A METHODOLOGY FOR THE TRANSFERENCE OF IMPROVED TECHNOLOGY IN THE CAQUEZA PROJECT *

by:

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INTRODUCTION

The rural sector in Colombia is one of an accentuated dualism. The traditional rural sector is characterized by low incomes near the subsistence level, little education, poor housing, small farm size, mountainous terrain, high population density, and traditional agricultural technology.

Over the years, national plans have concentrated efforts on the more developed, commercial sector. However, since 1966 attention has been focused on the traditional sector.

The Caqueza Project, one of six original rural development projects in Colombia, is a pilot project engaged in finding a methodology to increase incomes and to study the process of socio-economic change in the traditional rural sector.

The Caqueza area is typical inter-mountain, minifundista area, with a 1972 per capita income of US$ 86. The principles of the pilot project should be readily transferable to other traditional sector areas, and in fact have been largely incorporated in the new national rural development plan (see Appendix I).

This paper emphasizes one aspect of the Caqueza Project, the methodology of transference of improved technology. The concept of analytic evaluation, which attempts to identify and diminish constraints limiting adoption of new
technology, is explained. Two fundamental approaches — modification of the technological package and modification of institutional services — are explored, and factors of risk, credit, input costs, labor supply and marketing are considered.

THE CAQUEZA PROJECT: OBJECTIVES AND INSTRUMENTS

In 1971 the Instituto Colombiano Agropecuario (ICA) created the "Rural Development Project of Eastern Cundinamarca" (Caqueza Project), which had as its objectives: (9)

1) Accelerate productivity improvements and the process of socio-economic change.

2) Implement programs of informal education.

3) Coordinate the activities of institutional agencies which operate, or should operate in the region.

4) Develop advanced methods and systems to promote rural development and train technicians in these methods.

The Caqueza Project team is attempting to maximize the objective function: (2)

\[ D = f(\Delta K, Y_d, \Delta L) \]

where \( D \) = Development (acceleration of the socio-economic process)
\( \Delta K \) = Capital formation
\[ Y_d = \text{Income distribution} \]
\[ \Delta L_L = \text{Improvement in the level of living} \]

Six instruments are employed to implement these objectives. They are:

(9)

1) Improved agricultural technology for both crop and animal production, and adjusted over time to increase its appropriateness within the area.

2) Economic technology to improve the economic decision making process; e.g. increase in production of crops with favorable elasticities of demand, market structure improvements to reduce margins in favor of the producer, and evaluation studies of production efficiency.

3) Income utilization programs to reorient existant income expenditure and to direct increments in income produced by (1) and (2), through operational programs to improve nutritional level, quality of housing, family health, and other variables affecting the level of living. *

4) Communication systems to diffuse information to the campesino and government and private agencies. Extension activities, social organization

* For a complete explanation of the level of living strategy see: Escobar, G. and K.G. Swanberg. *Metodología para la investigación del nivel de vida como componente de una estrategia de desarrollo.* (Research methodology for the level of living as a component of a rural development strategy). Mimeoographado. CÁQUEZA, 1972.
groups, technician training, and publication of research results are the principle vectors.

5) Institutional service improvements to increase the efficiency, effectiveness and coordination of service agencies. Supplemental institutional service projects are also employed.

6) Evaluation process to appraise project activities and suggest improvements in basic strategies and tactics.

The Strategy.

The project team started investigating and defining traditional production systems. Basic improved agronomic technology existed, but an intensive process to adjust the production technology to the conditions of the region was initiated. The team concentrated on corn, potatoes, and their most common crop combinations, and considered factors such as varieties, fertilizer levels, pesticides, sowing densities, seed treatments, dates of sowing. Later, experiments were conducted on horticultural crops, also common in the area. These agronomic tests were performed in the project area and within the conditions of the campesino's production systems.

At the same time other activities were carried out by the project team. A socio-economic base line study of the area was completed. The home
economics program initiated work on informal education in nutrition, health, housing, and formed organized groups among housewives. A communication program executed the introductory promotion and started the extension activities by providing farmers with the partial results from the adjusted production technology.

To summarize, the project's action strategy may be explained by the following points:

1. The introduction of improved technology is the principle source of change. However, it should be introduced in such a fashion that the campesino will not face extremely difficult situations in terms of drastic changes.

2. The institutional arrangements are accepted as fixed in the project, e.g. the present land tenure and distribution systems, the formal educational level of the population, capital supply, availability of technicians, and the bureaucratic system itself.

3. The socio-economic base line research represents only one source of information. The evaluative activity was not very important at the beginning of the project, but was expected to measure the differential adoption rates of the suggested new technology.
A change in Strategy.

In the second year an analysis of differential adoption of the new technology for corn (6), indicated that the farmers adopted primarily those recommendations which did not increase cash inputs, such as density of sowing and date of sowing. Recommendations increasing cash costs, such as fertilizer and pesticide use, were not well received, even when credit was available.

It was soon realized that the evaluation activity has a roll to play in redefining the new strategy in each time period. Since that time, the evaluation program has included not only an appraisal of the technological adoption rate, but goes further to explain how such an adoption takes place, and—the most important issue—why the technological recommendation is not adopted as it was expected to occur. (16)

The new strategy—which has been stressed in the last two years—may be summarized as follows. With analytic evaluation, the bio-physical and socio-economic constraints limiting adoption are identified, and the adjustment of the production technology is oriented towards these constraints of labor supply, market structure, capital supply, capacity to absorb risk, and present crop combination patterns. In addition, means of diminishing the constraints faced by the farmer are explored through a critical analysis of institutional services and development of new activities outside the range of normal extension work, which supplement the existing institutional services.
A NEW DIAGNOSTIC OF THE STRUCTURE FOR AGRICULTURAL PRODUCTION

As a result of the "new strategy" it was possible for the project team to re-analyze the campesino's behavior in the face of the technological change to be introduced. The new diagnostic focuses on the identification of the campesino's needs, the consequences of introducing the new technology, and some of the constraints inherent in the farmer's production structure. The following aspects are considered.

1.1. What does the campesino need to introduce changes in his production patterns? From the institutional services point of view it may be said that there should be security in obtaining adequate information, a successfully proven technical recommendation, a marketing service, an adequately input supply, and a credit service.

1.2. What will the campesino not accept in the new technology? Many farmers in the Coqueza project area have resisted technical practices that have considerably increased the cash cost of production and that do not offer reasonable security of the same income that can be made under traditional production conditions.

1.3. What changes in the farm economic structure result from the new technology? Two years of research within the project area show that the most
important changes are: a) changes in production levels and net gains; b) changes in investment requirements; c) changes in the returns to land, labor and capital; d) changes in labor requirements; and e) changes in risk levels.

Although some of the change are in favor of the farmer, e.g., increase in production, net gains, and return to factors, it is evident that other changes are incompatible with the farmers' requirements and constraints. To solve the conflict between the requirements of the new technology and the farmers' constraints, the project team intensified the economic research activity. To explain such a process some of the research results will be summarized. The target of this summary is to illustrate the way in which the aforementioned questions were approached. From those results, the creation of the supplemental institutional infrastructure will be explained.

Because 63% of the cultivated hectares in the area were seeded in corn and 27% were seeded in potatoes*, these crops were emphasized in the biophysical research. The regionally adjusted recommended technology was based on more than thirty experiments carried out in small plots in the campesino's

* References to corn and potatoes include all combinations with other crops. Improved technology for these crops (e.g., sowing density) is adjusted to the most common crop combinations.
fields, using their traditional cultivation practices. Socio-economic research was also conducted. Tables 1 and 2 compare the traditional and recommended technology for corn and potatoes.

The corn recommendation increased production by 202% and net earnings by 25.3% (see Table 1), while the potato recommendation increased production by 51% and net earnings by 30%.

The technical recommendations were widely communicated to the farmers within the area, and at the end of the first year, an adoption rate analysis was carried out. The sample was drawn from producers who requested credit from the agrarian bank (Caja Agraria), the group which received the most concentrated technical assistance efforts. To simplify the presentation of this paper, more attention will be devoted to corn producers who are the biggest group of producers. Moreover, the adoption rate analysis shows that they have the lower percentage of adoption.

For the corn growers, the fertilizer adoption percentage was not very high. The second date of fertilization was adopted by only a small number of growers. Only 9% of the producers applied a quantity equal to the recommended one and no one applied the recommended quantity of fertilizer at the second fertilization date. It seems that those practices which cause a considerable increase in cash cost were rejected. On the contrary, the low

<table>
<thead>
<tr>
<th>Variety or hybrid</th>
<th>Traditional technology</th>
<th>New technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regional</td>
<td>H203 - H255 - H302*</td>
</tr>
<tr>
<td>Seeding density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rows per hectare</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>plants per 100 meters of row</td>
<td>90</td>
<td>125</td>
</tr>
<tr>
<td>plants per hill</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Fertilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-30-10</td>
<td>0</td>
<td>200 kg</td>
</tr>
<tr>
<td>Urea. First application (at seeding)*</td>
<td>0</td>
<td>25 kg</td>
</tr>
<tr>
<td>Urea. Second application (40-50 days after seeding)</td>
<td>0</td>
<td>125 kg</td>
</tr>
<tr>
<td>Pest Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ear worm (Heliothies spp.)</td>
<td>no control</td>
<td>control</td>
</tr>
<tr>
<td>Army worm (Spodoptora Rugiperda)</td>
<td>no control</td>
<td>control</td>
</tr>
<tr>
<td>Cut worm (Agrotis spp.)</td>
<td>no control</td>
<td>control</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average yield</td>
<td>907 kg/ha s.d (660)</td>
<td>2740 kg/ha s.d (1170)</td>
</tr>
<tr>
<td>Net Earnings **</td>
<td>US $ 58/ha</td>
<td>US $ 205/ha</td>
</tr>
</tbody>
</table>

* The recommended hybrid varies according to altitude.

** Exchange rate: 28 pesos = US$ 1.00


<table>
<thead>
<tr>
<th>Variety</th>
<th>Traditional technology</th>
<th>New technology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pardo, Pastusa</td>
<td>ICA-Guantiña</td>
</tr>
<tr>
<td>Seeding Density *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rows per hectare</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Holes per 100 meters of row</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>Tubers per hole</td>
<td>2-3</td>
<td>1</td>
</tr>
<tr>
<td>Fertilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-30-10 (at seeding)</td>
<td>750 kg</td>
<td>700 kg</td>
</tr>
<tr>
<td>Pest Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flea Beetle (Epitrix spp.)</td>
<td>poor control</td>
<td>control</td>
</tr>
<tr>
<td>Cut woom (Agrotis spp.)</td>
<td>poor control</td>
<td>control</td>
</tr>
<tr>
<td>Late Blight (Phytophthora infestans)</td>
<td>poor control</td>
<td>control</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average yield</td>
<td>11.280 kg/ha</td>
<td>17.040 kg/ha</td>
</tr>
<tr>
<td>s.d (9.710)</td>
<td></td>
<td>s.d (9.610)</td>
</tr>
<tr>
<td>Net Earnings **</td>
<td>US $ 313/ha</td>
<td>US $ 406/ha</td>
</tr>
</tbody>
</table>

* Seeding density was increased (more holes/ha). The tubers per hole were reduced because the new variety had bigger tubers and more buds and, as a consequence, only one tuber was required per hole to produce the same amount of branches.

** Exchange rate: 28 pesos = US $ 1.00

cost practices of variety, seeding density, and pest control, were reasonably well accepted.

TABLE 3. Adoption rates for the new corn technology. *

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>None</th>
<th>Inappropriate Amount</th>
<th>Appropriate Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid</td>
<td>17 %</td>
<td>(n.a)</td>
<td>83 %</td>
</tr>
<tr>
<td>Seeding density</td>
<td>(n.a)</td>
<td>16 %</td>
<td>84 %</td>
</tr>
<tr>
<td>Fertilization 10-30-10 (at seeding)</td>
<td>0 %</td>
<td>91 %</td>
<td>9 %</td>
</tr>
<tr>
<td>Fertilization Urea (at seeding)</td>
<td>83 %</td>
<td>17 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Fertilization Urea (at 40-50 days)</td>
<td>52 %</td>
<td>48 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Pest control</td>
<td>17 %</td>
<td>42 %</td>
<td>41 %</td>
</tr>
</tbody>
</table>


Knowing the adoption rates of the new technology, the next step was to compare the changes caused by the recommendations with the most important variables identified in the "new diagnostic". This is what the project team has called "identifying causes for partial new technology adoption".

From the institutional services point of view, two of the campesino's requirements were fulfilled: adequate information and a successfully proven technical recommendation. The market structure was able to absorb the
increased regional production. However, the supply of the improved potato variety was insufficient to satisfy the demand. For corn, no major input shortages were recorded.

The most important economic relationships for corn are presented in Table 4. The upper part of the table is devoted to the negative changes caused by the new technology, and the lower part presents the positive aspects of the technical recommendation. It is clear that the negative changes are in conflict with the variables which have been rejected by the campesino, e.g., the increment in cash cost of production, and the increased risk.

For a farmer who is close to the subsistence level, an increase of 1530% in the expected value of loss of cash inputs is a serious matter. To understand the meaning of the risk factor, it is useful to compare cash requirements of the new technology with average disposable income in the area. Data obtained in 1973 demonstrated that the average income per hectare was US$ 235 (8). From another study carried out in 1974, it was learned that the average food expenditure was US$ 178/ha. at 1973 prices (13). Hence, farmers had only US$57/ha. in cash for investment in the production system. The new technology investment was US$ 142 in 1973 rather than US$ 21 which was required with traditional technology. Farmers, in order to adopt the new technology, must enter the credit market (17).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Traditional technology</th>
<th>Recommended technology</th>
<th>% of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost</td>
<td>85</td>
<td>229</td>
<td>170</td>
</tr>
<tr>
<td>Cash costs for material inputs</td>
<td>21</td>
<td>142</td>
<td>575</td>
</tr>
<tr>
<td>Return to cash invested in material inputs</td>
<td>3.75</td>
<td>2.44</td>
<td>-58</td>
</tr>
<tr>
<td>Expected value of the loss* function using total cost</td>
<td>37</td>
<td>78</td>
<td>111*</td>
</tr>
<tr>
<td>Expected value of the loss* function using cash cost for material inputs</td>
<td>3.25</td>
<td>53</td>
<td>1530*</td>
</tr>
<tr>
<td>Production (kg/ha)</td>
<td>907</td>
<td>2740</td>
<td>202</td>
</tr>
<tr>
<td>Net gain</td>
<td>58</td>
<td>205</td>
<td>253</td>
</tr>
<tr>
<td>Labor returns (/men-day)</td>
<td>3.07</td>
<td>5.10</td>
<td>73</td>
</tr>
<tr>
<td>Land return (/hectare)</td>
<td>95</td>
<td>241</td>
<td>155</td>
</tr>
<tr>
<td>Total investment returns</td>
<td>1.68</td>
<td>1.89</td>
<td>13</td>
</tr>
<tr>
<td>Probability that gross income will be less than total cost</td>
<td>0.28</td>
<td>0.13</td>
<td>-53</td>
</tr>
<tr>
<td>Probability that gross income will be less than cash cost for material inputs</td>
<td>0.12</td>
<td>0.06</td>
<td>-50</td>
</tr>
<tr>
<td>% of return on incremental cost</td>
<td></td>
<td></td>
<td>141</td>
</tr>
</tbody>
</table>

* See Appendix III.

The recommended technology for potatoes does not introduce major changes in investment requirements, which may be one reason it was more widely accepted.

Sixty-five percent of the families in the Caqueza area use credit. The major source is the agrarian bank (Caja Agraria). Production capacity is not considered when granting credit, and a long bureaucratic process makes the credit expensive to obtain, and often untimely. The average real cost of credit is equivalent to 43% interest. (14) This rate exceeds the current inflation rate (20%) and the opportunity cost of capital (30%) in Colombia. However, productivity in the traditional cropping systems is generally high enough to justify the use of credit.

The introduction of new technology caused changes not only in economic relationships, but also in other variables at the regional level which could intervene in the adoption process. A labor study carried out in the area of the Caqueza Project (10) shows that the labor demand is not constant throughout the year. During peak periods of labor utilization, at planting and first weeding, the region is close to full employment.

The new technology labor requirements appear in Table 5. The increase in labor requirements for corn is substantial, especially because of the two fertilizations, pest control, and increase in total production.
TABLE 5. Labor requirements for corn and potatoes with traditional and new technology, 1975.

<table>
<thead>
<tr>
<th>Product</th>
<th>Traditional technology requirements (man-days)</th>
<th>New technology requirements (man-days) (two fertilizations)</th>
<th>Percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>43</td>
<td>111</td>
<td>258</td>
</tr>
<tr>
<td>Potatoes</td>
<td>164</td>
<td>158</td>
<td>11</td>
</tr>
</tbody>
</table>


It has been estimated that the full employment level will be exceeded if all growers adopt the new technology (see Figure 1A). This may be one reason for the low adoption rates in corn, especially for the second fertilization, which should occur in April and May. Figure 1B will be explained on page 22.

Differential adoption rates, caused either by seasonal labor shortages or by cash constraints has serious implications. Farmers who used the hybrid seed corn without fertilizer expressed dissatisfaction with total production. Hybrid seed is not superior to traditional varieties over the entire range of the production functions (see Figure 2). Because of the strong positive interaction between hybrid seed and fertilizer (17), the farmer is better off using the traditional varieties, unless the complete technological package is applied.
TOTAL EMPLOYMENT WITH IMPROVED TECHNOLOGY IN CORN AND POTATOES - TWO FERTILIZATIONS

FIGURE 1 A

TOTAL EMPLOYMENT WITH IMPROVED TECHNOLOGY IN CORN AND POTATOES - ONE FERTILIZATION

FIGURE 1 B

Figure 2. Corn Production Functions.

Improved technology

Traditional Technology

\[ Y = 1.90 - 0.76V + 1.328N + 0.52NV - 0.228N^2 \]

Where:  
- \( Y \) = Production of corn in tons/ha,
- \( V \) = Traditional (0) or hybrid (1) seed,
- \( N \) = Nitrogen fertilizer in units of 100 Kgs.

The most important negative changes caused by the new technology may be summarized as follows:

1) Total costs and total cash costs increase substantially for corn production. The producer is forced to enter the credit market.

2) The expected value of loss increases spectacularly with the recommended technology. This implies that the corn producer must accept a much higher level of risk.

3) The new technology labor requirements are higher than in the traditional system. Labor demand exceeds labor supply at the peak period if the new technology is widely adapted. As a consequence, the shortage of labor retards the expected physical production of the new technology.

4) There also exist problems in the institutional infrastructure. Improved potato seed available in the region was insufficient to meet demand. The existing credit service is bureaucratic, expensive, and often untimely. Although the marketing structure was able to absorb increased potato and corn production, difficulties were encountered when an improved technology increased production in beets, onions, lettuce, and cabbage. Little irrigation is used in the area and the harvest is concentrated in short time period, when prices are at the minimum. Many farmers suffered a net loss, even with higher production levels. Studies carried
out by the project team show that market intermediaries work under atomistic internal competition, although the average commercialization margin is high due to under-utilization of equipment. (4)

Confronting the adoption constraints: four tactics.

1) The Caqueza Project team developed "production plans", or supplemental institutional services. These mechanisms were introduced into the project activities as experiments, useful in learning more of the project area, and to be adjusted over time. The fundamental ideas of the plans are to reduce the cash requirements of the farmer for the new technology, and to share some of the uncertainties and risks. (12)

In 1974, twenty-seven corn growers were involved in the "corn production plan" which was administrated by a farmer's cooperative. A farmer who participates receives from the plan appropriate quantities of hybrid seed, fertilizers, and pesticides. He signs a contract, pays an inscription fee of US$ 10 per hectare, and promises to use the complete recommended package. The plan offers to the participant a guarantee such that if his production is below a certain yield per hectare (800 kg), he does not have to pay for the interest or the material inputs which he received in kind. When total production exceeds the minimum level, the farmer pays to the plan in kind his yield above 800 kg, with a maximum payment of 900 kg/ha. Production above 1700 kg/ha belongs to the producer.
With the production plan, all the negative factors of the new technology have been reduced. Returns to total investment and cash investment are improved, and input and credit supply are guaranteed. The expected value of the loss function using cash costs is reduced from 1530% (without plan) to -85% (with plan) in relation to the traditional production loss function. Table 6 presents some comparisons.

TABLE 6. Comparison of the traditional technology, recommended technology and corn production plan. (US$ per ha.) 1975.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>A Traditional technology</th>
<th>B Recommended technology</th>
<th>C Corn production plan</th>
<th>Percentage Change (A and C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash investment by farmer</td>
<td>21</td>
<td>149</td>
<td>31</td>
<td>48</td>
</tr>
<tr>
<td>Net gain of farmer</td>
<td>61</td>
<td>214</td>
<td>175</td>
<td>186</td>
</tr>
<tr>
<td>Returns to total investment</td>
<td>1.68</td>
<td>1.90</td>
<td>3.42</td>
<td>104</td>
</tr>
<tr>
<td>Returns to cash investment</td>
<td>3.75</td>
<td>2.44</td>
<td>6.42</td>
<td>71</td>
</tr>
<tr>
<td>Expected value of the loss function using total cost</td>
<td>37</td>
<td>82</td>
<td>39</td>
<td>5</td>
</tr>
<tr>
<td>Expected value of the loss function using cash cost</td>
<td>3.25</td>
<td>55</td>
<td>0.50</td>
<td>-85</td>
</tr>
</tbody>
</table>


Financial aspects of the corn plan have been satisfactory. Initial 1974 capital was US$ 3,500, and has been growing about 20% per year. With the increased capital base, the number of participants has expanded 67%, to 45 farmers in the 1976 plan. Capital increases have also financed, in part, new production plans in onions, tomatoes, and peppers, which are slightly modified versions of the corn plan.

Lack of capital to increase the expansion rate of the plans, control of cheating, and full participation by the cooperative are the major problems with the plan.

A 1976 study, after two years of experience with the plan, indicates that plan participants have adopted 91% of the recommended practices of the technological package. For the same year, producers who used only credit and technical assistance adopted 19% of the technological package. (3) Figure 3 presents a summary of the adoption rates measurements in which four different credit-technical assistance groups are compared. The supervised credit system will be explained in part 4 of this section.

2. In order to reduce peak period labor demand required by the recommended package, nine experiments were carried out in 1973 and 1974. It was found that experiments of one fertilizer application 25 days after seeding yield the same as experiments using two fertilization dates (17). This advance has reduced labor requirements of the new technology 11 man-days per hectare. (10) (See Figure 18).
FIGURE 3. Adoption rates of the new technology for corn by different credit-technical assistance groups. 1976.

% Adoption

Corn production plan

Supervised credit
(ICA-Caja Agraria agreement)

Traditional credit

Without credit

Years

The implication of such a change in labor requirements is very important at the regional level. With traditional corn technology, labor is under-utilized. \( \frac{MV_{PL}}{PL} = 0.428 \). Among corn growers who have adopted the new technology with one fertilization, labor is over-utilized. \( \frac{MV_{PL}}{PL} = 2.86 \). (11) More analysis is needed to explain why the efficiency of labor changed from under-utilization to over-utilization, and to discover methods of moving the labor efficiency ratio closer to 1.

3. The project team is also working on marketing problems, which are a substantial source of uncertainty, especially with horticultural crops. A theoretical analysis indicates that vertical and horizontal integration are necessary to improve the marketing structure. It would facilitate classification of products and would achieve greater efficiency through fuller use of labor and equipment with increased volume. Marketing margins would be reduced and prices paid to farmers would improve.

Due to the inadequacy and rigidity of existing market channels, the project team with a farmer organization opened in 1974 a new vertically integrated channel on an experimental basis. A Bogota warehouse was obtained as a center for storage, classification, repackaging, and distribution to final retailers. At first, these services were available only to producers from the Caqueza Project, but later producers from two other areas (Arbolaoz and La Mesa) were incorporated to guarantee a permanent product supply to the
retailers who participated in the plan. (14)

Due to lack of experience, gross margins during the first four months of operation were negative, but later reached 16%. In 1975 and the first semester of 1976 the marketing project was disfunctional for lack of administrative funding. Producers of the three areas are organized, and retail outlets have been contacted to reiniciate commercial activities when funding again becomes available. There is still not enough data available to assure an adequate analysis of the impact of the marketing project.

4. One approach to solve credit problems has been through production plans. However, for the immediate future, these plans will reach only a limited number of producers. ICA and the agrarian bank (Caja Agraria) signed a national agreement in 1972 to improve the credit system. Supervision by ICA assures the farmer of a more appropriate amount of credit and adequate technical assistance. The agreement has had some impact, as can be seen in Figure 3. However, an investment plan is required for each farmer, bureaucratic requirements are high, and timeliness is still a problem. In the new national development strategy (DRI) (see Appendix I), the amount of credit available to the farmer is larger.
Conclusions.

This paper has emphasized the crucial role played by the methodology of transference of improved technology in the Caqueza Project. The major component of the methodology, analytic evaluation, attempts to identify the important constraints limiting adoption and diminish these constraints by two different approaches. An integrated project team engaged in constant socio-economic and bio-physical research should suggest and implement adjustments in the technical package to make it more appropriate to farmer conditions. The labor adjustment described previously is an example. A second approach involves adjustment in the institutional infrastructure which may hinder the adoption process. The supervised credit program is an example. However, adjustments of existing institutional services are usually not possible. The Caqueza Project has demonstrated that other alternatives, such as the production and marketing plans, are useful in diminishing the constraints limiting adoption.
THE INTEGRATED RURAL DEVELOPMENT PROGRAM.

In 1975 the national planning office designed a national development plan, of which the Integrated Rural Development Program (DRI) is a part. The first five year plan has a budget of US$230 million, is concentrated in six large areas of the country, and will service 85,000 inhabitants. The DRI program constitutes official recognition that multiple sector activities are necessary in a rural development program. Twelve governmental institutes work together in three broad areas:

a) The productions component which includes technological research, technical assistance, credit, marketing, and an agricultural labor capacitación program;

b) The social infrastructure component which includes a health service, a formal education program, and an agro-industrial program; and

c) The physical infrastructure component which includes programs in road construction, rural electrification, and public services. (5).

The two basic objectives of the program are: a) increase the efficiency of the market linkages between the farm economy and the national economy; and b) increase real income, production, productivity, and employment in the rural sector. The Caqueza rural development project has similar objectives and instruments, although more limited, and was one of the principle models of the national DRI.
APPENDIX II

GEOGRAPHICAL AND PHYSICAL CHARACTERISTICS.

The Cauca project is located in the eastern part of the Department (State) of Cundinamarca which is situated in the middle region of the country.

It covers 277,000 has, which are divided into nine municipalities (counties). Four of these municipalities, Cauca, Ubaque, Chipaque, and Une, have been the focus of the project's action. These municipalities represent 37% of the total area and nearly 72% of the population.

Approximately 40% of the land in the project is not suitable for agricultural production due to topographic limitations. Altitudes range from 1,000 m.o.s.l. to 3,900 m.o.s.l. and slopes range from 10% to more than 50%. Differences in elevation create a wide range of temperatures and cropping systems. The rough topography makes the use of machinery impossible in most places (1).

Only a very generalized soil map is available of the project area. It shows that the land falls into classes III, IV, V and VII in the U. S. soil conservation classification system, which indicates significant erosion, poor drainage and high levels of claypan (1). The soil tests performed by the project team show that the level of organic matter, nitrogen, phosphorus and potassium are highly variable.

The rain pattern affects the timing of production activities. In general, the project area has a dry and a rainy period. Rains begin in the
middle of March and reach a maximum in June or July. In September a new short rainy period starts and lasts a month. The precipitation ranges from 951 mm to 2,236 mm, and varies with the altitude (8).

LAND DISTRIBUTION AND TENURE SYSTEMS.

Farm size is, in general, very small. On the average, there are 1.27 has. of permanent crops and 1.11 has. of annual crops per farm. Larger farms are limited by topographic characteristics or are in forest. Table A contains data about farm sizes.

The Caqueza project area can be stratified into two basic crop zones. The higher, or potato zone has a higher economic return per hectare than the lower corn zone.

In 1970, 11% of the total Caqueza area was in annual crop production, 3% in permanent crop production, 34% in pasture, 31% in forest, and 21% not utilized. The zone contains 13,836 exploitation units, and 15,909 hectares in annual crop production (8). Table B demonstrates the diversity of crop production patterns.

More than 80% of the farm units are owned by their operators, 18% are renters, and less than 1% belong to other tenure classes.
<table>
<thead>
<tr>
<th>Size (Has.)</th>
<th>% Exploitations</th>
<th>Cumulative percentage</th>
<th>% area (Has.)</th>
<th>Cumulative percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>9.9</td>
<td>9.9</td>
<td>0</td>
<td>9.9</td>
</tr>
<tr>
<td>1.1 - 3</td>
<td>34.6</td>
<td>44.5</td>
<td>2.5</td>
<td>28.5</td>
</tr>
<tr>
<td>3.1 - 5</td>
<td>20.2</td>
<td>64.7</td>
<td>28.5</td>
<td>28.5</td>
</tr>
<tr>
<td>5.1 - 7</td>
<td>11.8</td>
<td>76.5</td>
<td>11.1</td>
<td>39.6</td>
</tr>
<tr>
<td>7.1 - 9</td>
<td>6.2</td>
<td>82.7</td>
<td>96.1</td>
<td>57.7</td>
</tr>
<tr>
<td>9.1 - 11</td>
<td>4.2</td>
<td>86.9</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### TABLA B. COMMON CROP COMBINATION EXTENSIONS AND YIELDS.

<table>
<thead>
<tr>
<th>COMBINATIONS</th>
<th>Has.* (1970)</th>
<th>TRADITIONAL AVERAGE YIELD (Kgs/Ha.)(1973)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn - beans</td>
<td>2663</td>
<td>881 - 135</td>
</tr>
<tr>
<td>Corn - broad beans</td>
<td>2507</td>
<td>1010 - 257</td>
</tr>
<tr>
<td>Corn - beans - broad beans</td>
<td>1897</td>
<td>977 - 93 - 92</td>
</tr>
<tr>
<td>Corn</td>
<td>476</td>
<td>900</td>
</tr>
<tr>
<td>Potatoes - pêas</td>
<td>1569</td>
<td>9145 - 29</td>
</tr>
<tr>
<td>Potatoes - beans</td>
<td>1269</td>
<td>6821 - 457</td>
</tr>
<tr>
<td>Potatoes</td>
<td>312</td>
<td>9500</td>
</tr>
<tr>
<td>Peas</td>
<td>957</td>
<td>240</td>
</tr>
<tr>
<td>Cassava</td>
<td>404</td>
<td>unknown</td>
</tr>
<tr>
<td>Onions</td>
<td>475</td>
<td>9245</td>
</tr>
<tr>
<td>Beets</td>
<td>355</td>
<td>4961</td>
</tr>
<tr>
<td>Lettuce</td>
<td>230</td>
<td>4164</td>
</tr>
<tr>
<td>Cabbage</td>
<td>195</td>
<td>5112</td>
</tr>
</tbody>
</table>

* Data: Drawn from the 1970 National Agricultural Census and modified by a crop combination frequency study conducted in the Caqueza area.

POPULATION CHARACTERISTICS.

In 1975 the estimated total population was 92,414 inhabitants. In 1970, 85% lived on farms and the remainder lived in villages.

In 1972, 45% of the population was under 15 years of age, and 54% was younger than 40 years old. The average family size was 7.51 persons, and the population density was estimated at 41.4 inhabitants/km² in 1975. However, because of unequal distribution of cropping land within the area, the population density is much higher in some places. In Caqueza County the population density for 1975 was estimated at 168 inhabitants/km².

The 1970 census data show some evidence of rural migration from the project area. In 1972, seasonal migration was registered in 22% of the households. The regional population is increasing about 2% year, which is significantly smaller than national rate. This suggests a large migration from the region-probably to Bogotá - among young people.

EDUCATIONAL CHARACTERISTICS.

The school-age population represented 24% of the overall population in 1970. Of these, only 72% were registered as formal students.

The educational level of the entire population is low. A 1972 survey showed that 27% of the population had never gone to school. This proportion is being reduced, but only at an estimated rate of 1.2%/year.

There are 227 primary schools in the area, most of them in the countryside. There are 18 secondary schools.
The degree of informal education has not been measured. However, through the project team experience it is known that many people who went to primary school cannot be considered functionally literate.

THE NUTRITIONAL STATUS.

A nutritional study in the Caqueza project has shown that the nutritional quality of the diet is fairly acceptable in terms of protein, calories, niacin and riboflavin. Other nutrients, particularly vitamin A and calcium are deficient. Consumption of iron, thiamine, and vitamin C are more than adequate. (13).

The study reports that children obtain a more adequate diet than adults, regardless of income level. For example, the protein consumption level was higher in the pre-school group than in other age groups.

Food consumption is, in general, highly related to income. However, deficiencies in certain nutrients (vitamin A) are not income dependent. It was reported that food consumption quality varies according to the altitude. The population in lower altitudes has a poorer diet than the population in higher altitudes, probably because of the lower average income in the lower zone.

COST OF THE PROJECT.

Two institutions have funded the Caqueza project: the Instituto Colombiano Agropecuario (ICA) and the International Development Research Center of Canada (IDRC). IDRC's contribution has paid for advisors (12 man-years), cost of the communication equipment, five cars, a training center, and some
experimental expenses. ICA has paid for most operational expenses and
the colombian technical staff. The average technical staff has included
7 professionals, 16 technical assistants, 2 secretaries, 3 chauffers, and
1 unskilled worker.

A rough, unofficial estimation of the project cost from 1971 to 1975
is as follows:

ICA contribution : U.S.$ 400,000
IDRC contribution : U.S.$ 474,000
U.S.$ 874,000

Average cost per year is U.S.$ 174,800. These figures do not include
the value of scholarships for two members of the project team and indirect
support through the graduate school of ICA- National University.
MATHEMATICAL DERIVATION OF THE EXPECTED VALUE OF THE
LOSS FUNCTION

Let \( f_q(y) \), the probability density function of yields \((y)\) for a crop in a given zone \((f_q)\), be defined as follows:

\[
f_q(y) \sim N(u, \sigma^2)\]

\( f_q \) is a normal function with a mean, \( u \), and a variance, \( \sigma^2 \).

Let the loss function, \((f_1)\), be defined in terms of costs, yields, and prices in the following way:

\[ f_1(y) = C - yp \]

Where:

- \( C \) = Production costs (total or cash for material inputs).
- \( y \) = Yield in kilograms.
- \( p \) = The price per kilogram of product.

In this study, the specified loss function is not an actuarial function, in the sense that it does not accept negative values (see Halter and Dean, 1971).

The loss function is then defined as:

\[ f_1 = C - yp \text{ for } C \geq yp \text{ or } y \geq \frac{C}{p} \]

and
\[ f_1 = 0 \text{ for } C \leq y_p \text{ or, } y \geq \frac{C}{p} \]

Hence, the expected value of the loss (1) will be:

\[ E(1) = \int_{-\infty}^{+\infty} f_1(y) f_q(y) \, dy \]

or

\[ E(1) = E(C - y_p) \text{ for } y \leq \frac{C}{p} \]

\[ E(1) = C - (p \cdot E(y)) \text{ for } y \leq \frac{C^*}{p} \]

or

\[ E(1) = C - (p \cdot E(y \mid y \leq \frac{C}{p})) \]

In this way expected value of the loss can be calculated from production costs, product prices, and the expected value of the truncated normal distribution for yield.

There are three reasons why it was decided to use the expected value of the loss function as an estimate of risk for the small farmer. Two of them are based on the importance that the negative extreme of the net gain function (to the left of the equilibrium point where net gain equals zero) has for the small farmer.

1) The estimate takes into account the value of production costs in the sense that this measurement can compare technologies with equal average gains and variances, but different costs.

2) In addition, it permits classification of technologies whose accumulated density functions intercept below the point of equilibrium.

* This calculation assumes that product price and production costs are independent of yield.
3) Finally, the expected value of the loss function can be expressed in monetary terms, which facilitates comparison of production alternatives in different regions. The possibility of adding the expected loss values also permits comparison between combinations of alternatives and the use of this measurement of risk in the development of linear programming analyses.
SELECTED BIBLIOGRAPHY


