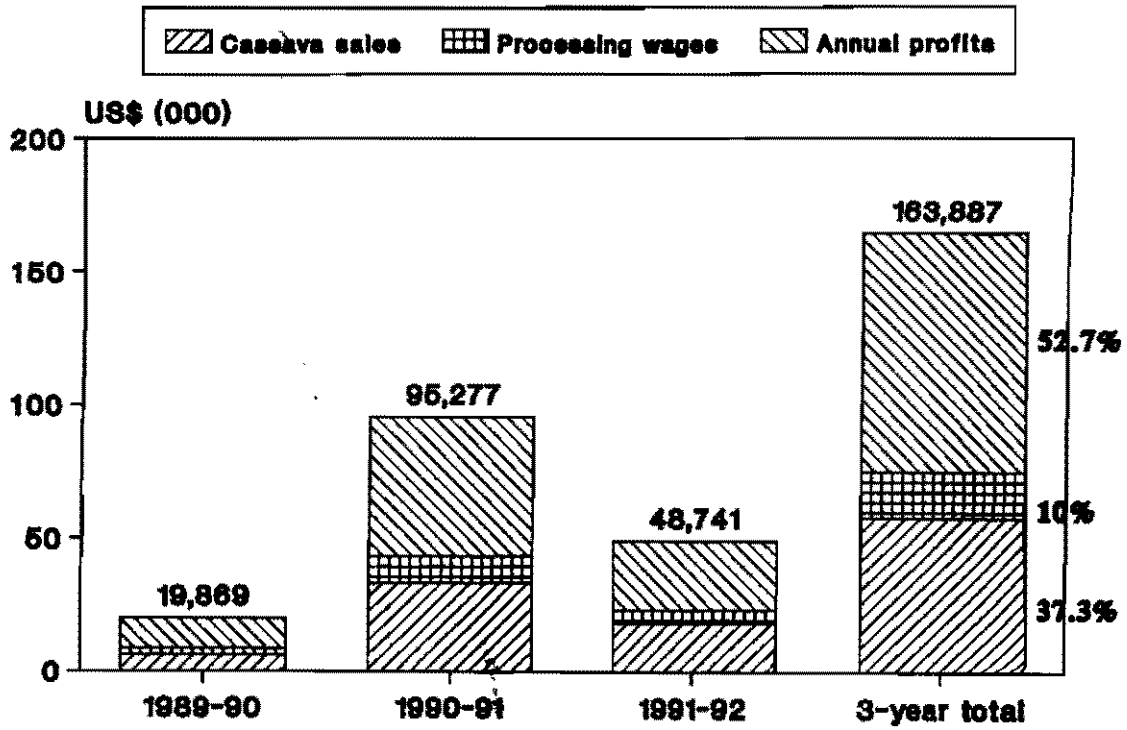


Fig 5. Total incomes for members. Ceara 1989-92

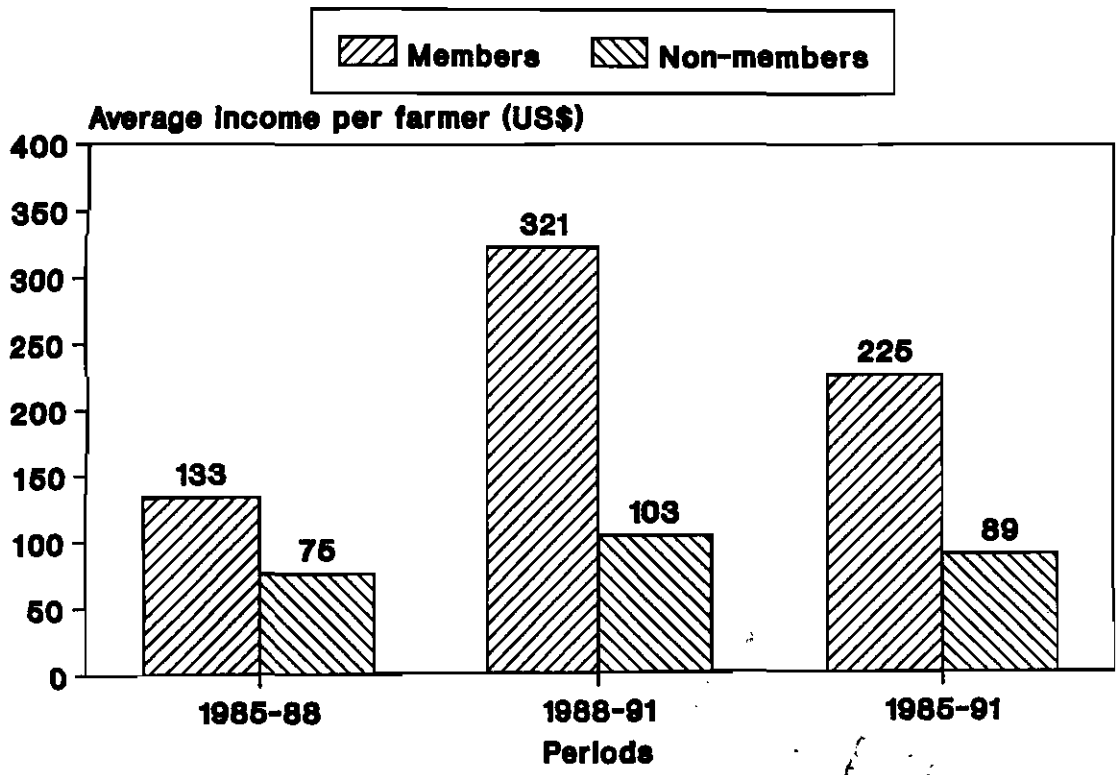


Fig 6. Income earned by members and non-members. Ecuador 1985-91