INTEGRATED EX-ANTE AND EX-POST IMPACT ASSESSMENT IN AGRICULTURAL TECHNOLOGY GENERATION: CASSAVA IN THE ATLANTIC COAST OF COLOMBIA

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Introduction

Technology generation efforts are often distinguished in two broad categories. The first category concerns research, frequently seen as a creative process in which innovative solutions, out of reach of non-specialized people, are identified. The second category concerns development, the massification and multiplication of these solutions in a specific situation. Development is normally considered more of a managerial than of a creative process.

A second distinction often made with respect to technology generation is the ex-ante versus the ex-post measurement of impact. Ex-ante impact measurement is linked in with research, often in order to define pay-off of alternative research strategies. Ex-post impact measurement comes after research and development and most often reviews the effectiveness of a given R and D effort. Ex-ante impact evaluation has a speculative focus, *ex-post* impact evaluation an historic focus. In case both types of analysis are applied, the time span between one and the other might be considerable.

When development projects are similar to projects executed earlier, the *ex-post* evaluation of the earlier projects will be useful. When a certain development project is rather original in nature, such information comes only available by the time the critical decisions have long been made and *ex-ante* evaluation is needed. Research projects, because of their creative nature, can hardly rely on *ex-post* evaluation of similar projects.

The distinction between research and development often implies a certain rigor in technology generation. Research comes first, development takes the research results and applies these in a specific socio-economic context. Information feed back and redirection of research as well as development projects get constrained. The flexibility of technology generation suffers severely. This problem has been recognized widely and has given rise, among others, to the development of on-farm research methods.

The present paper presents a case study on a project with more advanced integration of research and development, outside on-farm research. Simultaneously *ex-ante* and *ex-post* evaluation are interwoven in a continuous socio-economic monitoring process. What results is a project of genuinely mixed nature, where research and development obtain both creative as well as managerial characteristics. A continuous flow of new information leads to stepwise reassessment of earlier decisions as based on *ex-ante* knowledge. On its turn this leads to increased goal orientation and improved distributional and total effectiveness of the project.

The project described in this paper is located in the Atlantic Coast Region of Colombia and was developed in very close collaboration with the Colombian DRI (Integrated Rural Development) Program. It focuses on one of he most important crops in this area, cassava. Before the actual integration of research and development and *ex-ante* and *ex-post* evaluation in the project can be treated, a classification of technology generation efforts will be made. This classification is then applied to the cassava system in the region to forecast the potential benefits of the project. These forecasts provide the basis for the managerial choices to be made in the project. These forecasts and decisions are then reviewed in the light of information that became available through socio-economic project monitoring. Subsequent project redirection will be discussed. Finally conclusions are drawn on the feasibility of integrated project evaluation.

Crop technology generation, traditional perspectives and their usefulness for cassava

Following the classification of Ruttan (1982), four dimensions in the cassava technology generation process for the Atlantic Coast Region of Colombia were considered:

1) The geographical dimension. Although the Atlantic Coast Region was predefined, the heterogeneity of the region might request further detail in the technology generation process. Potential impact and equity effects are major criteria for region selection.

2) The range of product activities from which to choose. Both authors were members of CIAT's cassava program when the reported research was undertaken. It will be clear that, be it for very justified reasons, in the present study this dimension was predefined.

3) The commodity system dimension. For every commodity a set of integrated production, marketing, processing and consumption activities can be distinguished. One should known in which activity technological improvements will impact most and how other parts of the system can modify the impact. As will be described in great detail, this dimension proved of critical importance for the reported study.

4) The disciplinary organization of crop technology generation. On the one hand technology generation needs researchers, which can have a plant, soil, social or economic orientation. On the other hand it needs technology "diffusers" coming from a similar range of disciplines. The separation between diffusion and research is not always very clear, but decisions on disciplinary composition as well as research versus extension are critical for any successful technology generation effort.

Well known forms of traditional technology generation are the package approach and the marginal approach. In the package approach, a set of inputs is combined to enhance the effect of each individual input. Early green revolution rice technology is probably the most well known package: High yielding dwarf varieties are combined with increased levels of fertilizers and improved chemical disease and insect control. Availability of capital resources (credit) becomes critical for diffusion and success of the technology.

The marginal approach originated as a response to diffusion problems as caused by lack of credit or inputs. The marginal approach interchanges components within the crop production activity. The generation of low input, disease resistant varieties (beans, maize) is an example of this marginal approach.

The package approach does not have a solid regional basis, neither a commodity system focus, nor a mixed socio-technical scope. The marginal approach has incorporated more socio-economic and regional considerations. Nevertheless both forms of crop technology generation have brought large benefits to the agricultural sector of the world.

With cassava, technology induced production increases have often led to decreasing farmer incomes, due to constrained markets. Projects have been located in zones without sufficient production potential. Available technology (especially for processing) has often not been compatible with scale of production. Production costs indicated large expansion possibilities in areas were nothing really happened. Such experiences, among others, indicated the need for an integrated, novel vision on cassava development.

<u>Integrated cassava technology generation in the Atlantic Coas. Region of Colombia</u>

The Atlantic Coast Region of Colombia is a hot region of some 120000 square kilometers with low to moderate rainfall. Its population totals some five million souls, of which 70% is living in the urban areas. Land distribution in the region is highly skewed, a prolonged consequence of the colonization process (Spijkers). More than 85% of the land is in the hands of less than 20% of the land owners. While large farmers mainly involve themselves in cattle production, small farmers need more intensive but also more risky crop activities to earn their living. Because cassava can tolerate the erratic rainfall and the intermediate fertility better than other crops, it is an important crop in small farm agriculture.

The decision to research cassava for this region is an obvious one, given its importance in small farm production on the one hand and human consumption on the other. Cassava is hardly ever grown in monoculture in the region, but in fairly complex associations with maize, maize and yam or maize, millet and pigeon pea. Additionally, cassava farmers allocate parts of their land to cattle holding. The cattle serves as a risk absorber, a nutrition source, a savings and cash flow instrument and a flexible labor activity. For detailed information how cassava development in the region affected other crops see Janssen.

The commodity system proved to be most critical for cassava technology generation in the region and consequently ex-ante forecasting focused on this dimension. At the start of the study (around 1982) fresh cassava consumption was the major utilization of the crop. Fresh cassava consumption is significantly lower in urban than in rural areas, because it is a difficult product to market. The on-going urbanization put downwards pressure on cassava demand. At the same moment market channels for non-traditional food crops improved (eg. potatoes that come in from the Andean region). This formed another downward pressure on cassava demand. Also, many producers in the region sell their supply in narrow markets, where prices tend to fluctuate strongly and where only the better roots are acceptable for sales. The initial diagnosis of the cassava system suggested that low productivity was inherently related with the deteriorating prospects and the price instability of its major market. Not productivity improvement, but market amplification or market diversification were most needed. Production technology was considered to be the derivative of market prospects.

Two technological solutions to the market problem were suggested. The first solution implied the improvement of cassava's marketability, by means of plastic bag packaging. The plastic bag in combination with some harmless fungicide prevents the cassava from physiological as well as microbial deterioration (Janssen and Wheatley). This allows consumers to buy bigger lots at once and traders to discard less cassava because of deterioration. The second solution implied the development of a drying industry, that would sell cassava chips to the rapidly growing animal feed industry. In this market cassava prices are linked to government supported sorghum prices, the main animal feed raw material in Colombia. This paper will treat forecasting for the cassava drying industries and the ex-ante evaluation of drying industry development versus fresh cassava market improvement. For reasons of brevity specific issues on fresh cassava market improvement, some of which are treated in Lynam and Janssen will not be discussed here.

The challenge for the ex-ante forecaster thus became to integrate processing and marketing technology changes with production and consumption, considering substitution possibilities with other products or activities at different levels of the product chain. The exercise was further complicated by the absence of reliable time series on production, consumption and prices.

Ex-ante impact estimation procedures

Two major questions needed to be resolved in order to obtain good forecasts on the development of cassava drying industries. These questions concern market risk and its influence on production patterns, and fresh cassava versus dried cassava demand development. Given the hypothesis that changes at one level of the product chain might have consequences at other levels, the individual answers to these questions were not considered to be a sufficient answer. It was thought necessary to integrate the basic mechanisms with respect to these questions in a simulation model.

1) Market risk assessment and its impact on agricultural production.

Does market instability really increase the risk the farmer faces? The traditional hypothesis is that prices are high when supply is low, in which case market instability compensates price instability (Robinson). However for individual farmers, or subregions, production conditions in a specific year can differ considerably from the average. This is, aggregation to market level eliminates the variability and insecurity that a single farmer faces. Market instability should then be studied at the individual level.

An interview procedure with flash cards was designed to match production expectations with market expectations. Table 1 presents the average results of these interviews. It is clear that price expectations and yield expectations are rather unrelated. Consequently the coefficient of variation of income is 0.36 while the coefficient of variation of yield is only 0.33. Since market instability increases the farmer's income risk, there might be reason to suspect that it influences production decisions.

In the same interview procedure it was established that market prices present too favorable an impression on cassava's profitability. This is because some thirteen percent of cassava was not acceptable for fresh markets and because the farmer had high transportation and market arrangement costs. The cassava price as obtained by the farmer was some 24% higher than the price corrected for selection and marketing costs.

The next question was to assess the effect of cassava's market instability on production. A normative and a positive method were used to answer this question. The positive method consists in an elicitation approach with respect to planting behavior at contracted prices. The normative method consists in the development of a Quadratic Programming model, that evaluates price instability. Appendix 1 provides methodological detail on these methods, their advantages and disadvantages. Table 2 summarizes the main features of these methods, as well as of other methodological procedures used in this paper.

The expected production changes per farm as the result of the market stabilization that cassava drying plants might cause is given in Table 3. The elicitation approach forecasts bigger percent wise changes in area planted than the Quadratic Programming approach. This is due to a large extent to the fact that the QP-models overestimate areas planted in the situation without drying industry. The absolute difference in area planted for the two methods is very similar, except for the small farm. In any case, both methods forecast considerable allocation shifts if cassava markets would be stabilized through a drying industry. Both methods forecast bigger shifts with large than with small farms.

The hypothesis that market instability constrained cassava production, as well as that a drying industry might increase the role of the crop in the region, did clearly hold up. Effective cassava development thus became dependent on the adequate integration of marketing and production. The question became, how to arrange access of small farmers to the large volume animal feed market. Small scale natural drying plants, organized through farmers associations appeared the appropriate answer, as will be discussed in more detail in the project design section of this paper.

Since quality requests in the animal feed market were less stringent than in the fresh cassava market, the introduction of highly yielding, but less culinary varieties would be eased. As well the analysis suggests to concentrate drying plants in those areas with low quality cassava, where large amounts are discarded and prices are low.

The forecasts show considerable production increases among all farm groups, but most so with larger farmers. Also given the need to finance drying plants, the conclusion was drawn that drying development should be directed to the larger of the small farms and to those areas where land is available to expand production. The economic forecasts stressed that cassava development could be focused on poor farmers but that some resource availability would still enhance its potential. The conclusion that follows was that cassava development is no substitute for rural development, but only one component. Especially for small farmers, to be effectively included in these projects, other components should be in place, such as production and processing credit.

Since the expected benefits at this stage of the analysis were measured as a function of cassava production, farmers with best possibilities to increase production showed up as the most feasible target group. Anyway, the chances of cassava productivity improvements once the spell of the unstable and untransparent fresh cassava market was broken appeared good.

2) Alternative demand estimation and its integration with fresh cassava demand.

The former section suggests that small farmers can be feasibly integrated in more stable animal feed markets. In that case the potential benefits of such a strategy depend to a large extent on the future demand for dried cassava. An assessment of the animal feed industry's demand for dried cassava was therefore needed.

The animal feed industry can be considered a very rational consumer of raw materials. Quality differences of raw materials are reflected in prices differences. In fact, most animal feed industries use minimum cost linear programming models to decide on raw material purchase and utilization.

On the basis of a methodological procedure reported in Appendix 2, a potential national demand of some 140000 tons of dried cassava was estimated. This would equal 350000 tons of fresh cassava, 50% of existing production. Some 30% of this demand was located in or at small distances from the Atlantic Coast Region. A price elasticity of -3.18 was found. This is a very high value, but in accordance with the knowledge that the animal feed industry is very price sensitive.

At the same moment fresh market demand equations for human consumption were estimated in a region wide survey. Marketing margin behavior was determined. On the basis of marketing margin behavior and final consumer demand, farm gate demand functions were derived. Dried cassava demand at the animal feed factory was converted in fresh cassava equivalents at the farm gate. By simple aggregation, the different demand functions were integrated.

It appeared that dried cassava demand could provide the dynamics to cassava production that were absent in the stagnating fresh cassava markets. The high price elasticity confirmed the expected price stability in this market, as long as sorghum prices were stable. The attention therefore turned to the development and implementation of small scale processing technology, in order to produce dried cassava of sufficient quality but of minimum costs to the producer.

The absorption capacity of the regional dried cassava market appeared sufficient for rapid initial drying plant development. Research to reduce transport costs was only considered necessary in the intermediate term. The large national demand potential suggested that utilization research on dried cassava was not needed. Linking small farmers with the animal feed market through small scale drying plants appeared an excellent mean for converting risk averse, resource poor peasants in entrepreneurial farmers.

A useful side-benefit were the contacts established with potential purchasers. Afterwards they have been consolidated in a client data base, used to establish sales contacts. Impact forecasting thus had a direct managerial input as well.

3) <u>Integrated ex-ante forecasts of cassava development through simulation models</u>

The former parts of this analysis have forecasted supply and demand for a cassava drying industry in the Atlantic Coast region. Extensive fresh cassava marketing and consumption studies and dried cassava marketing and processing studies were made also but are not reported here. These studies delivered appropriate insight in the mechanisms that determine the potential of cassava development, but do not provide much insights in the dynamics of that development. As well, they provide estimates on the production and consumption shifts per individual, but not on the overall expected developments of the commodity systems. To estimate regional production and consumption shifts as well as the different benefits of cassava development a simulation model was developed.

This model has a recursive nature with a ten year horizon and interprets the static results of the former analysis in a dynamic context.

Population and income growth are included in demand equations; a distributed lag specification is chosen for cassava supply; the development of the cassava drying industry is made endogenous to the model. A schematic presentation of the simulation model is given in Figure 1; a brief explanation is given in Appendix 3.

The model was first used to evaluate the development of a cassava drying industry versus the development of fresh market storage methods, naturally in comparison with zero development of the cassava system. The model was also run at different assumptions, among others, for expected cassava productivity, drying industry growth and dried cassava demand growth. A summary of results is presented in Table 4.

The first outcome of the model is that the cassava economy without drying or storage development essentially stagnates at current production and consumption levels. Rural-urban migration and substitution of cassava with more convenient foods counter the effect of increasing population.

Drying industry as well as storage development significantly changes the prognosis. In the case of drying industry development production would increase at 3.7% per year. Storage technology would induce a growth rate of some 1.5% per year. In both cases the expected fall in the farm-gate price would be countered, but storage technology would be more efficient in this respect. Although cassava is mainly grown by small farmers, drying would most favor the larger small farmers. The area planted and the yields in case of drying development are larger than in case of fresh storage development.

The impact of alternative market development on traditional markets is a major point of interest. Cassava drying would slightly reduce fresh cassava consumption, but almost completely generate its own supply. Fresh storage would firmly reverse presently declining consumption trends.

The benefit parameters show that cassava drying would create quite some rural employment as well as rural income (as measured through the producers surplus), more so than fresh storage. The fresh storage technology would generate more consumer benefits, in the form of reduced consumer prices. Drying can be considered a rural, storage an urban strategy.

Although total benefits in the case of storage are bigger, the strategy appeared more risky and not oriented towards redressing the structural unbalance in rural-urban development. For this reason drying industry development was given priority.

The size of total benefits in case of cassava drying industry development was more sensitive for drying capacity growth than for cassava productivity growth or increased dried cassava demand growth. In fact producers benefits are hardly affected by differences in productivity growth. Mainly the benefits to the animal feed industry are influenced.

More rapid dried cassava demand growth would mainly affect urban consumers but not produce more benefits to cassava producers.

A simulation model always responds to the assumptions on which it is constructed. Some conclusions were logical extensions of the previous analyses, such as the size of benefits to large versus small farmers in case of drying industry development. Other conclusions however, would not have been derived without the capacity of such a model to integrate and compare complex mechanisms at different levels of the commodity system. The overwhelming importance of drying plant building versus production development had not been foreseen. The impact of fresh cassava storage was larger than expected, and although discarded because of urban-rural equity considerations, gave rise to some small scale storage projects.

A major conclusion from the simulation was that emphasis should not be put on improved utilization of dried cassava (eg. by nutritional research), nor on pursuing rapid productivity increases. Project benefits would be enhanced most by focusing on drying capacity establishment. In more abstract terms, not productivity growth or demand growth, but the linkage of demand with production would be the key factor for improving the role of the crop in the region.

The simulation model suggested that cassava's development depends on the capacity to redefine the role of the crop in the rapidly changing structure of the Colombian agricultural sector. Where as for the traditional rural consumers, production cost decreases would enhance the dietary role of the crop, for the growing group of urban consumers marketability improvements would have most impact. With respect to the animal feed industry, twenty years ago it was non-existent, but now it would provide the opportunity for long-term production and income growth to the cassava farmer. The simulation model became the ex-ante proof that the integrated analysis of the cassava commodity system would provide the adequate technology design parameters not to be obtained in more isolated production analysis. The model also showed that crop development should not depend only on the solution of technological problems of today, but more so on the anticipation of future problems and opportunities.

Issues in cassava technology design and transfer

The ex-ante forecasts, reported in the previous section provided a considerable number of design criteria. These became especially useful with respect to the definition of the organizational concept; the ownership of the cassava drying plants; the region selection; and the disciplinary composition and institutional strength of the project team.

1) The organizational concept.

The cassava market risk assessment made clear that drying plants could stabilize markets and help to increase production. Then, why had this development not taken of by itself? Timing appeared to be one reason. The slow deterioration of the fresh markets, coupled with the recent presence of a Rural Development Program (credit!) and a rapidly growing animal feed market provided the conditions in the early eighties to develop cassava drying in the region.

Another reason for the absence of spontaneous development was the price illusion in the fresh market, where only good quality cassava could be sold. The availability of low quality cassava would be a first significant drive for drying development. The ability to sell commercial quality cassava to a drying plant in years of poor fresh market conditions would form a secondary drive. Successful drying development would thus depend on the very close integration of farmers with the drying plants to be established. Small scale drying development appeared the most appropriate solution.

It was decided to develop a pilot drying scheme in one area before stimulating development on a larger scale. Such a pilot project would allow for technology adaptation at processing level, would be the basis for establishing commercial contacts and the location for agronomic experiments to increase cassava productivity. The pilot project would hopefully provide insight in previously non-researched issues. The pilot project would serve to test the possibilities of linking small farmers with the large scale animal feed market. The pilot project should produce a small, scale neutral prototype for cassava development, easily to be reproduced in other parts of the region.

A last advantage of the small scale pilot project was the limited cost in case of unsuccessful development. While allowing more control over the critical variables of technology generation, expected losses in case of failure would leave neither CIAT nor DRI broke and without prestige.

2) <u>Drying plant ownership</u>

Drying plants could be alternatively owned by private entrepreneurs, individual farmers, groups of farmers or state organizations. State organizations were quickly discarded because this would imply long term government involvement and because it was in some way contradictory to the analysis that cassava drying was profitable and promising.

Choosing between farmer or entrepreneurial ownership was done on the expected character of the drying plants, as arising from the market assessment. In their initial stages, cassava drying plants were expected to play an important role in stabilizing the fresh market. This implied that in years with very high fresh cassava prices, drying activity might be very low. In such a situation the income from cassava processing would be rather unstable and would not offer a sufficiently secure profit perspective to private entrepreneurs. Since drying plants would allow cassava farmers to play their market with more success, by selling either in the fresh or in the dried market, ownership would be most attractively located with the cassava producer.

Nevertheless, individual small cassava growers would not have enough production to enter the large scale animal feed market, nor sufficient capital availability or credit facilities to build their own plant. The organization of farmers in associations appeared the best form to obtain a minimum scale of processing capacity and sufficient credit and capital availability. As well farmers associations would be able to provide the labor to run the plant from their own ranks (Bode).

3) Region selection

The Atlantic Coast Region is too large and diverse for an overall technology generation effort. The adequate selection of target regions for drying plant development was seen as a first condition for rapid initial development of the industry, once the pilot phase was passed. The relevant part of the region consists of four departments and these were taken as the basis for selection. Although department borders do not reflect appropriately ecological differences, they form the political boundaries for all rural development efforts in the region and appeared the best reflection of the regional dimension of technology generation.

Three criteria for region selection were identified. The first two criteria, production and processing potential, were supposed to define the appropriateness of the region and were largely based on the outcomes of the market risk assessment and the simulation model. The third criteria, the project's impact on the selected area, tried to maximize its social pay-off.

For each criterion, a number of determinants was fixed. The resulting decision scheme is shown in Table 5. After recollection of regional data, Table 6 resulted. Applying a simple Pareto-criterion (something is better than something else only if it is equal or better in all aspects) it is possible to rank the department of Cordoba as the best place for cassava drying industry development, and Sucre as the second best. Between the two other departments no unambiguous choice can be made. Equity considerations favor Bolivar, processing feasibility favors Atlantico. The choice was left to the government officials in charge. Since scores on all determinants were known, they had all tools available for an easy decision.

4) Disciplinary composition and institutional strength

Plant development and market linkage appeared to be the critical factors for cassava drying development in the region. Therefore the initial bias in disciplinary input was towards processing, marketing and economics. Production research was supposed to become useful only after new or improved cassava markets had been opened. Agronomic experiments were planted but the lead time to adoption of new technology was expected to be several years.

It was considered that after the pilot phase, when the project was supposed to cover more areas in the region, institutional strength would be a critical variable. Government institutions were assumed to assist in the formation of farmer associations, to arrange credit and to provide technical assistance in the first year of operation. Nevertheless, because of the profitability of cassava drying, farmers associations were expected to expand their operations afterwards at own initiative.

It was expected that with the existing institutional resources, some 20 plants could be formed, each of 250 tons of dried cassava production per year. Considering the autonomous expansion by older drying associations, the ability to form twenty associations per year was considered sufficient. It was decided that the project could be developed with the existing resources and did not need additional manpower.

By a systematic analysis of cassava within the rural economy of the Atlantic Coast Region of Colombia it was possible to specify alternative technology development efforts and choose between them. Ex-ante project feasibility and impact estimations produced clear guidelines for its conceptual structure, organizational form, most feasible target regions as well as disciplinary composition and institutional strength. The knowledge base at the start was well developed, allowed conscious decisions, and suggested a prosperous future for this technology generation effort. Technology management however does not end when the development strategies have been made up. Project monitoring is the logical extension of ex-ante feasibility and impact assessment studies. From a theoretical perspective, monitoring is also instrumental in reviewing the ex-ante forecasting methods and their conclusions, as will be clearly shown in the next section.

Project monitoring and adjustment

Ex-post impact assessment often assumes that the effect of the technology has worked its way through the economic system. Such a concept implies their is little analysis to be done between the *ex-ante* and the *ex-post* assessment; moreover it assumes that new technology autonomously diffuses through the crop sector along a determinant path, fixed by the characteristics of the technology and the structural features of the sector.

The diffusion of new cassava processing technology, and its impact on production technology, follows from a very different concept. First, significant technology diffusion through project management is necessary before the market is sufficiently consolidated for further autonomous diffusion. Second, key interventions, through what may be termed social technology, can alter the diffusion path and the resultant distribution of benefits. Third, technology transfer and initial diffusion are organized within a project framework and can be easily linked to development activities. Within this concept *ex-post* impact assessment becomes a continuous activity, synonymous with monitoring in the project literature, and involves the translation of the *ex-ante* results into an actual field situation.

Thus, in the case of cassava there is a major amplification of the adaptive research and transfer stage, compared to other crop research programs. Adjustments to processing technology, to production technology, to technology delivery systems, and to farmer organization radically extend the boundaries of adaptive investigation as currently defined by farming systems research. These adjustments are made not just on the basis of a technology testing activity but also on an evaluation of institutional resources, deployment of plant management, of differential production response by farmers, and of benefit distribution. Monitoring is a key activity when the focus of technology transfer expands beyond production to encompass processing and farmer organization.

The diffusion of cassava processing and production technology on the Atlantic Coast of Colombia has not yet reached the autonomous growth stage. What shall be analyzed here are issues that have arisen in the project monitoring phase and the degree to which they were predicted in the _ex-ante_ planning phase. Since the design and implementation of the monitoring system is still evolving, these results are only preliminary, but they do suggest the value of a continuous evaluation of the technology transfer process.

1) _Region Selection_

Project implementation adopted a different strategy in plant location from that recommended by the _ex-ante_ analysis. The project did focus on

Sucre and Cordoba in developing plants (Table 7). Sucre, however, superceded Cordoba, which was the first priority in the planning phase, due to much better institutional development and a problem in timing of harvest and drying in Cordoba. However, although Sucre and Cordoba were the two highest priorities, the project decided to set up plants in all the other departments of the Atlantic Coast. A strategy decision was taken to make the project truly regional. Plants were developed in other departments in order to promote their demonstration effect and to act as a catalyst for developing institutional capacity.

Nevertheless, the setting of regional targets was confirmed. Performance indicators for the plants were much higher for Sucre and Cordoba than for Bolivar and Atlantico. In the latter two departments there was greater competition with the fresh market for raw material supplies, as well as more severe constraints on the expansion in cassava production. These results confirmed the hypothesis that certain regions would have something of a comparative advantage in processed cassava, and that this "demand" for technology was determined by constraints on or high costs of access to established cassava markets. Regional stratification was therefore a necessary step in developing an efficient technology transfer system.

2) Farmer Production Response

A critical hypothesis within the project is that stabilizing access to cassava markets provides a major incentive for expanding production, both through area expansion and yield improvement. An early validation of the <u>ex-ante</u> results was essential to project expansion, especially in defining the rate at which new plants could be established. However, the evaluation of the farmers' production response to plant establishment was not easy, as it became difficult to control for other factors affecting production response.

There was no firm basis for a sampling frame for cassava production in the whole region and little institutional support outside the area of influence of the plants. Production monitoring thus focused initially on farmers who sold to the plants, a list of which was developed from the monitoring of the plants. This meant there was no control group. Moreover, cre it, yearly price variation in cassava and competing crops, the relative incentive between being a member of a plant association or only selling to a plant, and relative differences in efficiency between plants all introduced alternative determinants of farmer' production response ans sample size often limited the ability to control for these factors. The monitoring system at this early stage principally suggested improvements with respect to its own comprehensiveness, rather than a conclusive test of the production response hypothesis.

The monitoring results showed a 17% increase in area between 1984 and 1985 by a sample of plant members and a 26% area increase between 1985 and 1986. The <u>ex-ante</u> analysis indicated that the area increase would occur principally in farms of over 8 ha with secure access to land. The monitoring results, however, suggested a quite different pattern. First, there was an unexpected tenancy effect. Farmers with insecure access to land made up a significant portion of many farmers associations. They were in fact first to respond (Table 8), with land owners lagging somewhat behind. However, if the farmers were not direct members of the plants, then the effect was an expected, with owners showing a more consistent response. This was an important result, since it suggested that the social technology -- i.e. the farmers' association -- could be combined with the processing and production technology to reach the poorest and most insecure portion of the population, results that could not be incorporated in the <u>ex-ante</u> analysis. Project design was shifted to further incline benefits to a segment of the population that had been very difficult to target.

Secondly, the monitoring results suggested that the principal response was coming in farms whose cassava area was well below the optimum as predicted by the <u>ex-ante</u> model (Figure 2). The initial response was coming in farms with apparent excess capacity and with farmers renting land. There was a significant lag in the response of farmers who were already growing at least 3 hectares of cassava. This implied either a longer reaction time on the part of farmers who had already committed signficant resources to cassava or constraints on expansion not captured in the model. This observation raised the still deeper question of how to evaluate the efficiency of plant operation as an organizational constraint limiting farmer production response versus land or labor resources as the primary constraint.

3) <u>Demand assessment</u>

Alternative demand for cassava as an animal feed raw material was critical to project success since it would stabilize prices in the traditional cassava market, allow integration with the grain, i.e. sorghum, market and provide significant potential for production expansion. The project did produce the desired price floor (Table 9), which, however, did not prevent the price in the fresh market from rising in 1985-86 to the point that it constrained raw material supplies. Moreover, the project appears to be having a stabilizing impact on prices in the fresh food market, indicative of both the effect of the supply response and the relatively marginal intervention needed to influence prices in the traditional fresh market.

Market access, in one sense, was expanded, as is shown in the diversity of outlets utilized and the movement of dried cassava out of the region (Table 10). However, the decline in dried cassava use on the Atlantic Coast is indicative of the thin market in that area. Market access in the Coast was conditioned by periodic sorghum imports, both legal through the ports and illegal across the border from Venezuela. Cassava became much more competitive in inland deficit markets. This gave rise more rapidly than expected to a second generation problem; how to increase the bulk density of the product to reduce transport costs. An impending issue became when to introduce pelleting technology and what should be the organizational strategy for such an introduction. The <u>ex-ante</u> studies to a significant extent oversimplified the sorghum market but there was sufficient scope for adjustments so that price stabilization was in fact achieved at a relatively early stage.

4) Market simulation

The simulation model added a forecasting component to project planning. The project did start with the development of the dried cassava market; only in 1987, with the market consolidation based on dried cassava achieved, was the fresh cassava storage technology introduced. The model suggested that these would be complementary strategies. In practice this has so far been the case. The initial focus of fresh storage technology introduction was Atlantico, a department where dried cassava plants had difficulty competing for raw material supplies with the fresh market. These plants, in turn, were utilized to process the roots that were discarded for storage; as well, the farmer associations provided the organizational nucleus to introduce storage technology efficiently at the farm level.

The project also recognized that the growth ot the cassava processing capacity would determine the size of project benefits. The predicted stabilization in cassava prices was achieved in a relatively short period. However, plant efficiency indicators suggested that plants were operating below capacity due to insufficient rawmaterial supplies. Achieving a balance between demand expansion and production response was proving difficult due to a longer lag time than was expected in the model. This was especially so since a principal response came from renters and the project was driving up the rental price of land.

Moreover, the relatively larger farmers between 8 and 20 hectares were not quick to respond. Access to the rental machinery market appeared to be their constraint, especially since a boom in the local cotton market was drawing tractors to large-farm land preparation. In two cases, however, the success of the farmers associations in managing dried cassava processing provided a sufficient capital flow to purchase, through a credit line, their own tractor. Changes in commodity markets were thus inducing changes in factor markets, an issue which was not incorporated in the simulation model, apart from a calculation of the increase in labor use. There has been pressure by farmers for a similar credit line for land purchases, but this has so far been resisted by the local credit institutions. Nevertheless, the economic and organizational pre-conditions for the success of such a credit line are in place.

The ex-ante model demonstrated the significant growth potential from an integrated cassava project. The great utility of ex-ante impact studies lies in just such a diagnosis. However, the leap from potential to realized increases in cassava production and utilization is still a large one, even with a model as detailed as this one. Such detail is only captured in partial equilibrium approaches and yet these often must exclude interactions with other output and factor markets. Predetermining which substitution or factor market effects will be significant is difficult and very dependent on prior knowledge.

However, this leap between potential and actual interactions goes beyond just defining the structural limits of the model. First, it would be useful to have a probability of success factored into the model but it is difficult -- impossible (?) -- to identify the key variables that define success, much more so attaching a probability to them; moreover, some probability distributions will be conditioned on others. Second, institutional support was key to project implementation, and it is difficult to see how institutional requirements could be forecast, much less the extent to which existing institutions posed a constraint or were amenable to modification. Third, the farmers' associations were probably the key factors in successful technology transfer to this socio-economic stratum. The association proved to be the pivotal organization concept which gave the project flexibility in adapting to unforeseen problems or constraints. Such a role was not predefined, but was identified early in the project and then utilized in its expansion. All of this points to the fact that technology transfer in developing countries is very much an under researched area.

Conclusions

The integrated ex-ante and ex-post evaluation of cassava technology generation in the Atlantic coast Region of Colombia strongly improved creativity, focus and goal orientation of the project. It has emphasized that agricultural technology not necessarily has to be production oriented, to improve overall efficiency of a commodity system. It has helped to rebalance the disciplinary composition of the project, to define target areas and to refine the bias towards small farmers. The procedure however is costly in time of project analysts. This last section will try to derive some general conclusions on the feasibility of these methods in other circumstances.

A first conclusion should be on the usefulness of the ex-ante - ex-post evaluation for CIAT's cassava program research and development planning. Understanding of supply-demand linkages has helped to focus utilization research. It has also given rise to an extensive, Latin American wide study on ex-ante cassava demand prospects and CIAT's potential to link its research to these prospects. As well, it has proved critical for the development of other Integrated Cassava Projects, in Panama, Ecuador and Mexico.

The conclusions on organizational aspects and farmer involvement have obtained particular significance. Where as before the cassava program considered that processing and production research would do the (technology generation) trick, the program is now more aware of the need for social technology. Especially with respect to the scale adaptation question in production-market linkages (eg. from small farmers through associative drying plants to large scale animal feed industries) appropriate organizational arrangements have proven their worth. The existing lack of ex-ante assessment of organizational arrangements reinforces the importance of early monitoring in Integrated Cassava Projects.

A second conclusion should be made with respect to the methods applied in the ex-ante phase of the analysis. These methods originated mainly in the field of economics. This has provided a number of very valuable conclusions, eg. on area planted and market stabilization. However it has also failed to preview some other important developments. Small farmers appear to be more motivated to join cassava drying associations, because they hope to win more by organizing themselves. In a similar way, the progress of the drying industry was badly assessed, because the motivation of government programs to pursue this development was not correctly judged. In the project design as presented in this paper, forecasting was done by economists and monitoring by economists, anthropologists and organizational scientists. For further refinement of project evaluation and planning methods it is essential that anthropologists and organizational scientists enter the traditionally economic domain of forecasting. Such a move will initially make their work more speculative and their conclusions more risky, but later on will improve applicability and disciplinary strength. The ex-ante evaluation is more risky and more difficult than the ex-post one, but also provides a bigger challenge and a higher pay-off if correctly applied.

Some remarks should be made with respect to the degree of problem complexity that can be handled within a technology generation project. The present paper deals with a relatively small scale technology generation effort, rather location and very crop specific. Issues at different levels of the product channel were studied, and, although the study is of applied nature, rather elaborate data manipulation was needed. Still most conclusions of the study have to be drawn within a partial equilibrium framework, as can be derived from the simulation model and from the production monitoring problems. More comprehensive analytical methods could be developed, but they might well loose their versatility as a project forecasting mean or become available too late to influence major decisions. A structure, where the detailed analysis and modeling of a specific commodity system is linked with an aggregate general equilibrium model and iteratively corrected with new findings, might be the theoretically most advanced solution that still has sufficient applicability.

Ex-ante and ex-post evaluation should thus try to identify the project components that are most critical for successful technology generation and application. These components should then be the focus of the analysis and lead to rapid redirections of the planned strategy. The definition of precise hypotheses on technology generation becomes key to efficient and flexible resource use. Intimate knowledge of socio-economic conditions is needed to define these hypotheses, and requests "feet on the ground" knowledge of the analysts involved.

With respect to project design, a single crop single region technology generation effort as described in the present paper already requests complex analysis and integration of numerous components. This tends to suggest that technology generation efforts should limit their scope. Technology generation efforts that depend on components from many different crops or different levels in the commodity system might rapidly become too complex to be manageable or too diluted to be effective.

A last conclusion to be drawn is on the character of agricultural technology generation. Ruttan (1977) has made clear that technology generation is not an exogenous process. He writes that the understanding of farmer's and society's needs leads to a certain allocation of research resources. This allocation influences the speed of technology generation. The present paper supports these conclusions but would draw them even further. Technology generation is not only induced by research resource allocation, but as well by market forces. Technology generation reacts to demand pressure in a similar way as supply reacts. Absence of demand or obscured demand (by inefficient market channels or rigid quality criteria) reduces the momentum among the farmers population to search and test technological alternatives. Market instability reduces the inclination to experiment or to introduce new technology even further. Successful technology generation is intrinsically linked with the existence of promising, expandable markets, especially where concerns for small farm income are dominant. Where traditional markets are stable or deteriorating, market development, although speculative and risky, should have priority over production technology generation.

Appendix 1: The positive and normative procedures used to assess the impact of market risk and their advantages and disadvantages.

1) <u>The positive procedure</u>

Define:

AMR = Area planted at the existing price expectation

AWR = Area planted if the present price would have been guaranteed

ADM = Difference between AMR and AWR because of elimination of price variability

E(P)= Expected cassava price

PR = Subjective cassava price variance

YR = Subjective cassava yield variance

COV = Subjective covariance between yields and prices

OTH = Other factors that influence area planted

A simple function to express area planted could be as follows:

AMR = a + b*PR + c*YR + d*COV + (e + f*PR + g*YR +h*COV)*E(P) + i*OTH (1).

This equation assumes that the area planted has a linear dependence on price and other factors. The income variance is divided in a yield variance, a price variance and a covariance component. The squared covariance component has been left out, following Hazell. The variance components affect the intercept (through the first four terms) as well as the slope (through the terms within brackets).

The function to express area planted at contracted prices would be as follows:

$$AWR = a + c*YR + (e + g*YR)*E(P) + i*OTH \quad (2)$$

Now the price variance terms fall out because this has been eliminated. Since there is no price variance, covariance terms fall out as well.

For each farmer, one point at the original supply curve (1) was known, because price expectations and area planted had been asked. Supply curve (2) was estimated by means of the elicitation procedure in which farmers were asked about their planting behavior at guaranteed prices.

Now equation (2) can be subtracted from equation (1). This gives:

$$ADM = b*PR + d*COV + (f*PR + h*COV)*E(P) \quad (3)$$

This equation expresses the difference in area planted for an expected price versus a contracted price. This difference expresses the impact of price uncertainty on planting decisions. Within a cross section framework parameters b and d (that shift the intercept) and f and h (that shift the slope) can be estimated. Knowledge of these parameters allows estimations of the impact of non complete price stabilization on planting behavior by solving equation (3) for the observed differences.

2) The normative procedure

The normative procedure to estimate the impact of market risk consists in the development of a quadratic programming model:

$$\text{Maximize } E(u) = r'x + 1/2\ L\ x'Qx \quad (4)$$

$$\text{subject to:} \quad Ax \leq b \quad (5)$$

$$x,\ L \geq 0 \quad (6)$$

where r is a vector that represents income values of different farm activities, x is the vector that represents the level of these activities, Q is the variance-covariance matrix of the income values, A is the matrix of technical coefficients, b is a vector that describes resource availability and L is a scalar that weighs risk aversion versus expected income maximization. This model was specified for one of the major cassava producing areas of the region.

Dried cassava production would provide an outlet for cassava currently discarded and allow a floor price, in case prices in the fresh cassava market plunge. To calculate the effect on the expected price and on the price variance the cassava price to be paid by the drying industries was imputed for presently discarded cassava. As well for those points in the fresh market price probability function where fresh cassava prices are below drying industry prices, the drying industry price was imputed. In this way price expectations and variances with and without drying industries became known.

The effect of non complete price stabilization can be estimated by running the Quadratic Programming Model at the different combinations of price expectations and variances.

3) Advantages and disadvantages of market risk assessment procedures

The QP-model allows understanding of how farm organization will change because of improved cassava market perspectives. It indicates how supply of other products changes and evaluates technological changes in cassava production, by including alternative production technologies in the activities matrix. The elicitation approach has the advantage that it does not involve an estimation of the degree of risk aversion.

A problem encountered with both methods is that they are not sufficiently region specific. The elicitation analysis needs cross section data for supply curve estimations. By using the variability in the data to calculate an overall supply curve, it cannot use this anymore to estimate supply curve differences per department. In case of the QP-model data collection is timely and costly and could not be justified for the different departments.

Appendix 2: The procedure used to estimate dried cassava demand

Dried cassava is comparable or slightly superior to sorghum with respect to caloric contents. It is quite inferior in protein contents. A rough guideline would be that one ton of dried cassava plus 0.2 tons of soya would replace 1.2 tons of sorghum, This delivers the following price equation:

PCCS = 1.2*PSOR - 0.2*PSOY (7)

where:

PCCS = Price at which a ton of cassava competes with a ton of sorghum

PSOR = Price of sorghum per ton

PSOY = Price of soya per ton

Nevertheless LP-models calculate a shadow price for cassava of around 80% of the price of sorghum in chicken feed but close to 90% in pig feed. The willingness to pay for cassava depends on the (protein contents of the) diets produced by the manufacturer. Cassava will first enter those diets where its shadow price relatively to sorghum is highest.

This implies that an ordinary demand curve for dried cassava should be estimated. A questionnaire was sent to the animal feed industry to estimate demand at three different price levels. This delivered the slope for a dried cassava demand curve. Since dried cassava demand is also determined by its relative price with respect to sorghum, the slope coefficient was related with the difference between the real price of dried cassava and the price at which cassava would be competitive with sorghum, as determined in equation 7. The final demand equation for dried cassava had the following structure:

$$QCAS = a - b*(PCAS - PCCS) \quad (8)$$

Appendix 3: A brief description of the simulation model used to forecast cassava development in the Atlantic Coast Region

The model exists of six components (for more detailed information, see Janssen, pp 198 - 223). The first component is the consumption component. Fresh cassava demand equations are developed for different urbanization strata, a dried cassava demand equation is included and some secondary demand components are distinguished. Shift factors are included in the fresh cassava demand functions to simulate successful introduction of convenience increasing storage technology. Dried cassava demand is modeled as described before. Demand equations are linear.

The second component is about cassava production. Distributed lag functions are estimated for area planted, as well as for yield. Production is then defined as yield times area. Area and yield functions are shifted upwards for that part of the region where drying plants have stabilized market perspectives. Yields have a randomized nature.

The third component treats marketing and processing. Marketing margins for different urban strata are determined on the basis of farm gate prices. Shift factors are included to express the potential margin reduction if successful fresh cassava storage technology is introduced. Dried cassava processing costs and marketing costs are modeled.

The fourth component treats the development of the drying industry. This is made indigenous with respect to existing drying capacity, fresh market prices, potential dried cassava prices and realized drying profits. This component feeds directly back to the production component, by defining the part of the region where drying plants have been built and market perspectives stabilized.

The fifth component defines equilibrium conditions for the cassava system in the region.

The sixth component calculates potential project benefits. Four types of benefits are distinguished: foreign exchange saved by consuming dried cassava in stead of sorghum; employment in the cassava sector, in the rural as well as the urban areas; the discounted ten year producer surplus per farm size group; the discounted ten year consumer surplus for various types of rural and urban consumers and for the drying industry. By means of the project benefit parameters the planned cassava development can be evaluated with respect to the overall objectives of agricultural policy.

The model can be written as 45 condensed equations but involves the balancing of some 90 behavioral relations per year of simulation. The model was written in Fortran. To facilitate its use, a panel was designed to set the values of the most important parameters. Since the model has a stochastic nature 25 runs were made for each modeled situation.

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Table 1: Subjective yield and price probabilities for cassava

	Expected yield good year (10.5 tons/ha)	Expected yield normal year (7.3 tons/ha)	Expected yield bad year (4.2 tons/ha)	Average probability
Expected Price good market (US$0.114/kg)	0.07	0.12	0.17	0.36
Expected Price normal market (US$0.083/kg)	0.16	0.14	0.07	0.37
Expected Price bad market (US$0.055)	0.18	0.08	0.02	0.28
Average probability	0.41	0.34	0.26	
Expected price =	US$0.085/kg	C.V. =0.28		
Expected yield =	7.8 tons/ha	C.V. =0.33		
Expected income =	US$653/ha	C.V. =0.36		

Table 2: Main features of ex-ante technology development and impact assessment methods used in Atlantic Coast Project

Forecasting/project management method	Sources of information	Main focus of method	Methodological complexity	Disciplinary Orientation	Expected ex-ante reliability	State of the art of comparable methods
Market Risk assessment	personal interviews	Partial supply side analysis	high	farm economics	intermediate	sophisticated for production risk, less developed for market risk.
Alternative demand estimation	questionnaires by mail	Project growth, Possibilities	intermediate	market economics	good	well developed (marketing)
Simulation models	Previous analytical studies	Ex-ante impact comparisons	very high	Agricultural Economics	bad in absolute sense, good in comparative sense	methodologies available, applications are rare in ex-ante framework
Region selection	secondary data	Efficient Project design	low	geography	good	simple
Institutional Strength estimation	Key-informants	Expected project growth rate	high	Organizational Sciences	bad	absent

Table 3: The expected effect of price stabilization, as would occur by establishment of cassava drying plants, on area planted in cassava.

	Existing Situation	Expected Situation	Absolute Difference	Percentual Difference
Small Farm (3 ha)				
Elicitation Approach	1.54	1.96	0.42	27
Quadratic Programming	1.76	1.93	0.17	10
Middle Sized Farm (6 ha)				
Elicitation Approach	1.90	3.09	1.19	56
Quadratic Programming	2.84	3.97	1.13	40
Large Farm (15 ha)				
Elicitation Approach	2.23	3.83	1.60	72
Quadratic Programming	3.08	4.25	1.17	38

Table 4: Simulation Results for the cassava system in the Atlantic Coast Region of Colombia: Production, Consumption and Social Benefit Parameters

	1985*	A* 1994	B* 1994	C^1* 1994	C^2* 1994	C^3* 1994	C^4* 1994
Total production/year (tons)	480.878	497.001	551.886	666.137	682.471	698.738	678.255
Average yield (tons/ha)	6.82	7.10	7.44	8.20	8.50	8.35	8.25
Area planted large farms (ha's)	26.801	26.398	28.743	32.496	32.078	33.710	32.956
Area planted medium sized farms (ha's)	21.142	20.916	22.301	24.708	24.472	25.433	24.972
Area planted small farms (ha's)	22.502	22.344	23.076	23.699	23.583	23.983	23.821
On-farm cassava price (US$/kg)	0.085	0.076	0.088	0.082	0.81	0.85	0.85
Cassava consumption/cap., urban area (kg)	29.9	21.6	39.4	21.1	21.2	21.0	20.9
Cassava consumption/cap., rural area (kg)	80.6	63.7	83.3	62.2	62.6	61.7	61.5
Dried cassava consumption (tons)	4.089	4.681	3.494	80.108	84.880	95.797	88.593
Rural employment in cassava (man/years)	21.608	21.541	23.740	27.422	27.530	28.597	27.927
Producers surplus (million US$)	n.a.	—	20.6	33.3	33.1	50.8	35.8
Consumers surplus (million US$)	n.a.	—	40.0	-5.7	-4.3	-8.3	-6.5
Animal food industry surplus	n.a.	—	-1.9	7.2	8.5	8.1	7.0
total surplus	n.a.	—	58.7	34.8	37.4	50.6	36.3

1985 = Situation at start of the model

A = no drying industry development, no fresh storage development

B = fresh cassava storage successfully introduced

C^1 = successful development of cassava drying industry

C^2 = yield increase 50% above estimated increase

C^3 = drying industry grows at double the expected rate

C^4 = dried cassava demand grows at double the expected rate

Table 5: The potential to establish cassava drying industries

Major Criteria	Defined by	Reasons	Way of Measurement	Explanation
Production Potential	Land Availability	Land is needed to grow more cassava	Farm Size	Land available within the farm defines expansion potential.
			Types of Land Tenure	Secure land tenure increases continuity of production.
	Mechanization Possibility	Where partial mechanization is possible, production can be increased more.	Tractor Availability	Defines access of farmers to mechanization means.
			Land Topography	Defines feasibility of mechanization in the region.
	Potential Productivity	Alternative way to increase production, strong effects on net income	Cropping System	System has to allow cassava productivity increases.
			Soil Quality	Soil quality influence expected productivity gains.
Processing Potential	Fresh Market Competition	Vigorous fresh markets provide strong competition for roots	Present Market Access	Farmers with good market access will not be interested in alternative market development.
			Fresh Cassava Quality	Farmers with low quality cassava face more fresh marketing problems.
	Length of Dry Season	Lenght of dry season defines feasibility of sun-drying	Number of Dry Months	Each month more of drying increases plant occupation with 8%
	Institutional Presence	Needed for successful association formation and plant establishment	Number of Officials in the zone	Proposed technology development is strongly dependent on institutional intervention.

Table 5: The potential to establish cassava drying industries

Major Criteria	Defined by	Reasons	Way of Measurement	Explanation
Project Impact on the Region	Importance of Cassava within the region	Where cassava is important project will benefit more people	Absence of other crops and climatic /edaphologic conditions	In certain regions cassava is about the only way to earn an agricultural living.
			Off-farm Employment	Alternative employment defines the importance of cassava development.
	Present Institutional Support	Forgotten zones will benefit more from cassava development	Historical presence of of government institutions	If the region has been involved in many other projects, cassava projects will only bring marginal benefits.

Table 6: Scores on different factors, in order to define regional feasibility for establishing cassava drying plants

		Atlantico	Bolivar	Sucre	Cordoba
Production Potential	Farm size	0	4	1	3
	Type of land tenure	3	2	3	4
	Tractor availability	3	0	4	2
	Land topography	1	0	3	3
	Cropping system	3	3	1	1
	Soil quality	1	2	2	3
	Sub-total	2	2	3	4
Processing Potential	Fresh market access	1	3	2	3
	Fresh cassava quality	2	2	2	2
	Length of dry season	3	1	2	2
	Number of government officials	3	1	3	2
	Sub-total	3	2	3	3
Impact on the region	Absence of other crops	3	2	2	1
	Off-farm employment	2	2	3	4
	Historical presence of government institutions	1	3	2	2
	Sub-total	2	3	3	3

Note: scores on all factors are high if the score would favor drying plant development in the region and low it the score would indicate any obstacle.

Table 7. Evolution in the Number of Drying Plants by Department.

Department	Number of Drying Plants						Drying Area
	1981/82	1982/83	1983/84	1984/88	1985/86	1986/87	m^2
Córdoba	-	1	1	4	9	9	6,379
Sucre	1	3	3	7	12	12	12,252
Bolivar	-	-	-	2	3	3	1,516
Atlántico	-	1	1	3	4	4	3,000
Magdalena	-	2	2	3	4	4	4,420
Cesar	-	-	-	1	2	2	1,320
Total	1	7	7	20	34	34	28,925

Table 8. Percentage Increase in Area Sown of Cassava by Land Tenancy and Membership in a Farmer Association.

Land Tenancy	Member of Farmer Association		Non-Member of Farmer Association
	1984/85	1985/86	1985/86
Land Rental or Share Tenancy	36%	11%	- 25%
Land Owner	12%	32%	29%

Source: Monitoring Data.

Table 9: Evolution of costs and prices in 1983 constant prices during project existence, 1983-1987

Item	1983/84	1984/85	1985/86	1986/87
	1983 Pesos/t			
Price of Fresh Roots	4,980	4,870	5,340	5,100
Total Processing Costs [1]	14,895	14,280	15,719	16,855
Price Dried Cassava	17,180	18,220	18,770	20,454
Profit Margin	2,285	3,941	3,053	3,653
Conversion Rate [2]	2,53	2,38	2,43	2,57

1 Includes raw material costs

2 Fresh roots per unit of dried cassava

Table 10: Breakdown in dried cassava sales by market

Marketing Year	Atlantic Coast			Interior		
	Cartagena (%)	Barranquilla (%)	Medellin (%)	Bucaramanga (%)	Val (%)	Total (t)
1983/84	100.0	—	—	—	—	946
1984/85	37.5	15.8	15.6	3.2	4.9	3.006
1985/86	6.9	27.0	46.5	9.4	10.2	2.980
1986/87	9.5	14.8	67.7	6.7	1.3	3.853

Source: Monitoring data

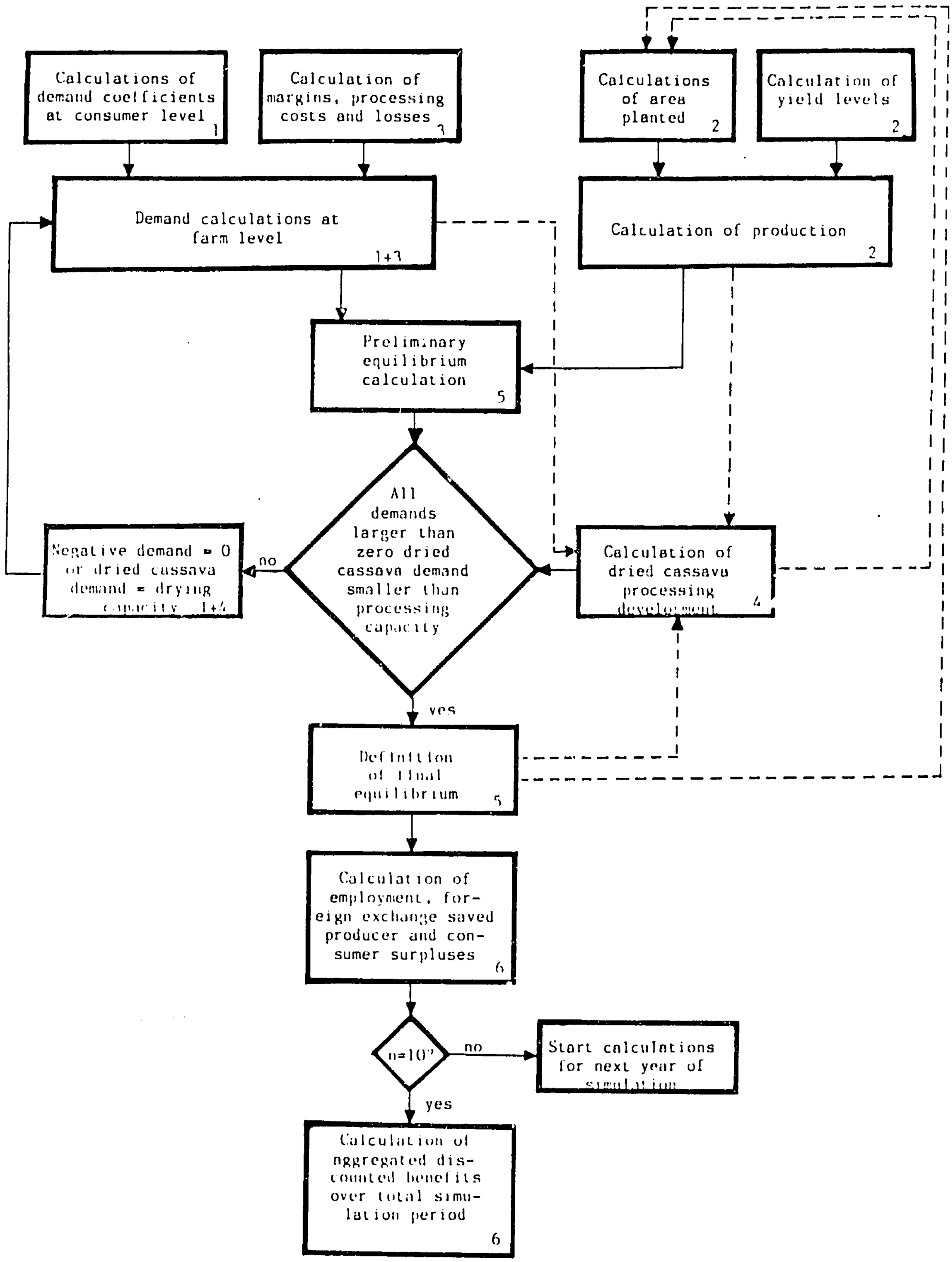

Figure 1. A schematic representation of the Atlantic Coast cassava system simulation model.
Notes: - Closed lines indicate the effect within one year of simulation, interrupted lines indicate the effect from one year to the other.
- Influence of exogenous variables has been omitted from the diagram.
- Numbers in left lower corner of each block correspond with model components as explained in text.

Figure 2. Atlantic Coast, Colombia: Increase in cassava area planted in 1985 over 1984 according to average cassava area planted in 1984.