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RELATIVE PROFITABILITY OF IMPROVED ON-FARM WATER MANAGEMENT PRACTICES AMONG TENURE CLASSES IN MILAGRO COUNTY, ECUADOR

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The object of the study is consideration of the profitability of private investment in on-farm irrigation capital before public funds are committed to project enlargement. The relative profitability of such private investments among tenure classes is also a consideration.

A comparison, by tenure class, of returns to area farmers without irrigation vs. those having supplemental water indicates internal rates of returns are associated with the larger size farms. A test of the sensitivity of these results to a range of yields, prices and costs reveals that, for all tenure classes, the internal rate of return remains well above 12% except in the most pessimistic of simulated production conditions.

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UTAH WATER RESEARCH LABORATORY PRWG 69-10

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MARCH, 1973

ABSTRACT

RELATIVE PROFITABILITY OF IMPROVED ON-FARM WATER
MANAGEMENT PRACTICES AMONG TENURE CLASSES IN
MILAGRO COUNTY, ECUADOR

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Utah State University

Morris Whitaker
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A test of the net worth of a whole "package" of modern inputs raises some question about whether the inputs other than the water will pay off at a rate above the opportunity cost of capital (12%).

ACKNOWLEDGEMENTS

This report is the result of a cooperative effort in Ecuador involving Instituto Ecuatoriano de Recursos Hidráulicos, USAID/Ecuador, and Utah State University. Many people have contributed to the study. Engineers Lionel López and Miguel Chehab of INERHI were extremely helpful in conceptualization of the study, and in facilitating the research. Direct support was given by Carlos Calderón of the Quito office, and Eng. José María Rodríguez and Gustavo Salazar in the Guayaquil and Milagro offices. Richard Winters and Neil Fine, Agriculture Division, USAID/Ecuador resolved logistics problems and gave their support to the study. David Daines (U.S.U. Water Management Program - Law), assigned to INERHI, was directly involved in management of the field research. To all these people we offer our thanks.

Phillip Lloyd was the USU student responsible for most of the field work. He worked directly with Señores López and Calderón of INERHI. This report is based upon his M.S. thesis.*

Financial support for the field research was provided partially by an Institutional Development Grant (211-D) to Utah State University from the United States Agency for International Development (AID/csd-2459). INERHI provided all in-country transportation plus lodging in Milagro. Arrangements for field research, management, all technical support, research design and reporting (other authors) was supported under contract AID/csd-2167 between United States Agency for International Development

*"Impact on Rural Incomes of Improved Water Management Practices in Milagro County, Ecuador." Unpublished M.S. thesis. U.S.U. Library. 1972.

and Utah State University. Coordination was provided by Dr. Howard B. Peterson of Utah State University.

All reported conclusions or opinions are those of the authors and are not intended to represent the official or unofficial positions of INERHI, USAID/Ecuador, TAB/USAID, or GOE.

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SUMMARY

The Government of Ecuador (GOE) is seeking ways to increase food production, increase employment and worker productivity, and equalize distribution of income.

One strategy to increase food production and raise productivity and income of campesinos utilizes development of irrigation projects coupled with agrarian reform.

In Ecuador, the Ecuadorian Institute of Hydraulic Resources (INERHI) plays a central role in this strategy as it is responsible for developing and protecting Ecuadorian water resources.

INERHI currently administers six separate public irrigation projects covering 19,620 hectares. It is the concessionaire for the GOE for water sales in these projects; it delivers and measures water to users, maintains diversion and distribution systems, and collects the water tariffs. INERHI also plans and constructs new projects. The data for the present report comes from one of these projects which is in operation in Milagro County, in the Guayas Basin.

The Milagro project currently irrigates over 7,000 hectares or approximately 38% of the land using irrigation water from INERHI projects. Current plans call for the expansion of the Milagro project to irrigate an additional 7,800 hectares.

Under the existing law the cost of amortizing the project and of annual maintenance must be recovered from the water tariffs levied on users. That is, water users bear the cost of project construction and maintenance; in addition such users must invest in their own on-farm

irrigation systems, since the project only delivers water to farm boundaries.

Before public funds are committed to enlargement of the Milagro project it is important to consider profitability of private investment in on-farm irrigation capital. Given the interest in income distribution, the relative profitability of such investment among various tenure classes also should be considered.

Consequently, as part of Utah State University's water management research program, USU agricultural economists, INERHI and USAID/Ecuador, developed a plan of work and methodology to answer the above questions. The basic approach used to assess profitability of on-farm water management investment is to calculate net returns achieved by farmers using traditional methods and no irrigation, (I_1) vs. those using traditional methods and irrigation (I_2). The difference in net returns between the two kinds of farms is assumed to be the return to the private irrigation capital and water, assuming all other factors of production are homogeneous.* Data are from sample surveys of farms with project water in 1968 and without project water in 1971. This base is supplemented by personal interviews in the project area, and by the Charles T. Main report (6).

The difference in net returns is treated as an income stream over the life of the irrigation capital, and the rate or return is found which equates the present value of this stream with the cost of the on-farm irrigation capital in year zero.** This rate is known as the internal

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*The homogeneity assumption is borne out by the fact that there is a common micro-climate, common market prices, etc., and that there is no significant difference in irrigated and nonirrigated farm size among tenure classes.

**Thus, the calculation of annual net returns for the farms using irrigation excludes allowance for annual depreciation and interest on the private irrigation investments.

rate of return. Such calculations are made for four tenure classes, minifundios, family farms, extended family farms, and latifundios. Comparison of the internal rates of return indicates relative profitability has an inverse relationship to tenure class. At current prices, yields and water tariffs, minifundios earn 44% on their investment, and this scales down to latifundios which earn 24%.

Rates of return are also calculated, assuming simulated yields, product prices, and factor prices. Yields are allowed to vary from 80% to 120% of 1971 levels, and product prices from 70% to 110% of 1971 levels (10% increments). Costs are allowed to rise to 105% and 110% of 1971 levels. For all tenure classes, and all but the most pessimistic of the simulated production conditions, the internal rate of return remained well above 12%, (12% is considered to be the cost of production loans). In all simulated situations, the highest rate of return is always greatest on the smallest size farms.

Irrigation project planning is often based on studies which assume that the water supplies will be combined with modern inputs including high yielding seeds, fertilizers, etc. To allow for these expectations, net returns for probable crop rotations are calculated for another type of farm. These are farms expected to adopt irrigation and modern inputs (I_3). The difference between average net returns on this type, compared to those without project water, is assumed to be the return stream for adopting a complete "package" of modern inputs and cultivation techniques.

The expected internal rate return for the modern situation is calculated for all tenure classes using 1971 yields and prices plus simulated yields and prices as mentioned above. Under 1971 conditions, the family farm class has the highest return at 49.09%, followed closely by the extended family farm class at 49.43%. The minifundista earns only 39.63%, while the latifundista earns 32.57%.

This procedure generates two sets of internal rates of return: one to irrigation capital plus modern factors ($I_3 - I_1$); the other ($I_2 - I_1$) is the return to irrigation capital alone. The difference between these sets is the profitability of adding modern factors to irrigated farms presently relying on traditional inputs. In the case of minifundios, the cost of adding modern inputs actually causes the internal rate of return to fall from 44.36% to 39.63%. Modern inputs add only 7% - 9% for the other tenure classes. This suggests that the return to the addition of modern inputs is less than the 12% opportunity cost of capital. This helps to explain the observed resistance of farmers using Milagro project water to also adopt modern factors. Yet, at the same time, they do very well with the supplemental water alone.

Finally, the water tariff that amortizes the project cost and pays maintenance ($200/ha.) is simulated to rise until the internal rate of return drops to 12% for each tenure class. This step is included only for the investments in irrigation capital ($I_2 - I_1$). However, all simulated, as well as current yields and crop prices, are tested. The purpose of this exercise is to determine the economic rents being earned on an average unit basis and in total, for each tenure class. Surprisingly, the minifundios earn the highest rent per hectare at S/. 1,408, while the latifundios earn only 610.36. When the computation is based on the total number of farms in each tenure class rather than on a per hectare basis, the minifundios get only 2.7% of total rents, while the latifundios get 40%.* This suggests the possibility of introducing schemes for the water tariffs which will influence the distribution of rents conferred by the project.

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*Relative to people outside the project, all tenure classes improved their position in the distribution of income.

INTRODUCTION

Problem

This research is concerned with an economic evaluation of the success of an Ecuadorian irrigation project. The specific objective is to determine the relative profitability of private investment in on-farm water distribution systems among various tenure classes. The Milagro Project is an example of what may someday be a widespread program of irrigation development in the Guayas Basin. Assessments of the success already achieved are mixed. For example, one claim is that farmers will not accept the water. If true, this might reflect economic barriers that should be identified and corrected.

The Milagro project is one of the oldest and perhaps best established irrigation projects in Ecuador. It is located in Milagro County, where export crops such as bananas, coffee and cacao are grown, along with consumption crops such as pineapple and corn (see Figure 1).

The irrigation project itself provides irrigation water to a little over 7,000 hectares, 5,000 of which are within the Valdez sugar plantation. A second phase of construction proposed for the area calls for delivering water to some 7,800 additional hectares (14, p. 7). This expansion would provide a significant increase in the total irrigated farm area in the country, as well as increases in production.

The critical question concerns the profitability of private investment necessary to utilize the publicly provided water. Such profitability is calculated under both 1971 and simulated product and factor prices, and yields, but with 1971 water tariffs.

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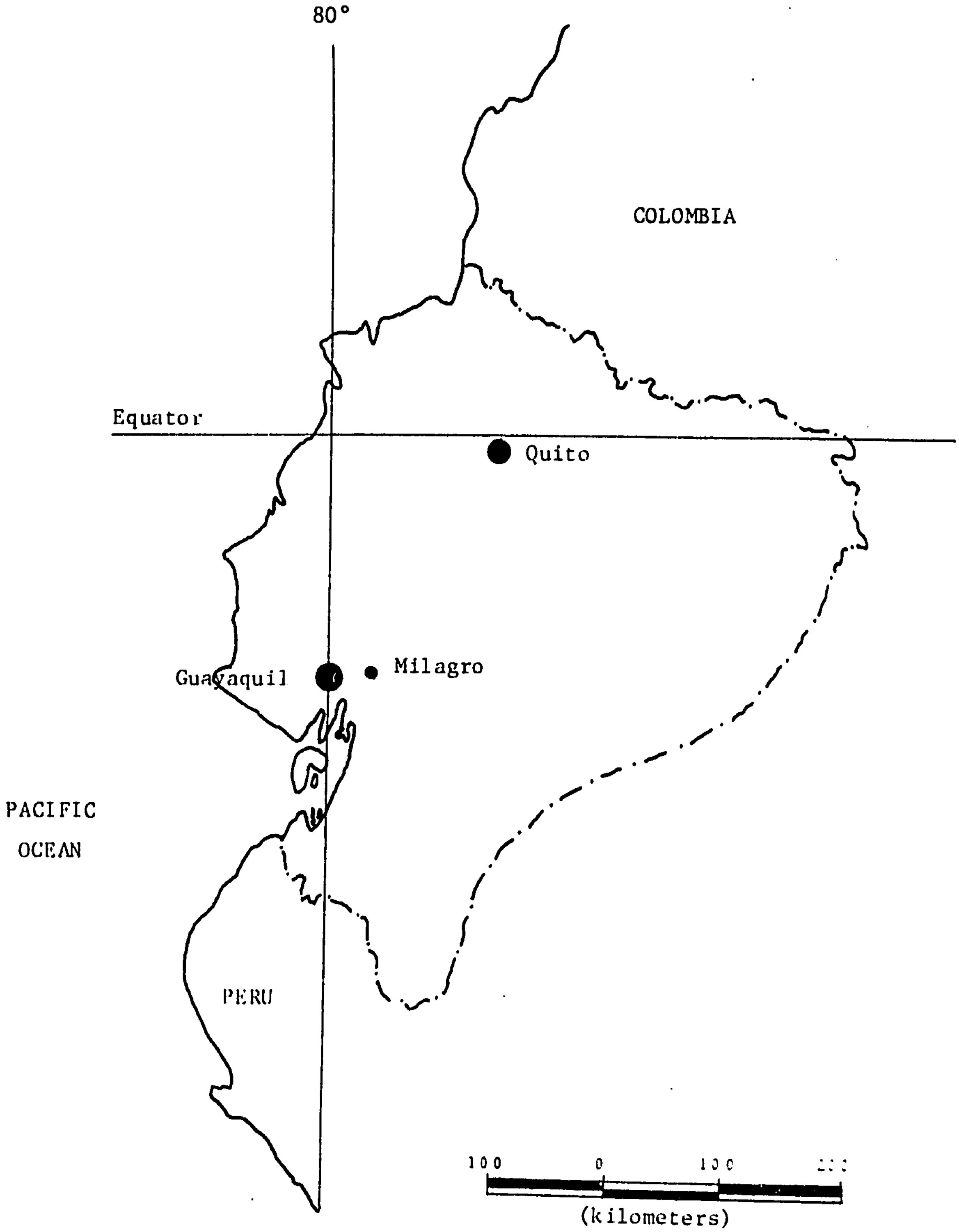

Figure 1. Sketch of Ecuador showing Milagro study area.

Another aspect of the problem is the extent to which economic rents (losses) are conferred on users by the project. Consequently, the water tariff is found for each tenure class (with both 1971 and simulated factor and product prices, and yields) that causes profitability of the on-farm investment to equal 12%. The difference between the 1971 and calculated water tariffs is taken to be the economic rent (loss) accruing to the average farm in a tenure class.

Objectives

1. To describe the current conditions and production for all tenure classes of farmers in the Milagro project area.
2. To develop a conceptual model for measuring the relative profitability of investing in on-farm water distribution systems for all tenure classes, given current prices for water and other factors and for products, and under current yields. This model is to consider the profitability of such investment under two cases: 1) coupled with traditional techniques; and 2) with modern techniques.
3. To develop a conceptual model to consider the sensitivity or profitability of investing in on-farm distribution systems to simulated changes in water prices, other factor prices, yields, and product prices, for all tenure classes using both traditional and modern techniques of production.
4. To develop a conceptual model to calculate the price of water that will permit investment in on-farm distribution systems to earn a return (12%) equal to the best riskless alternative investment. The price is to be calculated under current and

simulated factor and product prices, and yields for all tenure classes, using traditional techniques of production.

5. To utilize data in survey farm budgets from the Milagro project, to estimate the models.

6. To interpret the results of the empirical analysis, set forth policy implications and offer suggestions for further research.

Procedure

The research topic water cooperatively chosen in discussions between USAID/Ecuador, Utah State University, and the Ecuadorian Institute of Hydraulic Resources (INERHI). Finalization of the study outline was done in Ecuador in consultation with INERHI, and USAID.

Extensive data files previously established by INERHI personnel provide the basis for background on the Milagro project and for the empirical analysis. Field trips to the project area were conducted to collect additional data and to cross-check other sources.

The two main sources of data used in the study were sample surveys of rural farmers carried out by INERHI in the Milagro project area in 1968 and 1971. The earliest study surveyed farms having irrigation contracts with INERHI. The latter was a survey of farms not yet receiving irrigation water. Data were also obtained from the feasibility study of Guayas Basin agriculture by Chas. T. Main made in 1968, (6) other sources internal to INERHI, and through field interviews in the Summer of 1971.

The internal rate of return is chosen as the relevant measure for comparing capital investment opportunities in on-farm irrigation infrastructure with other investment opportunities open to farmers within the project area.

The information necessary to calculate the internal rate of return to irrigation investment was returned to Utah State University and processed at the Computer Center.

The economic models were finalized in the United States, although a great deal of the static model was suggested by Economist Lionel Lopez of INERHI. The dynamic variations are designed to test the sensitivity of the empirical results of the static model to changes in the model parameters including pricing policies of water contracts.

BACKGROUND

The purpose of this section is to describe the Milagro project created by INERHI. A knowledge of the history of the project and some background material concerning the country's philosophy toward irrigation water management are essential to an appreciation of the problem in this study.

Agencies Involved in Irrigation Development

In Ecuador there are various governmental agencies that have jurisdiction over water usage. Among these are INERHI, the Commission to Study Development in the Guayas River Basin (CEDEGE), the Center for Economic Reconstruction of El Astro, the Development Board of El Oro, the Rehabilitation Center of Manabi, the Economic Recuperation Board and various municipalities that regulate water usage within the limits of their respective jurisdictions. This list is not exhaustive, but it does include the more important bodies.

INERHI

The agency of primary interest to this study is INERHI. It is the executive arm of the Ministry of Natural Resources and Tourism used to implement the national Irrigation and Soil Conservation Law. The fundamental purpose of INERHI is to develop and protect the water resources of Ecuador as an essential condition for the country's development.

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INERHI was created November 11, 1966, from the National Irrigation Board (CNR) and the Department of Hydraulic Resources of the Ministry of Agriculture and Livestock. INERHI possesses all of the responsibilities of the former bodies plus some additional ones. INERHI, then, became not just a body to study and construct irrigation and drainage systems, as the CNR was, nor merely a regulatory body to advise and make judgements in water disputes, as in the case of the Department of Hydraulic Resources. INERHI is a national board for the integral planning and execution of the development of water resources in Ecuador.

Ecuador, at the present time, contains about 26.4 million hectares. Approximately 2.7 million hectares, or about one tenth of the total land area, is arable (7). Total irrigated land area in Ecuador is roughly 40,000 hectares. INERHI presently is supervising the irrigation of 18,620 hectares in the country, while about 20,000 are under the direction of the agencies mentioned above (5).

INERHI administers six separate irrigation projects built with government funds. It is the concessionaire of water in these systems and delivers water to the individual users through its own canals.

History of the Milagro Project

The design and construction of the Milagro project was initiated in 1946 by the CNR. It appears that the CNR never made plans for the development of the area as a whole (3, p. 22). This is evidenced by the piecemeal progress of the project. Because of this and because of intermittent funding, the project has experienced elevated costs of planning and construction. This is borne out by comparing the water tariff of the Milagro project to that of the Manuel J. Calle Project, not far from it. The latter has a water tariff only three quarters that of Milagro (19).

The water flow from the diversion on the Chimbo River which supplies the Milagro project area is divided into two basic parts. The total flow is approximately 10 cubic meters per second into the INERHI canals. INERHI is under contract to deliver 2.5 m^3/sec to the Valdez sugar plantation at the far end of Milagro County. An equal amount is lost through seepage and evaporation while in that canal, leaving approximately 5 m^3/sec for INERHI to contract to individual farmers in the project area. This water is also susceptible to seepage and evaporation (19).

The first part of the Milagro project, completed early in its history, was primarily to supply water to the Valdez plantation. In addition, it did give some water to small farmers in the Milagro project area.

Table 1 shows the extent of irrigation use in 1966.

Table 1. Water contracts in Milagro, 1966

Canal	Users	Hectares
Valdez	1	5,000
Vuelta del Piano	2	18
Naranjito	10	326
Norton - Banco de Arena	5	84
Total	18	5,428

Source: (12)

Work was begun again in 1966, after the project was transferred to INERHI, and additional canals were constructed. A comparison of Table 2 with Table 1 shows an increase in total area under irrigation by 1971.

Table 2. Water contracts in Milagro, 1971

Canal	Users	Hectares
Valdez	1	5,000
Vuelta del Piano	39	640
Naranjito	33	447
Norton - Banco de Arena	21	274
Estero Anapoyo	7	105
Chimbo - S. Antonio Supaypungo	27	370
Las Lomas	4	60
Milagro	8	95
Chirijo - Pinuel	3	10
Total	143	7,001

Source: (13)

The size of the basic canal system has been stabilized for the present. Plans have been formulated to increase the canal system when adequate funding can be obtained, and there is also a plan for supplying water to inaccessible areas from wells. However, for the purpose of this study, project construction will be considered complete.

REVIEW OF LITERATURE AND SURVEY AREAS

Literature

The basic source documents for this study are two on-farm agricultural surveys carried out by INERHI in the Milagro project area. The first, chronologically, was an investigation in 1968 of all water users (9). In that year there were a total of 89 water users plus the Valdez plantation. In 1971, the number of users had increased to 142, exclusive of the Valdez plantation, although the number of hectares irrigated had not significantly changed (13). The original survey information was coordinated with the Ecuadorian Institute for Agrarian Reform and Colonization (IERAC) and brought up to date (1971) as to land tenure and farm size.

INERHI also made a sample survey of non-irrigated farms in 1971 (10). Information contained in the survey questionnaires as well as personal observations of Carlos Calderón, the survey enumerator, were used in this study.

The Chas. T. Main Company of Boston made a feasibility study of the Milagro project in 1968 (6). The study included two phases for the development of the water resources and outlined a benefit-cost study of the region. The "project" as called for in the Main study included the use of year around irrigation, greater application of fertilizers and pesticides, and the introduction of hybrid seeds. The people at INERHI were able to use the study to plan the future development of the area (18).

A major limitation in the study was its analysis of the water available for irrigation. The Main study shows a table of average river flow over a twenty-year period. The water availability used was the minimum flow over this time period, that of an unusually dry year, while the river flow is normally quite stable. The project size was thus unnessarily restricted (18). In a later INERHI revision of this study, a probable water flow was used and the oversight corrected.

In the Main study, the direct benefits of the project were assumed to accrue from implementation of the complete "project" package. The impact of irrigation water alone was not considered apart from other influences. The analysis considered investments to be the capital investment in the primary canal system alone. The benefits were the direct benefits to the farmer plus the secondary benefits to society. The question of private repayment of social capital investment through water tariffs was not considered. On-farm capital investment also was not accounted for. The study was, however, a valuable contribution to knowledge of the project area.

In 1970, the engineers, agronomists and economists of INERHI developed a revision to the Chas. T. Main study, including some original contributions (15). Their work is worthy of consideration as a separate study because of the addition of new data. It is concerned primarily with the second phase of the Milagro project. The land area covered by this proposed project expansion is greater than that of the second phase within the Chas. T. Main study. The detailed studies of probable river flows and water requirements of plants are detailed and complete.

INERHI's study also was based on the application of complete "project" infrastructure changes. In the first phase of the canal construction, now complete, few on-farm management practices changes in other than irrigation were made (9 and 10). There is little evidence that new on-farm management practices will be introduced in the second phase.

One feature of the INERHI revision is the introduction of the "ideal" crop distribution. Just as many farmers have been unwilling to accept new varieties of seeds (9 and 10), they are unwilling to plant crops according to an "ideal" plan. They will undoubtedly continue to plant crops according to how they view market pressures.

Both the Chas. T. Main study and the INERHI study base the effectiveness of their development programs on the benefit-cost ratio at selected rates of return. However, this study will use the internal rate of return to evaluate the investment.

The Survey Areas

The increase in revenue attributed to irrigation is measured by the difference between the net economic revenue on farms with irrigated crops and the net economic revenue on farms without irrigation water. Before equating this difference in net revenue wholly to irrigation, an assumption of basic homogeneity between farms with and without water is made.

Throughout the project area, farmers take advantage of the heavy winter rains to plant and water their crops. To supplement the winter rains, the irrigation canal system presently is serving approximately 2,000 hectares within the project area during the dry season. (For this study, the 5,000 hectares of the Valdez plantation will be excluded.) Within the Milagro project area, then, there are virtually two distinct systems of irrigation, farming with natural rainfall only and farming with supplementary irrigation, each confined, in the main, to a specific area of the project (see Figure 2).

The homogeneity assumption implies that (1) the farms in the entire project area are essentially homogeneous before the introduction of irrigation, and that (2) the only change in on-farm management in the project area is the introduction of irrigation on part of the farms. The purpose of the sections that follow is to substantiate the assumption that, on the average, all farms within the project area are homogeneous except for the use of irrigation water and the resultant changes in cropping patterns.

Soils

The soils of the project area were classified with the intent of establishing the extent and quality of their adaptability to year around irrigation. This was done by means of field samples taken to a depth of 150 cm.

The soils were identified according to the four soil classes that follow (6, p. 4).

Class I: Land that is highly adequate for agricultural irrigation.

Class II: Land that is moderately adequate for agricultural irrigation, being marked lower than those of Class I in their general capacity for production, etc. This land is subdivided into three subclasses:

Class II-W: Soils that have a high water table.

Class II-S: Soils that have limiting characteristics that are difficult or impossible to correct.

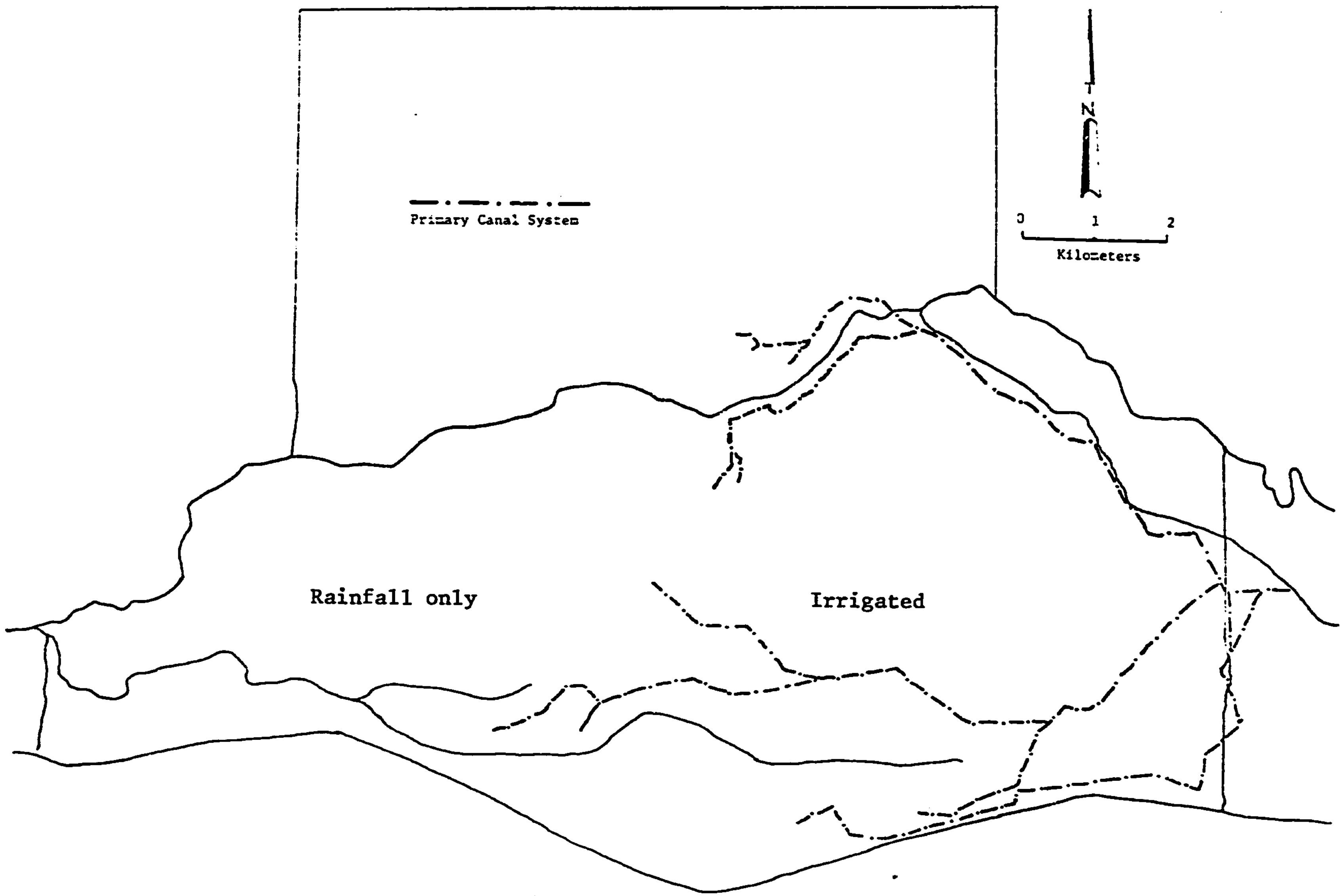

Figure 2. Milagro irrigation system

Class II-Sc: Soils that have a heavy texture in the subsoil or substrata.

Class III: Lands that are apt for irrigation development but have more extreme drainage restrictions than those of Class II.

Class IV: Lands for special uses, predominantly of fine texture.

The soils throughout the Milagro area are recent flood plains and deltas of the Milagro River. They are principally of medium stratified texture (silt and silt-clay) and of occasionally heavy texture (sandy silt and fine sandy silt), all of which are included in Class I soils. Some small areas also exist with heavy textures (sandy silt and sands of Class II-Sc). Generally, these soils have a medium or occasionally heavy texture and below 30 centimeters become sand. All of these soils are well drained and lack any characteristics indicating the presence of superficial ground water or poor aireation during any more or less prolonged period of time.

One zone, situated in the southeast part of the area on both sides of the Naranjito canal, has a very high water table. This land is classified as II-W. The cause of this elevated water table is probably seepage from the canal. Apparently, this is a deficiency that can be corrected with the lining of the canals. When it is corrected, the soils will become Class I soils.

Some small areas also exist with occasionally fine texture (Class III) that possess poor drainage characteristics. These soils were too scarce to appear on the map (6, p. 45) (see Figure 3).

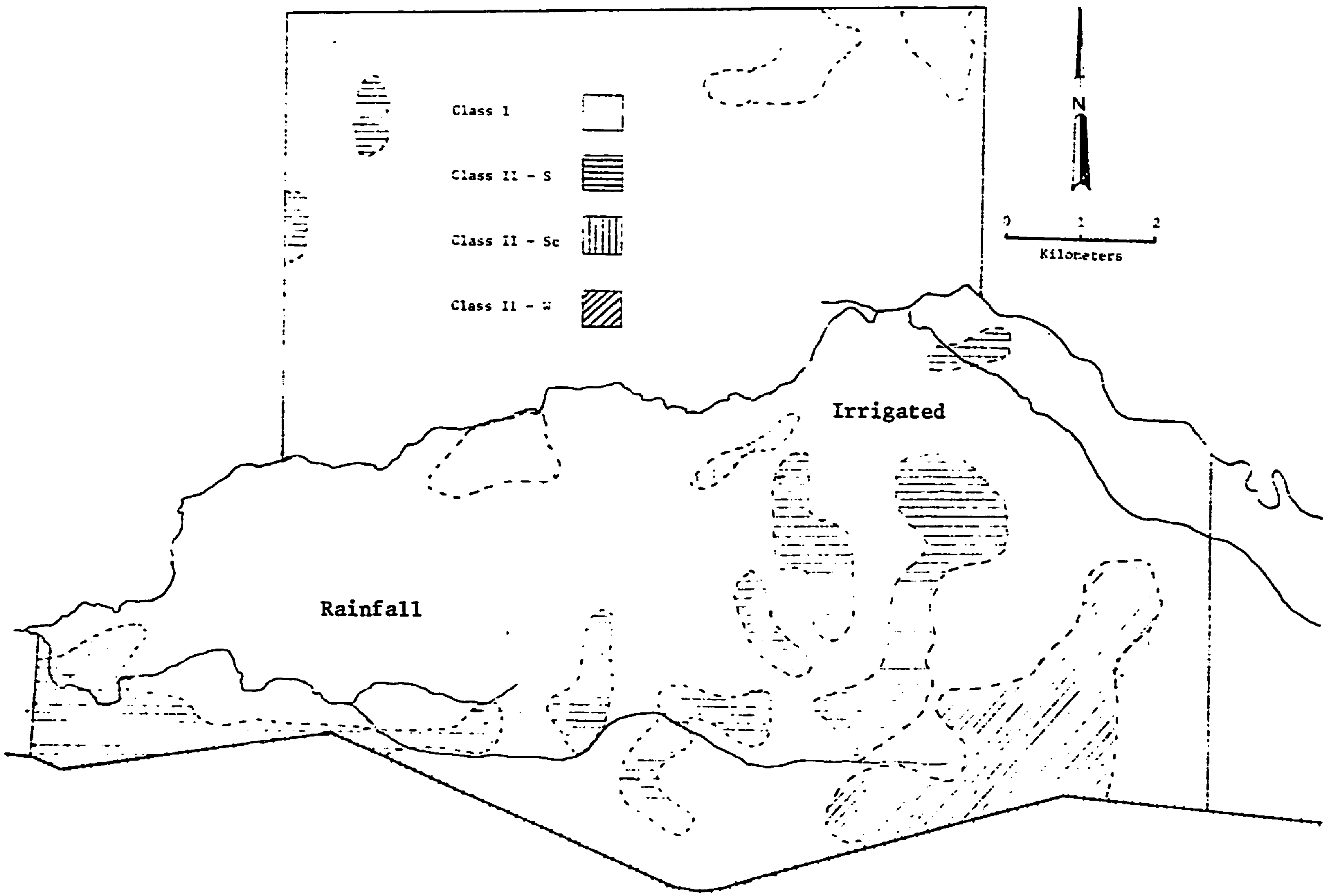

Figure 3. Soils of the Milagro area

Table 3. Soils of the Milagro area

Class	Percentage
I	81
II	19
II-S	11
II-Sc	3
II-W	5
III	0
IV	0
	100

Source: (6, p. 4)

Due to the great predominance of the Class 1 soils and the absence of soils that differ notably as to harvests or cultivating methods, the soils of all this area may be cultivated with the same general practices (6, p. 45).

Climate

The Guavas River Basin is characterized by a succession of micro-climates, and small changes in altitude and/or horizontal distance produce notable changes in precipitation. In these regions grow belts of semi-tropical vegetation intermixed with areas of vegetation of lower transpiration coefficients.

Specifically, the area of the Milagro project, which is a tributary of the Guavas River (see Figure 1), is one of those micro-climates. The Chimbo River is protected by a range of mountains that runs from north to south and produces a rain shadow in that portion of the

Guayas Basin. The project area generally has cloudy or overcast skies during the major part of the year.

The greatest number of hours of sunlight was registered during the rainy season. The predominantly cloudy skies are favorable for some crops, such as cacao, but may have adverse effects for others. It appears, nevertheless, that there is a sufficient quantity and quality of light for normal photosynthesis. Sugar cane is one of the plants that most needs the sun's light, and the harvests obtained in the area of Milagro are comparable to those obtained in the best areas of sugar cane production in the world (15, pp. 14-15). The micro-climate over the Chimbo River extends over the entire Milagro project area, giving it a uniform climate throughout.

Crops of the Milagro Project Area

The time for plants to reach maturity varies from crop to crop. In the Milagro project area, there are essentially two groups of crops classified according to the length of time it takes for the plant to mature.

Bananas, cacao and coffee beans, pineapples, sugar cane, papaya and citrus fruits and pasture land all require approximately a full year to grow to maturity for harvest. They are harvested in the fall, just before the winter rains. The plants begin to grow again during the season of heavy moisture. The rains are heaviest during the months of December, January, and February. They taper off during March, April and May and in the remaining six months of the year there is virtually no rainfall. The effect of irrigation water on these crops is increased per hectare yields at harvest time.

Corn, rice, tobacco, cotton, peanuts and oil seed crops are grown during the six months that provide rain for growth. Presently, on farms not being served with irrigation water, these crops can be grown only once per year. A year around supply of water to irrigate these crops will augment only slightly the per hectare yield on winter crops, but will allow summer harvests heretofore impossible. This, in effect, will more than double the total per hectare yields of these crops.

Because rainfall is sufficient during half of the year, from December to May, water is turned down the INERHI canals only from June to November.

A comparison of the two zones of the Milagro project covered by the two INERHI agricultural surveys shows a distinct average distribution of crops between the two groups.* With irrigation water available many farmers have abandoned traditional crops that do not respond to increased water application and have substituted crops that do indeed respond favorably to irrigation. However, family consumption needs and resistance to change, often found in tradition-oriented societies, impede complete abandonment of selected crops. Agricultural extension education is needed in this area of Ecuador. The conclusion is drawn that the difference in crop patterns found between the crops on irrigated farms and the crops on unirrigated farms are related to the introduction of irrigation itself.

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* This difference is shown in Tables 27 and 28.

Factor and Product Prices

Guayaquil, a port city and the largest city in Ecuador, is situated some 40 kilometers, by road, from Milagro, the county seat of Milagro County and the major trade center of the Milagro project area. Almost without exception, factors of production, which are usually imported from industrial countries, flow from Guayaquil, through Milagro to individual farms. Similarly, farm production is marketed through Milagro and shipped to Guayaquil, for export. Consequently, factor and product prices are equal to all producers in the Milagro project area.

Transportation Costs

Transportation costs vary with the distance to Milagro from individual farms. Because the area surveyed without irrigation is closer to the common market place than that zone surveyed having irrigation, the latter does incur a higher transportation cost per kilo than the former zone. However, the difference is relatively small, and this category of expenditure is a small part of the overall farm budget in either zone. In any case, the difference decreases the benefits that accrue to irrigation, reducing the internal rate of return by a relatively small amount.

Technology and Infrastructure

The survey conducted in the Milagro project area by the Chas. T. Main team revealed a general absence of modern agricultural practices, as Table 4 demonstrates:

Table 4. Use of on-farm practices, Milagro area

	Percentage Use	
Crop	Fertilizer	Insecticide
Banana	10	6
Cacao	13	30
Coffee	11	2
Pineapple	0	0
Corn	9	3
Rice	24	24
Pasture	0	0
Sugar Cane	0	0
Fruits	0	0
Others	27	46

Source: (6, p. 5)

INERHI has made diagnostic surveys to determine the use of inputs and farming techniques in all parts of the Milagro project area. Except for the Valdez and the San Carlos sugar plantations, machinery is very scarce (14). There are many reasons for this.

One of these is the fact that none of the farms in the Milagro project area are larger than 200 hectares (9 and 10). This is due to the success of the agrarian reform in the project area. Only a few of the land owners are able to make a capital investment in machinery.

Farm machinery and other capital goods are almost exclusively imported. Transportation costs and import taxes add to the already high cost of such items.

In Ecuador and in the project area in particular, there is a large surplus of agricultural workers. This is evidenced by the low wages paid to such workers, even lower than the legal minimum wage set by law (21, p. 44).

Perhaps more significant is the fact that for most crops in the area, such as banana, coffee, cacao and pineapple, production requires hand labor and a skillful eye. Machines do not exist that can perform many of the farm operations.

With few exceptions, farming techniques and inputs by the proprietor have not changed with the introduction of irrigation (18). The few exceptions are changes such as greater quantities of seeds, when irrigation permits closer planting, a larger expenditure for labor and transportation, both associated with larger yields, and double harvests on some crops with water available all year around instead of only during the winter and spring months. All these changes are direct results of irrigation.

Techniques, such as spreading fertilizers and use of hybrid seeds and improved tools, are slow in coming to Milagro County, with one major exception. In banana production, the changeover from the Gros Michael variety to the Cavendish variety has progressed with equal success in both the irrigated and unirrigated portions of the Milagro project area.

Techniques and infrastructure on the farmstead in the project area are homogeneous except where irrigation itself has been responsible for changes.

Management Ability

There are several important points that reflect upon the management abilities of the farmers within the project area. To begin with, very few of the farmers in the whole project area could be considered expert managers (6, p. 67).

A majority of farms within the project area are still totally without irrigation (851 farms), while an average of 142 contract for irrigation water during the dry season. Irrigation canals have been placed where they can most easily be built using the engineering skills of INERHI.

A great many of the farmers of the area are new to Milagro County, while a number have been on their farms for more than twenty years (10). The agrarian reform has touched most areas, on the average, equally (14).

Many farmers have been helped by educational programs that teach everything from literacy to agricultural extension. Education has been spotty in the County, but its impact is scattered fairly evenly over the area. If it has changed any area more than the others, it has been the areas closest to the population centers, such as the city of Milagro, and farther from the irrigated zone (2). This effect tends to reduce the economic differences between the irrigated and unirrigated farms. Overall, it has been the concensus of personnel interested in the area that management ability is generally homogeneous throughout the project area (18).

Land Tenure

The agricultural production sector of the Milagro project area was divided into four size levels on the basis that four types of land tenure exist in the area. This is suggested by the agricultural surveys of the area (9 and 10). It should be noted the class sizes between unirrigated and irrigated farms are not evenly weighted (see Tables 5 and 6). Finally, these four size levels are not intended to represent any differences in management ability among farmers. Size levels represent only average differences, in land ownership or tenure. The size groups are used to compare crop distribution and land distribution patterns between the two survey areas.

Table 5. Average farm size without irrigation

Size Level	Farms		Area		Mean
	No.	%	Has.	%	Has.
I	338	39.1	865.0	10.2	2.56
II	237	27.7	1635.7	19.2	6.90
III	170	20.0	2409.3	28.3	14.17
IV	106	12.5	3609.8	42.0	33.96
Total	851	100.0	8521.8	100.0	

Source: (10)

Table 6. Average farm size with irrigation

Size Level	Farms		Area		Mean
	No.	%	Has.	%	Has.
I	21	14.8	48.7	2.5	2.32
II	41	28.8	290.9	16.5	7.09
III	62	43.7	880.4	44.0	14.20
IV	18	12.7	781.0	37.0	43.39
Total	142	100.0	2001.0	100.0	

Source: (9)

A farm of Size Group I (0.0 to 4.9 hectares) is known generally as "minifundio", or the farm size not capable of supporting a family without the father, and perhaps even the mother and children, selling their labor off the farmstead as day laborers.

The farms of Size Groups II (5.0 to 9.9 hectares) and III (10.0 to 19.9 hectares) are similar in that they are both generally run by members of families living on the farmsteads who are able to live on the income provided by the farm production. A farm of Group II may produce enough to support one average family, while a farm of Group III may support more than one family unit, such as two or more brothers and their individual families. The latter situation is not uncommon in the project area.

The land tenure category "latifundio", which in the past has connoted absentee ownership and less than full utilization of factors of production, is seldom found since the widespread agrarian reform measures taken in the project area. Yet, Size Group IV (20.0 to 200 hectares) does include hired managers and hired day laborers.

One of the important parts of this study is the comparison of the average farm size with, and without irrigation, within each size group. The "Student's t" statistic will be used to test the hypothesis that the difference between two means of a given size level (irrigated and non-irrigated) is equal to zero:

$$-t < (\bar{X}_1 - \bar{X}_2) \ / \ S_{\bar{x}_1-\bar{x}_2} < t.$$

Table 7. Test for significant differences in mean size levels within the Milagro project area

Size Level	$(\bar{X}_1 - \bar{X}_2)/S_{\bar{x}_1-\bar{x}_2}$	Student's t	$H: u_1 = u_2$
I	0.36	2.228	Accept
II	1.06	2.160	Accept
III	0.05	2.060	Accept
IV	0.09	2.014	Accept

Source: (9 and 10)

Statistically, within each land tenure group, the average areas of the farmsteads are equal for irrigated and unirrigated farms. This analysis reinforces the basic assumption of homogeneity by pointing out the equality of farm size among farms with and without irrigation throughout the project area and by land tenure levels.

Because the average farmsteads within size levels are statistically equal between the two areas of the project being studied, and because the area of primary interest is the irrigated land, the average hectares for the irrigated land area is used in all calculations.

CONCEPTUAL MODEL

The purpose of the conceptual model is to establish a method to calculate the return from adding irrigation to farms using traditional farming methods, and to farms using modern farming methods. From the survey data (9 and 10) and the feasibility studies of Chas. T. Main (6), three distinct kinds of farms can be established along with the corresponding average yields and costs. The division to be employed is based on inputs or technology:

Input Level I: Traditional farming methods without irrigation, only natural rainfall = I_1

Input Level II: Traditional farming methods with irrigation from INERHI canals = I_2

Input Level III: Modern farming methods introduced on irrigated land = I_3

Since farms in the project area are apparently homogeneous, except for irrigation and the associated cropping pattern, the method relies on calculation of average net returns for I_1, I_2, and I_3, and attributes any difference in net returns between I_1 and I_2, and I_1 and I_3 to the addition of water.* Such a calculation is made for all four tenure (size) classes within each technology group. For example, net return on

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*Strictly speaking, the difference in net returns between I_1 and I_3 is due to the water and to the adoption of the more modern inputs. This is true since the homogeneity assumption requires a comparison between the average farm using modern inputs and the average farm with modern inputs and irrigation. However, comparison is between the average farm using traditional practices with no irrigation (I_1) and the average farm using modern inputs with irrigation (I_3). The difference is due to both irrigation and the use of modern factors. (Even though modern inputs are costed out in calculating net returns, their influence is reflected in yields.)

I_2 less net return on I_1 is the return from adding irrigation water to farms using traditional methods of cultivation.

Specifically, the procedure is to calculate gross returns, costs, and net returns for each year over the life of the on-farm distribution system by crop, per hectare, for I_1, I_2, and I_3. Then net returns are calculated each year for each average farm by multiplying the hectarage in each crop by the net return per crop, per hectare. This is done over the three kinds of farms I_1, I_2, and I_3, and for the four tenure classes within each type. Then returns for adding irrigation to traditional farms are calculated by subtracting net returns in I_1 from those in I_2. Returns from adding irrigation water to farms using modern farming methods are approximated by subtracting net returns on I_1 from net returns on I_3.

The internal rate of return on the investment necessary to add the irrigation water is calculated as a basis for determining the viability of the change. Consequently, when net returns are calculated for I_2 and I_3, they will exclude capital costs of adding the irrigation water. The rate of interest that equates the present value of the stream of differences in net returns (e.g., net return on $I_{2.y}$ less net return on $I_{1.y}$) to the cost of adding irrigation capital is the return on the investment.

Gross Revenue

Gross revenue for an individual farm is the summation of the sales revenue for each of the crops produced on that farm. Gross revenue for a specific crop is a product of the sales revenue per unit area of the crop and the total area devoted to the crop. Gross revenue per unit area of the crop is a product of the yield per unit area and the market price.

Gross revenue per unit area of a crop can be represented by equation (1):

$$GR = Y \cdot Py.$$

Variable Production Costs

The variable cost per unit area, per crop of any single factor of production is: $F_i \cdot P_i$, or the quantity of the factor employed per unit area multiplied by the price of that factor.

For any crop using more than one input, such as land, seed, labor, and water, the variable cost per crop/hectare is the sum of the costs of all the inputs used:

$$VC = \sum_{i=1}^{n} (F_i \cdot P_i). \qquad [2]$$

Net Revenue

Net Revenue per Unit Area of a Crop

Farmers, as all entrepreneurs, are not as interested in gross revenue as they are in net revenue, the difference between gross revenue and costs. Net revenue per unit area of a crop is defined by equation [3]:

$$NR_c = GR_c - VC_c - FC_c \qquad [3]$$

where: NR_c = net revenue per crop, per unit area

GR_c = gross revenue per crop, per unit area

VC_c = variable cost per crop, per unit area

FC_c = fixed cost per crop, per unit area

If gross revenue and variable cost are replaced by equations [1] and

[2], the result is equation [4]:

$$NR_c = (Y \cdot P_y) - \sum_{i=1}^{n} (F_i \cdot P_i) - FC_c \qquad [4].$$

Distribution of Crops

Each crop raised on a farm returns a distinct revenue per unit area. The value added to total farm net revenue by each crop may be calculated by multiplying the net revenue per unit area by the total area devoted to that crop on the farm. It follows that a different distribution of crops would produce a different expected net revenue for the farm.

An assumption in this thesis is that each farmer is a rational producer, that is, they produce the distribution of crops that yields the greatest expected net revenue from individual farms.

Net Return per Farm

The net revenue per farm is the sum over all crops of the net revenue received for each unit area of each crop multiplied by the area devoted to each respective crop.

$$NR_f = \sum_{c=1}^{m} [NR_c \cdot A_c] \qquad [5]$$

where A_c is the area on the farm devoted to the crop, c.

Internal Rate of Return

Input Levels

The one variable on the right side of equation [4] that is controllable by the farmer is the quantity of inputs (F_i) used in the production of the crops on his land. All other things being equal, a change in inputs should generate a change in yield. This study attempts to analyze the quantitative relationship between changes in inputs (farm production practices) and changes in yield.

Discounting Net Returns

At a certain input level, the difference between gross revenue and total costs (variable cost plus fixed cost) is the net revenue for that input level. As additional or new inputs (irrigation capital and water) are introduced into production, a new input level is established and a new net revenue is determined. The difference between the new net revenue and the former net revenue is the return due to the addition of new inputs (irrigation capital and water).

An investment, such as on-farm irrigation infrastructure, is not consumed in a single year. It has a cost that is incurred at the present, but the returns to that investment are realized in the future. To compare the present value of the investment cost to the stream of future returns, the future values of the returns are discounted back to their present values. The discount rate that equates the present value of future returns to the present value of the investment is the internal rate of return.

When net returns are used to represent the future annual income resulting from a present (current) investment, both gross revenue and total costs are discounted together at the same rate of discount. Therefore, all future values of revenues and costs are discounted to present values.

Net returns for each year are calculated independently of those of any other time period. Investment is made at the start of year zero. Net returns are realized at the end of each succeeding year.

The internal rate of return (IRR) is calculated by solving for i the equality between cost of investment in year 0, (C) and the present value of income streams from that investment, i.e.;

$$C = \frac{NR_1}{(1+i)^1} + \frac{NR_2}{(1+i)^2} + \ldots + \frac{NR_j}{(1+i)^j},$$

where NR_j = net return from investment in year j,

i = the internal rate of return,

C = cost of investment in year 0.

The program used to calculate the internal rates of return in this study used an iterative process to adjust the rate of discount (i) until the sum of future values is equated to the irrigation investment in year zero.

Simulation Analysis

The model introduced above may be used to determine the profitability of changing (F_i) (e.g., adding an on-farm water distribution system), under current yields, and product, and factor prices. However, it is necessary to understand how sensitive such profitability is the changes in these parameters. This sensitivity can be determined by calculating profitability of a change in (F_i) under simulated yields, and product and factor prices.

Marginal Value Product

The marginal value product of a factor of production is the marginal physical product of the last unit of the factor employed in production times the unit market price of that output. For a unit of any factor of production, an entrepreneur will be willing to pay any price less than or equal to the marginal value product of that factor

One factor of production used on some farms of the Milagro project area is irrigation water. For water contracts on this project, farmers presently pay a fee established only to recoup the actual costs of amortization and operation of the primary canal system.

The simulation analysis demonstrates that the net internal rate of return, the difference between the discount rate and the rate of return on the best investment alternative or similar risk available to entrepreneurs, is positive under normal fluctuations or market pressures and climatic conditions.

Unirrigated land in the Milagro project is valued at an average of about S/. 1500 per hectare. Irrigated land may have a value of double that figure, or about S/. 3000 per hectare (6, p. 135).

Heretofore, the value of the land itself has not been considered a parameter in any of the models. The implication has been that a farmer of irrigated land begins with unirrigated land and builds his own irrigation infrastructure. Now, the two options open to the owner of irrigated land will be examined. He can retain his land and work it, receiving a rate of return on his investment in land and irrigation infrastructure, or he can sell his land and receive the capitalized value of the irrigation system. Either option apparently yields higher returns to the farmer of irrigated land than to the farmer of unirrigated land, as evidenced by higher land values of the irrigated land.

Because the primary canal system is not as yet available to all local farmers, the effect of the project is to subsidize farmers that own land near irrigation canals. INERHI, the government agent for control of irrigation development, has a limited amount of funds with which to provide supplemental water to all farmers of the area. However, there is a possibility that budget limitations could be circumvented to a major degree if higher water fees could be charged. In that case the "surplus" returns to irrigation could be used to finance an expanded major canal system.

Increasing the water tariff will reduce farmers surplus return stream. This may be justified to the extent that the value of the water is greater than the fees presently charged.

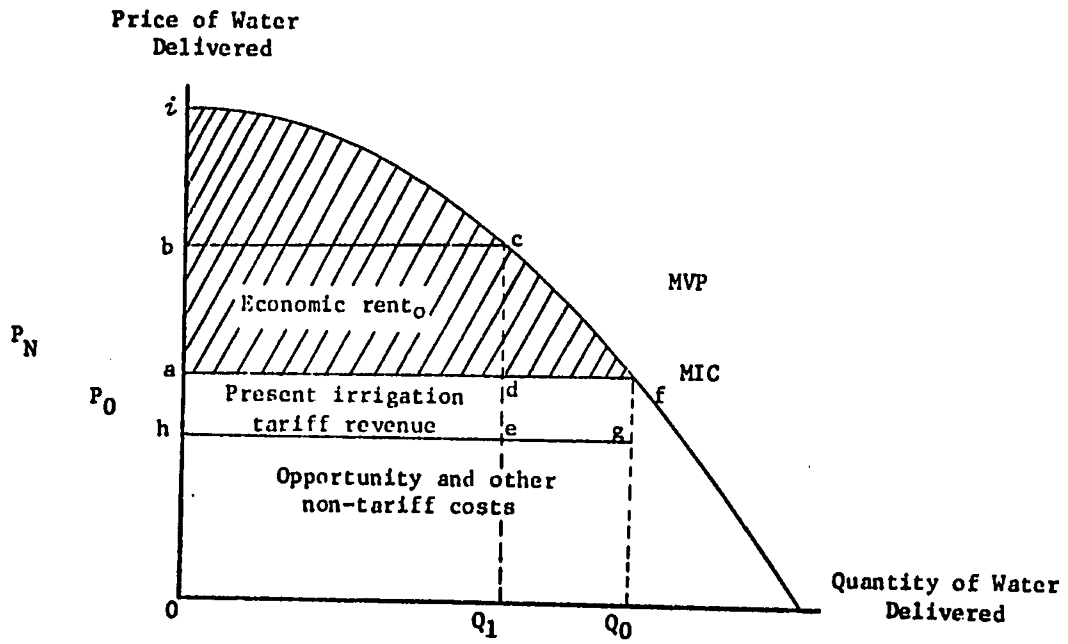

Figure 4. The MVP of irrigation water.

The non-tariff costs of Figure 4 include the cost of the privately supplied irrigation infrastructure capital investment explicitly as an opportunity cost to the farmer. The present cost of the primary canal system appears in the figure as the irrigation tariff revenue (which is a cost to farmers). Consequently, profitable management dictates operation with respect to water at input level Q_o.

Each farmer is entitled to contract for 1 liter/second for each hectare of land he owns, at a tariff of S/. 200. However, 1 liter/second/hectare will optimally irrigate (physically) any cropping pattern found on the project at 50 per cent efficiency. Assuming farmers use water at 50 per cent efficiency and given the price of water, each farmer will desire to use less water per hectare than he is entitled to, in order to maximize his returns. He does this by contracting for fewer liter/seconds of water than he is entitled to, and then spreads the water over his total hectarage. In this way, the farmer is able to adjust the quantity of water he utilizes, given the price.

The shaded area of Figure 4 is the return to fixed factors from water that is captured by the proprietor of irrigated land. If the water tariff is increased to the unit level (P_N) from (P_O), the tariff revenues will be increased by (abcd) and reduced by (defg). Use of water would fall to Q_1, and society would receive that portion of the original economic rent equal to the net difference in tariff revenues. The farmers receive the residual (ibc) as economic rent. The reduced amount of desired water (Q_o- Q_I) is available for sale elsewhere. That part of the original private rents now captured by society (INERHI) could be used to finance additions to the canal system, stage-by-stage.

The model above can also be viewed in terms of a product market. In Figure 5, P represents the weighted average price of the mix of products produced on a farm without irrigation (e.g., Input Level I), while Q_o represents kilos of total product. The area (OQ_oaP) is total revenue. The curves MC_I, ATC_I, and AVC_I, are the marginal cost, average total cost, and average variable cost for the aggregate product of the farm. The area(OQ_ocb) is the payment to the variable factors of production. The area(bcap) is the payment to the fixed factors. It is the sum of the areas enclosed by the marginal value product curves and the price lines of the variable inputs in the factor markets (see Figure 4 for illustration of one factor-water). The area (bcde) is the payment to the fixed factors (at their opportunity cost), while the area (edaP) is pure economic profit.* In the empirical section below the area (edaP) is referred to as net revenue.

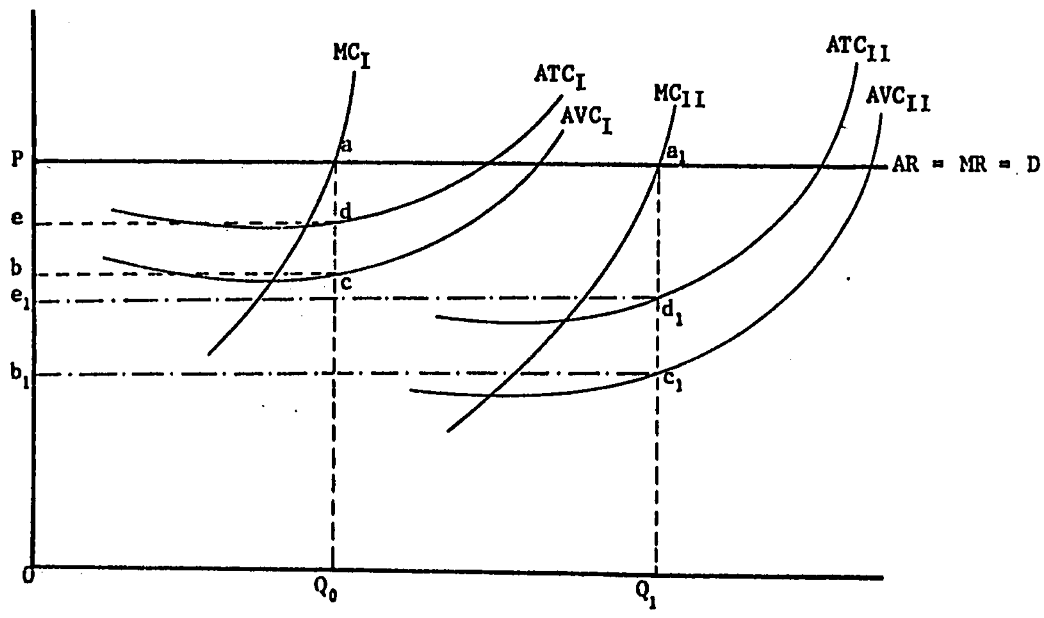

Figure 5. Economic profits and technology shifts.

*If all fixed factors are included in the budgets, it would be pure economic profit. However, neither costs of land nor management have been included. Hence, area (edap) may be considered the payment to land and management. If it is greater than the opportunity costs of those factors, the excess is economic profits.

We introduce a change from Input Level I to Input Level II by adding irrigation capital, water, and other needed variable factors to the same land and management base, with product prices, factor prices, and yields at present levels.* The MC, ATC, and AVC curves will all shift to MC_{II}, ATC_{II}, and AVC_{II} as productivity of the variable resources rise. (The shift is illustrated as very large for purposes of exposition).

Total revenues are now ($OQ_1\ a_1\ P$) and total variable costs (payments to variable factors) are ($OQ_1\ c_1\ b_1$). Total payment to the fixed factors are the area ($b_1\ c_1\ a_1\ P$). Once again it is the sum of the returns to fixed factors (rent) earned by each of the variable factors of production as illustrated for one of these variable inputs (water) in Figure 4. The area ($b_1\ c_1\ d_1\ e_1$) is the opportunity cost of the fixed factors, while ($e_1\ d_1\ a_1\ P$) is the pure economic profit or net returns on Input Level II. It should be remembered that land, management, and irrigation capital have not been costed out so area ($e_1\ d_1\ a_1\ P$) is the return to these factors.

Then the model proceeds by subtracting the area (edaP) from the larger area ($e_1\ d_1\ a_1\ P$) in order to calculate the annual return from adding the irrigation capital. (That is, the economic return to land and management is netted out). Then the discount rate is found that will equate the cost of the irrigation capital in year 0 to the present value of ($e_1\ d_1\ a_1\ P$) - (edaP) over the life of the irrigation capital. This is the internal rate of return on the irrigation capital given

*Actually, the average price may be expected to change since the mix of crops is different on the irrigated farms. However, for simplicity it is assumed to remain constant in Figure 5. (It varies in the analysis below.)

current product and factor prices and yields on the two kinds of farms.

This process is repeated in a simulation model for all combinations of product price changes of -30%, -20%, -10%, and ±10%, factor price increases of 5%, and 10%, and yield changes of -20%, -10%, 10%, and 20%. This constitutes the so called "simulation" analysis.

The model then proceeds to answer the question, "How much can the price of water (a variable cost to the farmer) be raised and still permit the farmer to earn the opportunity cost on his water investment?" (The opportunity cost of capital is assumed to be 12%.) That is, with reference to Figure 5, the cost curves are raised (by increasing the price of water) until the discount rate that equates present value of $(e_1\ d_1\ a_1\ p)$ - (edap) with the cost of the irrigation capital is just 12 per cent. This water tariff would just transfer all pure economic profit from the farmer to the public. This provides a basis for calculating the economic rent, and determines the water tariffs necessary to tax it away.

Note that this is not to argue that water is priced at its marginal value product by this procedure. From the farmer's point of view, the water is paid its marginal value product. Whether or not this corresponds to society's wishes is beyond the scope of this thesis.

The same process is repeated via the simulation model for all combinations of product and factor price yields mentioned above.

From a policy standpoint, it is useful to know the sensitivity of the total economic surplus to variations in the three exogenous parameters mentioned above. A simulation analysis is able to indicate the result of selected changes in the parameters with respect to the economic rent potential.

EMPIRICAL ANALYSIS

Analysis of the agricultural production units of the Milagro project area follows the model explained above. Production per unit area is assumed to be constant over farm size; therefore, gross revenue, variable costs and net revenue are also constant per unit area over all farm sizes of a given technological type.

Gross Revenue

Prices

Gross revenue for crops in the Milagro project area are calculated using the average market price paid in Milagro. Most production was marketed at the same time of year and received equal prices (14).

Table 8. Market prices received in Milagro, 1971 (sucres per kilo)

	Crop	Price		Crop	Price
1.	Banana	0.82	6.	Rice	2.90
2.	Cacao	9.90	7.	Pasture	0.12
3.	Coffee	10.10	8.	Cane Sugar	0.06
4.	Pineapple	1.00	9.	Fruits	1.40
5.	Corn	1.50	10.	Others	5.68

Source: (11).

Yields

Average yields per hectare have been estimated for unirrigated traditional (I_1), irrigated traditional (I_2), and modern irrigated

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crops (I_3) in the Milagro project area (9, 10, 6) and are reported in Tables 9, 10, and 11. Gross revenues are reported in Tables 12, 13, and 14 for I_1, I_2, and I_3 as the product of prices (Table 8) and yields (Tables 9, 10, and 11).

Fixed Production Costs

Land Values

In the entire project area land values generally have stabilized. These production costs will be treated in a manner similar to their treatment in the Chas. T. Main feasibility study. "Benefits derived from the land itself are excluded from production analysis of irrigated and unirrigated farms, because this value would be an invariable factor" (6, p. 67, translation supplied).

Primary Canal Investment Costs

This is a government initiated project; there is only public funding involved in its original construction. Yet, because Ecuadorian water law is explicit about legal constraints on social capital investment in irrigation projects, the cost of the primary canal system is shifted to the water users.

> For the management of irrigation services of the Ecuadorian Institute of Hydraulic Resources, the Executive Council will establish tariffs that will be readjustable and will cover the quotas for depreciation or amortization and the costs of operation and maintenance... (8, translation supplied).

In practice, the cost of the social capital is to be transfered entirely to farmers through water tariffs. If that is done, the farmers using the water ultimately bear the cost of construction of the primary canal system.

Table 9. Expected yields for technology (input) Level I; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	0.0	0.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	0.0	363.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	180.0	363.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	180.0	363.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	180.0	363.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	180.0	272.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
0.0	137.0	272.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5064.0	137.0	272.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5364.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5764.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
0.0	137.0	272.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5464.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5864.0	137.0	272.0	3000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	4000.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5964.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5944.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0
5954.0	137.0	272.0	3500.0	1136.0	1363.0	10880.0	45000.0	10000.0	696.0

Table 10. Expected yields for technology (input) Level II; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	0.0	0.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	0.0	606.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	590.0	606.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	590.0	606.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	590.0	606.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	590.0	454.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
0.0	455.0	454.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
0.0	455.0	454.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	7500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8500.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0
11728.0	455.0	454.0	8000.0	2728.0	2998.0	30264.0	60000.0	12000.0	900.0

Table 11. Expected yields for technology (input) Level III; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	0.0	0.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	0.0	908.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	360.0	908.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	360.0	908.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	360.0	908.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	360.0	680.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
0.0	343.0	680.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
0.0	343.0	680.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	5250.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	7000.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0
17592.0	343.0	680.0	6125.0	2613.0	2526.0	60000.0	90000.0	15000.0	1590.0

Table 12. Expected gross revenue per hectare for input Level I; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	0.0	0.0	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	0.0	3666.30	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1782.00	3666.30	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1782.00	3666.30	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1782.00	3666.30	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1782.00	2747.20	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
0.0	1356.30	2747.20	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
0.0	1356.30	2747.20	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	4000.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28
4808.47	1356.30	2747.20	3500.00	1704.00	3952.70	1305.60	2700.00	7999.99	3953.28

Table 13. Expected gross revenue per hectare for input Level II; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	0.0	0.0	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	0.0	6120.59	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	5841.00	6120.59	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	5841.00	6120.59	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	5841.00	6120.59	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	5841.00	4585.39	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
0.0	4594.50	4585.39	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
0.0	4594.50	4585.39	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	8459.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7959.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00
9616.95	4594.50	4585.39	7999.99	4092.00	8694.19	3631.68	3600.00	9599.99	5112.00

Table 14. Expected gross revenue per hectare for input level III; 30 year time horizon

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
0.0	0.0	0.0	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	0.0	0.0	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	0.0	9170.80	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3564.00	9170.80	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3564.00	9170.80	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3564.00	9170.80	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3564.00	6868.00	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
0.0	3395.70	6868.00	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
0.0	3395.70	6868.00	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	5250.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	7000.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20
14425.44	3395.70	6868.00	6125.00	3919.50	7325.40	7200.00	5400.00	12000.00	9031.20

The canals, headgates and other necessary works within the Milagro project area have been under construction since 1946. The costs represented in Table 15 are the investment costs of the Milagro project calculated by INERHI through 1970, year zero for this study.

Table 15. Public capital invested in the Milagro project

Headgates	S/. 1331035.	
Canals	6146748.	
Other Works	1780924.	
Access Roads	480000.	
Total		S/. 9738707.

Source: (16)

The sum of public capital investment is to be amortized in 30 years (14) (the horizon chosen for the present study) at an interest rate of 4 per cent, the rate granted INERHI by the World Development Bank (18). The value calculated in Table 16 is the required annual payment (tariff receipts) necessary to amortize investment in the primary canal system in Milagro.

Table 16. Annual amortization value of public investment, Milagro project

Total Investment	S/. 9738707	
Coefficient (4% for 30 years)	X 0.05783	
Annual Payment		S/. 563189

Since the project size stabilized by the year 1968 (18), the annual variable cost of the project is calculated as an average of the annual variable costs for the years 1968, 1969, and 1970, to reduce error due to any yearly fluxuation (Table 17).

Table 17. Average annual variable expenditure, Milagro project

Maintenance	S/. 323421	
Operation	164905	
Administration	176553	
Indirect Costs	90860	
Total		S/. 755739

Source: (13)

The sum of the two annual costs, amortization and variable, represents the total annual cost to INERHI of the primary canal system. This is the sum that must be recovered through the structure of water tariffs (Table 18).

Table 18. Average annual total expenditure, Milagro project

Annual Amortized Investment	S/. 563189.	
Annual Variable Cost	755739.	
Total Annual Cost		S/. 1318928.

The water tariff is calculated in the project area by the farmer receiving an average flow of one liter per second of water into his canals for every hectare of land which he contracts to INERHI to irrigate during the six dry months of the year. For example, suppose a farmer owns 10 hectares of land in Milagro County and happens to live where canals reach his farm. He wishes to irrigate seven hectares this year. At the end of the winter or rainy season, he begins to receive water from the primary canals. His neighbors also need water, so he may water once every three days. To water his land, he is given 21 liters per second into his canals all day every third day. The INERHI canals that run by his land carry 0.20 cubic meters of water per second. The 21 liters per second he receives are equal to 0.021 cubic meters per second.

At the end of the year, when the harvest is in, the farmer pays S/. 200 per hectare for all the water received or, in this case, a total of S/. 1400.

Any annual variance in the number of hectares contracting water supplies is due to climatic conditions and not due to changing project size. The average number of hectares contracted during the period, 1968 through 1970 was 7127. At the rate of S/. 200 per hectare, the average revenue to INERHI for the period was S/. 1425400 (Table 19).

Table 19. Average revenue, Milagro project

Average Contracts	7127	
Water Tariff	X S/. 200	
Average Revenue		S/. 1425400

Source: (16)

Table 20 presents a comparison of average annual revenue and average annual expenditure within the Milagro project area by INERHI, operator of the primary canal system in the project area.

Table 20. Average annual net revenue, Milagro project

Average Revenue	S/. 1425400	
Average Expenditure	- 1318928	
Average Net Revenue		S/. 106472

On the basis of the foregoing analysis, it can be concluded that all operating and maintenance costs plus amortization of the capital investments in the primary canal system are paid by the farmers using irrigation water within the area, just as required by law (8).

On-Farm Investment Costs

In addition to the primary canal system within the project area, the farmers using the water must have a certain amount of on-farm irrigation infrastructure. The cost of this, on the average, has been estimated by Caja Nacional de Riego engineers at S/. 3000. per hectare (4, p. 21). This cost does not enter into the calculation of annual costs reported below. Rather, it is part of the capital and "managerial" investment to which the internal rate of return accrues.

Variable Production Costs

Nonirrigation Production Costs

The variable costs of production for each crop in the Milagro project area include items such as seed, fertilizer, pesticides, and transportation. The variable costs also include labor costs. Since the proprietor may work himself, and most likely does, the opportunity cost of his labor is imputed as a cost of production.

Credit Costs

Annual production credit costs are figured as a percentage of all cash expenditures. A farmer may incur the credit cost by borrowing or by using his own capital, which imputes an opportunity cost to his budget. The rate may vary from farmer to farmer as risk to the lender changes. An average rate of interest was used in the production functions of the Milagro project area (18).

Because of the labor intensity of the production methods of the crops in the area, interest on capital investment in machinery is not a part of the average farm budgets. Some machinery investment may exist, but information about it is not available for this study. It is assumed that any machinery interest costs are included in the rental fees for machinery, which are included in the budget for Input Level III.

Irrigation Costs

Inclusion of irrigation in farm techniques creates some variable costs. There is an annual cost due to the water tariff, which is payment to the primary canal system, irrigation labor, maintenance, which is practically all labor, and increased costs related to higher yields, such as harvest labor and transportation costs.

Input Levels

While farmers have no control over product or factor prices, the level of technology under which they operate can be changed. Three levels of technology have been defined above, and yields and costs for average farms by tenure class calculated (see Tables 21-23 for costs per crop per hectare). In review, the technology levels are:

Input Level I: Traditional farming methods without irrigation, only natural rainfall.

Input Level II: Traditional farming methods with irrigation from INERHI canals.

Input Level III: Modern farming methods introduced on irrigated land.

Net Revenue

Net Revenue per Crop, per Hectare

Net revenue for each crop or group of crops presently being grown on farms within the Milagro project area has been calculated on the basis of the model presented above. This is accomplished by subtracting costs from gross returns for each farm type. Note that net returns on types I_2 and I_3 do not take into account the S/. 3,000 per hectare cost of a distribution system. The results of the calculations under static conditions are presented in Tables 24 through 26.

Table 21. Estimated per hectare costs by crops for Input Level I

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
1275.00	2033.00	634.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	716.00	595.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	440.00	949.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	540.00	949.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	540.00	949.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	540.00	949.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	540.00	833.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1275.00	516.00	833.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	933.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1275.00	516.00	833.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	2239.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	2057.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00
1748.00	516.00	833.00	1939.00	855.00	1383.00	582.00	2543.00	2555.00	1738.00

Table 22. Estimated per hectare costs by crops for Input Level II

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
2156.00	2170.00	766.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	832.00	637.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	572.00	1348.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	927.00	1348.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	927.00	1348.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	927.00	1348.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	927.00	1198.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
2156.00	839.00	1198.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
2156.00	839.00	1198.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	4087.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3657.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00
3182.00	839.00	1198.00	3537.00	1897.00	2858.00	648.00	3136.00	31040.00	1988.00

Table 23. Estimated per hectare costs by crops for Input Level III

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
6890.00	3390.00	2156.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
4812.00	1717.00	1717.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
4812.00	749.00	3257.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	918.00	3257.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
4812.00	918.00	3257.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	918.00	3257.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	918.00	2832.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4512.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
6890.00	677.00	2832.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	277.00	2832.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2932.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4012.00	877.00	2832.00	3490.00	1453.00	2499.00	2592.00	4323.00	5621.00	2992.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2952.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
6890.00	877.00	2832.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2922.00
4812.00	877.00	2832.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2932.00
4812.00	877.00	2832.00	4030.00	1453.00	2489.00	2592.00	4323.00	5621.00	2932.00
4812.00	877.00	2832.00	3703.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	877.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00
4812.00	377.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2992.00
4812.00	377.00	2832.00	3490.00	1453.00	2489.00	2592.00	4323.00	5621.00	2982.00

Table 24. Net revenue per crop per hectare for Input Level I

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
-1275.00	-2039.00	-634.00	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	-716.00	-505.00	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	-440.00	2717.30	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	1242.00	2717.30	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	1242.00	2717.30	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	1242.00	2717.30	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	1242.00	1914.20	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
-1275.00	840.30	1914.20	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
1275.00	840.30	1914.20	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	761.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1943.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28
3060.47	840.30	1914.20	1561.00	849.00	2569.70	723.60	157.00	5444.99	2215.28

Table 25. Net revenue per crop per hectare for Input Level II

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
-2356.00	-2370.00	-966.00	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	-1032.00	-937.00	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	-772.00	4572.59	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	4714.00	4572.59	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	4714.00	4572.59	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	4714.00	4572.59	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	4714.00	3187.39	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
-2356.00	3466.50	3187.39	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
-2356.00	3466.50	3187.39	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	3212.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4642.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00
6234.95	3466.50	3187.39	4262.99	1995.00	5636.19	2783.68	264.00	-21640.01	2924.00

Table 26. Net revenue per crop per hectare for Input Level III

Banana	Cacao	Coffee	Pineapple	Corn	Rice	Pasture	Sugarcane	Fruits	Others
-7090.00	-3580.00	-2356.00	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	-1417.00	-1917.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	-948.00	5713.80	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2446.00	5713.80	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2446.00	5713.80	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2446.00	5713.80	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2446.00	3836.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
-7090.00	2318.70	3836.00	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
-7090.00	2318.70	3836.00	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	1020.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	3097.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20
9413.44	2318.70	3836.00	2435.00	2266.50	4636.40	4408.00	877.00	6179.00	5849.20

Distribution of Crops

The sample data points from the two agricultural surveys were divided into four size groups. The basis for the division was explained in a previous section. The average areas within each group were compared in Table 7. It can be concluded that the average areas within each group in the two survey zones (with and without irrigation) are statistically equal. For the present study, the zone with irrigation is the area of interest. The average total farm areas for each size level within the irrigated lands are used to represent the average total farm areas on both the irrigated and unirrigated farms. This will eliminate a random variation from entering the analysis.

The percentage of the average farm land devoted to each crop, including land not cultivated, calculated by INERHI from the surveys (9 and 10) is used to represent the distribution of crops. The percentages are multiplied by the average total farm size, as discussed above, to determine the average land areas used to grow each crop within size levels on irrigated and unirrigated land in Tables 27 and 28. The distribution of crops on the irrigated land is also used to determine crop distribution under "modern" farming practices, as no information exists to indicate the actual distribution.

Net Revenue per Farm

The analysis of the crops within the project area has been on a unit area (per hectare) basis. To relate the information obtained about the individual crops to the present economic situation within the project area, the net revenues will be summed over the areas devoted to each crop within the average farm size for each of the land tenure groups. This will estimate average farm incomes (net revenues).

Table 27. Distribution of crops for Input Level I [a]

Crop	Size Level I		Size Level II		Size Level III		Size Level IV	
	%	Ha.	%	Ha.	%	Ha.	%	Ha.
1	7.4	0.17	9.0	0.64	6.3	0.89	12.3	5.34
2	22.3	0.51	34.3	2.43	32.2	4.56	19.6	8.50
3	10.2	0.24	16.4	1.16	11.6	1.64	13.1	5.68
4	32.8	0.76	17.4	1.23	19.0	2.70	10.6	4.60
5	0.6	0.01	0.6	0.04	0.9	0.13	1.0	0.43
6	0.0	0.00	0.0	0.00	0.0	0.00	2.3	1.00
7	19.2	0.46	18.0	1.28	22.5	3.20	23.2	10.07
8	0.0	0.00	0.0	0.00	2.5	0.36	11.1	4.82
9	0.9	0.02	1.8	0.13	1.5	0.21	3.2	1.39
10	0.0	0.00	0.3	0.02	1.0	0.14	2.1	0.91
W/O	6.6	0.15	2.2	0.16	2.5	0.36	1.5	0.65
Total	100.0	2.32	100.0	7.09	100.0	14.20	100.0	43.39

[a] Note that average farm size is assumed to be that of irrigated farms, since they are not statistically different.

Source: (10)

Table 28. Distribution of crops for Input Levels II and III

Crop	Size Level I		Size Level II		Size Level III		Size Level IV	
	%	Ha.	%	Ha.	%	Ha.	%	Ha.
1	12.2	0.28	25.2	1.79	20.6	2.93	14.5	6.29
2	19.4	0.45	21.6	1.53	16.0	2.27	30.2	13.10
3	22.3	0.52	17.1	1.21	13.8	1.96	11.4	4.95
4	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
5	0.0	0.00	0.0	0.00	1.1	0.16	0.0	0.00
6	20.9	0.48	2.6	0.18	0.0	0.00	0.8	0.35
7	0.0	0.00	8.2	0.58	16.0	2.27	20.1	8.72
8	25.2	0.59	16.1	1.14	18.9	2.68	13.1	5.68
9	0.0	0.00	0.0	0.00	0.0	0.00	0.5	0.22
10	0.0	0.00	0.0	0.00	0.0	0.00	0.9	0.39
W/O	0.0	0.00	9.2	0.66	13.6	1.93	8.5	3.69
Total	100.0	2.32	100.0	7.09	100.0	14.20	100.0	43.39

Source: (9)

To illustrate this process, the calculations for Size Level I will be presented. Only the final results for the other three levels are in this study, but the process is identical. Row 1, column 2 in Table 29 is the sum of the products of row 1 in Table 24 and column 3 of Table 27. That is, the row is the sum over all crops of average net returns per crop, per hectare in year 1 multiplied by the area in that crop.*

Internal Rate of Return to Technology Shifts

Net Return Defined

Corresponding to a shift from one input (technology) level to another, there is a difference in net revenue. The difference is termed for present purposes net return. For Size Level I, the shift from Input Level I to Input Level II would create the difference for each year between net revenue of Level I and Level II of Table 29. This difference is column 3 (returns) of Table 30.

Discounting

In Table 30, the future net returns to a technological shift, as described above, are discounted to year zero so that the sum of the present values is equal to the initial investment in year zero. The rate of return that equates these two values is the internal rate of return to an investment if that investment is responsible for the difference in net revenues (net returns).

The original investment value is obtained by multiplying the water distribution system costs of S/. 3,000 per hectare by the average.

*Table 28 is used in conjunction with Table 25 and 26 to calculate columns 3, and 4 of Table 29.

Table 29. **Net revenue per farm for Size Level I**

YEAR	INPUT(1)	INPUT(2)	INPUT(3)
1	-379.68	632.63	-2078.42
2	1960.85	3707.28	3744.17
3	2584.64	6637.27	7923.23
4	3442.46	9105.96	9450.53
5	3442.46	9105.96	9450.53
6	2834.46	9105.96	9450.53
7	3540.03	8385.66	8474.07
8	3044.85	7824.27	8416.79
9	3044.85	7824.27	8416.79
10	3044.85	7824.27	8416.79
11	1699.82	54.8.82	3795.83
12	3335.17	7824.29	8416.79
13	3044.85	7824.29	8416.79
14	3044.85	7824.29	8416.79
15	3044.85	7824.29	8416.79
16	2436.85	7824.29	8416.79
17	3335.17	7824.29	8416.79
18	3044.85	7824.29	8416.79
19	3044.85	7824.29	8416.79
20	3044.85	7824.29	8416.79
21	1699.82	5418.82	3795.83
22	3335.17	5418.82	8416.79
23	3044.85	5418.82	8416.79
24	3044.85	5418.82	8416.79
25	3044.85	5418.82	8416.79
26	2436.85	5418.82	8416.79
27	3335.17	5418.82	8416.79
28	3044.85	5418.82	8416.79
29	3044.85	5418.82	8416.79
30	3044.85	5418.82	8416.79

Source: (9, 10, 6)

Table 30. **Calculating the internal rate of return for Size Level I, when technology shifts from Level I to Level II***

YEAR	INVESTMENT	RETURN	FACTOR	PRESENT VALUE
0	6955.00			
1		1012.32	0.69258	701.11
2		1746.43	0.47967	837.72
3		4052.63	0.33221	1346.34
4		5663.50	0.23009	1303.09
5		5663.50	0.15935	902.50
6		6271.50	0.11037	692.16
7		4845.63	0.07644	370.39
8		4779.44	0.05294	253.02
9		4779.44	0.03667	175.24
10		4779.44	0.02539	121.37
11		3719.00	0.01759	65.41
12		4489.12	0.01218	54.68
13		4779.44	0.00844	40.32
14		4779.44	0.00584	27.93
15		4779.44	0.00405	19.34
16		5387.44	0.00280	15.10
17		4489.12	0.00194	8.71
18		4779.44	0.00134	6.43
19		4779.44	0.00093	4.45
20		4779.44	0.00064	3.08
21		3719.00	0.00045	1.66
22		4489.12	0.00031	1.39
23		4779.44	0.00021	1.02
24		4779.44	0.00015	0.71
25		4779.44	0.00010	0.49
26		5387.44	0.00007	0.38
27		4489.12	0.00005	0.22
28		4779.44	0.00003	0.16
29		4779.44	0.00002	0.11
30		4779.44	0.00002	0.08
TOTAL				6954.57

*PRESENT VALUE AT 44.39 PERCENT FOR 30 YEARS.

farm size for Level I (2.32 ha). The average sizes for irrigated farms (technology Level II) are used as a base in each instance.

Rates of Return Under Simulated Conditions

The internal rates for shifting technology on the Milagro project area farms are presented in Tables 31 through 38. These tables are three dimensional in nature, in that three parameters, yields, costs, and selling prices are varied simultaneously. Each size level is studied independently of the others. The rates reflect the reaction of the average farm of the size level, and no particular farm is expected to react in the same way as the average. Because of the homogeneity encountered in the project area, however, it is expected that there will not be a great deal of variance.

The internal rates of return have been calculated for two shifts in technology from I_1 to I_2 and also from I_1 to I_3. The first, changing from traditional unirrigated methods to traditional irrigated methods, describes what has happened in much of the project area. The second, changing from traditional unirrigated methods to modern irrigated methods is the proposed "project package" that is usually implied in feasibility studies. This is the case with the Chas. T. Main study and the INERHI study that followed.

It will be noted that a shift along one axis of such a three dimensional table may imply a necessary shift along another axis. For example, a higher yield might imply using a higher cost factor or perhaps a lower market price factor.

Table 31. Internal rates of return, Size Level I, $I_2 - I_1$

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	11.76	17.38	22.52	27.37	32.01
0.8	18.14	23.93	29.38	34.59	39.60
0.9	23.93	30.05	35.85	41.43	46.93
1.0	29.38	35.85	42.04	48.01	53.80
1.1	34.59	41.43	48.01	54.37	60.55

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	13.19	18.70	23.78	28.59	33.20
0.8	19.45	25.18	30.59	35.77	40.76
0.9	25.18	31.25	37.03	42.59	47.98
1.0	30.59	37.03	43.20	49.16	54.93
1.1	35.77	42.59	49.16	55.50	61.68

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	14.60	20.01	25.03	29.81	34.40
0.8	20.74	26.42	31.80	36.95	41.93
0.9	26.42	32.45	38.21	43.76	49.13
1.0	31.80	38.21	44.36	50.30	56.06
1.1	36.95	43.76	50.30	56.63	62.80

Table 32. Internal rates of return, Size Level II, $I_2 - I_1$

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	13.85	13.98	23.70	28.12	32.31
0.8	19.68	24.99	29.94	34.63	39.09
0.9	24.99	30.54	35.76	40.71	45.44
1.0	29.94	35.76	41.25	46.47	51.46
1.1	34.63	40.71	46.47	51.94	57.19

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	12.53	17.78	22.56	27.03	31.26
0.8	18.49	23.87	28.87	33.59	38.09
0.9	23.87	29.48	34.74	39.72	44.48
1.0	28.87	34.74	40.26	45.51	50.52
1.1	33.59	39.72	45.51	51.01	56.28

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	11.17	16.56	21.42	25.94	30.21
0.8	17.28	22.74	27.80	32.56	37.08
0.9	22.74	28.41	33.71	38.73	43.51
1.0	27.80	33.71	39.27	44.54	49.58
1.1	32.56	38.73	44.54	50.08	55.37

Table 33. Internal rates of return, Size Level III, $I_2 - I_1$

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
-0.7	10.14	14.82	19.01	22.88	26.50
-0.8	15.45	20.14	24.46	39.40	32.29
-0.9	20.14	24.97	29.46	33.67	37.65
-1.0	24.46	29.46	34.12	38.51	42.67
-1.1	28.49	33.67	38.51	43.07	47.40

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
-0.7	11.20	15.76	19.08	23.69	27.27
-0.8	16.37	20.99	25.25	29.24	33.01
-0.9	20.99	25.76	30.20	34.37	38.33
-1.0	25.25	30.20	34.82	39.18	43.31
-1.1	29.24	34.37	39.18	43.71	48.02

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
-0.7	12.24	16.69	20.73	24.49	28.04
-0.8	17.28	21.93	26.04	29.98	33.72
-0.9	21.83	26.54	30.94	35.07	39.00
-1.0	26.04	30.94	35.52	39.84	43.95
-1.1	29.98	35.07	39.84	44.35	48.63

Table 34. Internal rates of return, Size Level IV, $I_2 - I_1$

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	10.23	12.98	15.47	17.76	19.90
0.8	13.35	16.14	18.69	21.07	23.29
0.9	16.14	19.00	21.64	24.09	26.39
1.0	18.69	21.64	24.26	26.88	29.24
1.1	21.07	24.09	26.88	29.47	31.86

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	9.73	12.52	15.03	17.34	19.49
0.8	12.89	15.70	18.28	20.67	22.90
0.9	15.70	18.59	21.24	23.70	26.01
1.0	18.28	21.24	23.97	26.50	28.87
1.1	20.67	23.70	26.50	29.09	31.48

Cost variation 1.10

Price variation (%)	0.8	0.9	1.0	1.1	1.2
0.7	9.21	12.05	14.58	16.91	19.0[illegible]
0.8	12.42	15.27	17.86	20.26	22.51
0.9	15.27	18.17	20.84	23.32	25.63
1.0	17.86	20.84	23.58	26.13	28.49
1.1	20.26	23.32	26.13	28.72	31.10

Table 35. Internal rates of return, Size Level I, $I_3 - I_1$

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	0.00	7.29	13.62	19.21	24.46
0.8	8.27	15.26	21.50	27.36	32.98
0.9	15.26	22.25	28.78	35.04	41.07
1.0	21.50	28.78	35.72	42.39	48.85
1.1	27.36	35.04	42.39	49.49	55.40

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	1.93	9.59	15.67	21.19	26.41
0.8	10.51	17.28	23.46	29.30	34.92
0.9	17.28	24.20	30.73	36.98	43.03
1.0	23.46	30.73	37.66	44.35	50.83
1.1	29.30	36.98	44.35	51.46	58.39

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	4.81	11.79	17.71	23.18	28.39
0.8	12.68	19.31	25.44	31.27	36.89
0.9	19.30	26.18	32.70	38.95	45.00
1.0	25.44	32.70	39.63	46.32	52.82
1.1	31.27	38.95	46.32	53.46	60.39

Table 36. Internal rates of return, Size Level II, $I_3 - I_1$

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	4.93	12.79	19.54	25.76	31.72
0.8	13.80	21.35	28.34	35.03	41.48
0.9	21.35	29.19	36.66	43.84	50.77
1.0	28.34	36.66	44.62	52.29	59.71
1.1	35.03	43.84	52.29	60.44	68.34

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	7.65	15.12	21.76	27.90	33.94
0.8	15.10	23.57	30.56	37.25	43.70
0.9	23.57	31.41	38.80	46.06	53.00
1.0	30.56	38.80	46.84	54.52	61.95
1.1	37.25	46.06	54.52	62.63	70.61

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	10.22	17.44	24.01	30.22	36.18
0.8	18.41	25.81	32.80	39.49	45.94
0.9	25.91	33.65	41.12	48.31	55.26
1.0	32.80	41.12	49.09	56.78	64.23
1.1	39.49	48.31	56.78	64.96	72.92

Table 37. Internal rates of return, Size Level III, $I_3 - I_1$

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	6.84	14.16	20.58	26.55	32.23
0.8	15.12	22.32	29.02	35.37	41.46
0.9	22.32	29.83	36.92	43.69	50.20
1.0	29.02	36.92	44.43	51.62	58.56
1.1	35.37	43.69	51.62	59.25	66.62

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	4.02	11.81	18.37	24.39	30.10
0.8	12.80	20.13	26.87	33.24	39.54
0.9	20.13	27.69	34.79	41.57	48.09
1.0	26.87	34.79	42.31	49.50	56.44
1.1	33.24	41.57	49.50	57.12	64.49

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	0.82	9.41	16.15	22.25	27.90
0.8	10.44	17.94	24.74	31.13	37.24
0.9	17.94	25.56	32.69	39.47	45.99
1.0	24.74	32.69	40.21	47.41	54.34
1.1	31.13	39.47	47.41	55.03	62.38

Table 38. Internal rates of return, Size Level IV, $I_3 - I_1$

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	7.10	11.90	16.33	20.45	24.16
0.8	12.62	17.54	22.04	26.29	30.50
0.9	17.54	22.57	27.35	32.05	36.65
1.0	22.04	27.35	32.57	37.65	42.58
1.1	26.29	32.05	37.65	43.07	48.31

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	5.45	10.51	14.90	19.11	22.73
0.8	11.16	16.09	20.79	24.76	28.89
0.9	16.09	21.27	25.78	30.44	35.05
1.0	20.79	25.78	30.96	36.06	41.02
1.1	24.76	30.45	36.06	41.51	46.77

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	3.72	9.02	13.50	17.59	21.55
0.8	9.70	14.69	19.53	23.27	27.20
0.9	14.69	19.54	24.22	28.73	33.36
1.0	19.53	24.22	29.24	34.32	39.40
1.1	23.27	28.73	34.38	39.90	45.22

Yields

Even with the same inputs year after year (and the same costs), climatic conditions and other random factors will produce differing crop yields per unit area. In the model, random variations in crop yields range from 80% to 120% of the current situation, in 10% increments.

Prices in Ecuador

In Ecuador, many prices on both the wholesale and retail levels are established by law. Even with price controls, however, market pressures have an effect on the rates of exchange of goods and services.

Expanding production may be expected to exert downward market pressures in an area where developmental resources are directed to improve yields. This effect may be amplified since the facilities for processing in the area are used to capacity, thus adding to a strongly inelastic demand for agricultural production (18 and 19).

An increased demand for food products in the country as a whole, on the other hand, will apply pressure for rising prices.

The model examines the effects of both a rise and a decline in the prices paid to producers of agricultural commodities in the Milagro project area. Inelastic demand at the farmgate and falling prices have been prevalent (18); therefore, in the simulation program the range is for prices from 60% to 110% of the current level in 10% increments.

Factor prices reflect the rising costs of raw materials and production methods worldwide, because most of the factors of production come from sources external to Ecuador. Factor prices have been rising over the last few years (18). The simulation program varies the factor prices at 5%, and 10% more than current factor prices.

Gross Revenue

Gross revenue associated with each farm size is the product of prices and yields and may vary with a change in either parameter. A random rise in yields may also be offset by a lowering of prices, or vice versa.

Variable Costs

Variable costs for each of the farm budgets by size and technology as established by the survey information and the Chas. T. Main team are varied uniformly with one exception. The cost of the water contract, or the water tariff, is held constant in the simulations of changes in other factor prices, yields, and product prices. This is because changes in the cost of the water contract, itself, will be studied separately (see below).

Interpretation of Simulated Results

The shifts in the yield, cost and price parameters are simulated by percentage variations in a plus (minus) direction from the values revealed by the survey data. The internal rates of return for the original data are shown at intersections of the 1.00 row and column values and the 1.00 cost factor in each case. Thus, the internal rate of return computed in the example culminating in Table 30 is indicated in Table 31 at the location described (44.36%).

If it is supposed that a technology shift on the small size farms, from I_1 I_2 is accompanied by a cost increase of 5 per cent, the internal rate of return to the introduced irrigation technology will fall to 43.2 per cent and to 42.04 per cent if costs rise an average of 10 per cent (cost factor = 1,1).

Numerous other simulated results are depicted. In each case, the parameters are assumed to move on a percentage basis above or below the initial survey values. For example, if the shift I_1 to I_2, Size Level I (Table 31), is accompanied by a reduction in average prices received of 30 per cent, the rate of return will be 25.03. If yields i crease, due to random events, by 10 percent, and prices fall by 30 per cent, the rate of return to the shift will be 29.81 per cent. If an additional allowance is made for a shift in costs of 5 per cent upwards, the rate of return falls to 28.59 per cent.

Table 32 simulates the same technology shift, I_1 to I_2, but for slightly larger farm sizes (Level II), and so on. Starting with Table 40, the process is repeated, but for a technology shift from I_1 to I_3.

Water Tariffs Under Simulated Conditions

To determine the level of water tariff necessary to tax away the pure economic profit earned on irrigated farms, the simulation program is modified.

To this point in the study, the water tariff has been the legal rate as set forth in Ecuadorian water law, just high enough to pay the expenses of the primary canal system. (S/.200). In this modification of the simulation model the tariff will be set where it will allow a rate of return on water related investment of 12 per cent, which is the approximate rate of return of the best alternative investment possibility of similar risk available to farmers of the area. With a rate of return lower than alternatives, farmers will not invest in on-farm irrigation capital nor contract for water.

Tables 39 through 47 simulate total water fees per hectare that could be paid, leaving a 12 per cent return on the costs of investing in the technology shift from I_1 to I_2 under present and varying price, cost and yield conditions.*

The current situation for the smallest size irrigated traditional farms (Table 39), is that they pay a fee of S/. 200 per hectare at present. According to the simulation results, this could approximate 1608.39 _if_ no other investment or management return (unaccounted for in the survey farm budgets) were thought to be necessary.

To the extent the budgets are correct, an increment in fees of S/. 1408/hectare would just tax away pure economic profits on farms on this size level.

What this series of tables shows is the sensitivity of the average farmer's ability to absorb higher fees if yields, costs, and receipts move in unfavorable directions. In the worst situation simulated, costs up 10 per cent, yields down 20 per cent and prices down 30 per cent, the 1608.39 figure is reduced to 223.13. This is an amount greater than the present average water charges for technology level II farms of the size shown in Table 39. Tables 40 through 42 are interpreted in the same fashion.

The most interesting and revealing feature of these results is that the smaller size farm can bear the highest water fee increase, all other things equal.

Secondary Benefits

In the Milagro project area, the primary benefits accrue to the individual farmer due to on-farm infrastructure built to irrigate.

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*This modification is not made for the shift from technology level I to I_3.

Table 39. Water tariff = 12 per cent return on water related investment, Size Level I

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	223.13	420.34	596.24	807.80	1019.64
0.8	450.71	658.85	901.68	1142.47	1384.38
0.9	658.84	932.08	1204.11	1477.21	1749.96
1.0	901.68	1204.11	1501.90	1804.62	2106.05
1.1	1142.46	1477.21	1804.63	2137.18	2478.00

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	264.44	472.55	647.89	859.05	1072.14
0.8	500.00	710.70	949.84	1195.23	1437.41
0.9	710.70	980.30	1251.81	1524.14	1795.86
1.0	949.84	1251.81	1555.17	1858.01	2159.54
1.1	1195.23	1524.15	1858.01	2190.58	2521.22

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	311.77	500.00	699.32	910.73	1124.77
0.8	518.78	760.89	1002.07	1243.00	1484.32
0.9	760.90	1032.66	1304.82	1577.36	1849.21
1.0	1002.06	1304.82	1608.39	1911.29	2212.89
1.1	1243.00	1577.36	1911.29	2243.89	2574.65

Table 40, Water tariff = MVP, Size Level II

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	206.74	386.93	569.51	766.25	945.48
0.8	415.17	605.78	832.63	1059.21	1204.55
0.9	605.78	860.71	1112.37	1365.55	1618.50
1.0	832.63	1112.37	1394.36	1676.27	1957.14
1.1	1055.21	1365.55	1676.28	1986.03	2294.04

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	243.79	433.58	595.28	792.50	989.17
0.8	461.80	651.23	879.83	1103.26	1327.62
0.9	651.23	908.07	1160.55	1414.05	1667.15
1.0	879.83	1160.54	1442.05	1724.89	2005.83
1.1	1103.26	1414.04	1724.88	2034.69	2342.80

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	283.06	481.28	642.86	839.20	1037.03
0.8	500.00	698.57	923.48	1151.41	1376.09
0.9	698.57	951.76	1208.78	1462.52	1715.76
1.0	923.48	1208.78	1491.33	1773.44	2054.45
1.1	1151.41	1462.52	1773.44	2083.29	2391.49

Cost variation: 1.05, 1.00

Table 41. Water Tariff = MVP, Size Level III

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	179.73	313.43	471.19	594.25	751.87
0.8	335.49	500.00	660.36	840.01	1019.77
0.9	500.00	684.24	884.52	1067.13	1286.68
1.0	660.36	884.52	1109.79	1332.26	1554.21
1.1	840.01	1087.13	1332.25	1577.07	1820.70

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	205.25	346.61	500.00	626.85	784.95
0.8	370.28	515.20	695.09	873.57	1053.38
0.9	515.21	716.92	918.26	1121.33	1321.09
1.0	695.08	918.26	1144.03	1366.68	1583.73
1.1	873.57	1121.34	1366.67	1611.58	1935.30

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	232.21	381.42	504.75	660.69	818.26
0.8	403.46	550.49	727.46	907.27	1087.55
0.9	550.49	752.23	952.12	1155.59	1355.50
1.0	727.46	952.12	1178.30	1401.09	1623.25
1.1	907.27	1155.59	1401.10	1546.10	1889.89

Table 42. Water tariff = MVP, Size Level IV

Cost variation 1.10

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	152.23	241.75	335.17	440.70	516.51
0.8	254.11	367.63	495.55	579.20	[illegible]
0.9	367.63	500.00	610.55	756.17	[illegible]
1.0	495.55	610.56	771.49	930.71	[illegible]
1.1	579.20	756.17	930.71	1109.52	[illegible]

Cost variation 1.05

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	174.70	256.64	354.25	467.22	535.36
0.8	263.29	386.67	500.00	600.44	726.70
0.9	385.67	500.00	630.49	775.47	919.33
1.0	500.00	630.49	790.86	950.83	[illegible]
1.1	600.44	775.47	950.02	1129.62	[illegible]

Cost variation 1.00

Price variation (%)	Yield variation (%) 0.8	0.9	1.0	1.1	1.2
0.7	137.70	271.93	374.85	406.99	556.16
0.8	234.86	407.21	500.00	620.06	765.73
0.9	407.22	507.35	650.98	794.89	939.26
1.0	500.00	650.97	810.35	970.94	1129.60
1.1	620.06	794.88	970.84	1149.74	1345.14

his crops after the primary canal system is in place. Each farmer bears the cost of the amortization and operation of the main canals as an annual production cost.

Many non-farmers and farmers not irrigating crops also benefit indirectly from the water being delivered to help increase crops. Increased net revenue to some farmers means increased spending for factors of production, food and other staples, and luxury items. This translates into increased sales and revenue for others not necessarily concerned with direct agricultural production.

In the Chas. T. Main study, a comparison was made of several estimates of the multiplier for calculating secondary benefits. The value finally chosen for their use was 0.40 (6, p. 135). This value may be somewhat arbitrary, but it is now used to determine the value of secondary benefits generated in the Milagro project area.

No attempt will be made to estimate the value of increased export of agricultural commodities to the country's balance of trade and national income accounts. The effects considered are only regional.

Table 43. Secondary benefits, Milagro project

Management Level	No. of Farms	Mean Annual Direct Benefits per Farm	Total Annual Direct Benefits	Total Annual Secondary Benefits
I	21	S/. 4469	S/. 93849	S/. 37540
II	41	11674	478634	191454
III	62	12339	765018	306007
IV	18	61055	1098990	439596
Total	142		S/. 2436491	S/. 974597

POLICY IMPLICATIONS

Summary of Analysis

Surveys and studies made within the Milagro project area of Ecuador have shown that the farms of the area are basically homogeneous. The soils, the climate and the inate management ability of the farmers are considered homogeneous throughout the area. Technology and market pressures are also uniform in Milagro.

Land tenure differences are removed by dividing the farmers into size groups, representative of four basic land tenure systems. The small variation of farm size about the mean value for each group indicates that the four groups are representative of real grouping patterns of the area.

One nonhomogeneous factor found in the project area was on-farm irrigation and its respective infrastructure. There exists a distinct grouping of farms receiving water from the primary canal system and those that rely on natural rainfall.

The mean land areas within each tenure level for irrigated and nonirrigated land were compared statistically, and the results show that farm size is the same for both types of on-farm water management practices.

From survey information supplied by INERHI, three input/output relationships were estimated for each major crop of the area. These were: traditional unirrigated; traditional irrigated; and modern irrigated. They were designated technology Levels I, II and III. They are shown in Figures and Tables as I_1, I_2 and I_3.

The difference in net revenue between technology Level I and technology Level II is attributable to the differences in water management practices alone. All costs but water investment are considered in calculating net revenues; therefore, the difference in net revenues accrues to on-farm irrigation infrastructure investment. This is called net returns.

The internal rate of net return was calculated under dynamic conditions and the results tabulated to permit observation of the responsiveness of the rate to alterations in market and climatic conditions.

Justification of the Irrigation Project

The average rate of interest on time deposits in Ecuador is 6 per cent. Other investment opportunities available to farmers in the Milagro project area may reach 12 per cent (18).

The internal rates of return under present market and climatic (yield) conditions are presented in Table 44 and are compared with the 12 per cent opportunity cost mentioned above.

Table 44. Investment opportunity costs and net internal rates of return for technology shift I_1 to I_2

Size Level	Discount Rate (%)*	Opportunity Cost (%)	Net Rate of Return (%)
I	44.4**	12.0	32.4
II	41.3	12.0	29.3
III	35.5	12.0	23.5
IV	24.4	12.0	12.4

* See Tables 31-34.
** See Tables 30-31.

A similar analysis was made of the rates of return under dynamic conditions. Only under the most extreme conditions, such as a low yield with extremely low product prices (indicating a demand curve with a positive slope) and rising production costs at the same time did the rate of return fall below the estimated 12 per cent opportunity cost.

It is concluded, therefore, that there definitely is an economic incentive for acceptance of irrigation on the Milagro project.

Modern Inputs

The difference between net revenues of technology Level I and technology Level III is attributable to both changes in water management practices plus modern inputs, such as hybrid seeds and fertilizers. This combination of inputs is sometimes known as the "project package," and benefit/cost ratios used to justify irrigation projects are usually calculated on this basis.

From a macro-economic viewpoint, increased yields are desirable to feed the population of the country and alleviate some pressure on the balance of trade.

A problem of the Milagro project and other related projects has been the apparent reluctance of farmers to shift from the traditional irrigated type farms to the modern irrigated type. One hypothesis presented to explain this is that difficulties are encountered in obtaining credit for farmers in the area (18).

The internal rate of return to irrigation infrastructure was calculated by the difference between net revenues of technology Level I and technology Level II. The internal rate of return for the change from Input Level I to Input Level III is attributable to the "project package." If that portion of the internal rate of return that accrues to irrigation infrastructure is subtracted from the rate of return attributable to the change from traditional irrigated type farms to modern irrigated type farms.

As Table 45 demonstrates, under present conditions in Milagro, the change from traditional irrigated farming, I_2, to modern irrigated farming, I_3, is not the best alternative use of capital and labor in the project area. All four size levels indicate a return to incremental investment less than the estimated 12 per cent opportunity cost. Size Level I has a negative difference.

Table 45. Comparative internal rates of return

Size Level	$F_3 - F_1$	$F_2 - F_1$	$F_3 - F_2$
I	39.63	44.36	4.73
II	49.09	41.25	7.84
III	44.43	35.52	8.91
IV	32.57	24.36	8.21

Table 45 is based on static relationships implied by the farm budgets (input/output relationships) based on the field surveys (6, 9, 10). However, any similar comparisons are possible from rates of return shown in Tables 31 through 38 under simulated changes in cost, returns, and yield parameters.

Economic Rents

On average, in recent years, all expenses of the Milagro system, including amortization and operating costs, have been met by the water users through the water tariffs, as required by law.

From that point, the water tariff was examined to see if any economic rent was being captured by the farmers. This was found to be the case, and an attempt was made to estimate the value of that rent. Under static conditions, with an imputed 12 per cent return to irrigation investment, the tariffs that will capture all the economic rent for society are presented in Table 46.

Table 46. Economic rent captured by private investment per hectare, technology Level II

Size Level	Maximum Tariff	Present Tariff	Economic Rent
I	S/. 1608.39	S/. 200.00	S/. 1408.39
II	1491.33	200.00	1291.33
III	1178.30	200.00	978.30
IV	810.36	200.00	610.36

These results are only approximate. The static data do not allow for downward shifts in output (farm production) as a result of increasing the water tariffs. These shifts would reduce net revenues and implicit economic rents somewhat below the values shown.

In short, the "maximum" tariffs could not be as high as shown, even under average present conditions prevailing during the survey period. In addition, adverse shifts in expected yields, receipts and costs, would further reduce the limits to which the tariffs could be raised, given the risks of farming.

Accepting these indicative results, it was shown that only under the most extreme farming and market conditions, as described above, did the estimated potential tariff fall to a level indicating no existence of economic rents.

If the tariff adopted by INERHI were set at S/. 800, just under the lowest rate given in Table 46, some economic rent would continue to flow to smaller farms, those considered marginal operations by INERHI personnel (18). Table 47 shows the absolute magnitude of the rent that might be captured by INERHI, summed over the irrigated farms of the project area, for each of three possible tariff levels. Note that these results are based on the current values found in the survey data. Increased tariffs would have some impact on project output, and the implicit net revenues lying behind the figures in Table 46 would be somewhat reduced.

Thus, the maximum tariff does not imply water should be priced at the level; rather it is a technique for calculating the economic profits due to a change in technology. In order to suggest a price policy for water we would need to know society's valuation of the water; this is beyond the scope of this study.

Table 47. Total potential tariff revenue to INERHI, Milagro project

Size Level	Average Area Cultivated	Economic Rent per Hectare	Economic Rent per Hectare	Number of Farms	Economic Rent per Size Level	Share of Rent per Size Level
Tariff = S/. 800/ha.						
I	2.32	600	1392	21	29232	2.7%
II	6.87	600	4122	41	168902	15.6%
III	12.27	600	7362	62	456444	42.1%
IV	39.70	600	23820	18	428760	39.6%
Total					S/. 1083338	
Tariff = S/. 600/ha.						
I	2.32	400	928	21	19488	2.7%
II	6.87	400	2748	41	112668	15.6%
III	12.27	400	4908	62	304296	42.1%
IV	39.70	400	15880	18	285840	39.6%
Total					S/. 722292	
Tariff = S/. 400/ha.						
I	2.32	200	464	21	9744	2.7%
II	6.87	200	1374	41	56334	15.6%
III	12.27	200	2454	62	152148	42.1%
IV	39.70	200	7940	18	142920	39.6%
Total					S/. 361146	

Recommendation for Future Studies

If farmers of the Milagro project areas are assumed to be rational producers of agricultural commodities, a well developed survey could estimate the price elasticity of demand for irrigation water. This value could be used to assess the validity of the conclusions made in this thesis as to possible viable changes in water tariffs.

Further research could also accurately estimate the actual rate of return for alternative investments available to farmers of the Milagro area. The accuracy of this rate is crucial in calculating the water tariff to capture for society that portion of farmer's economic rent that may be thought to belong to the canal system.

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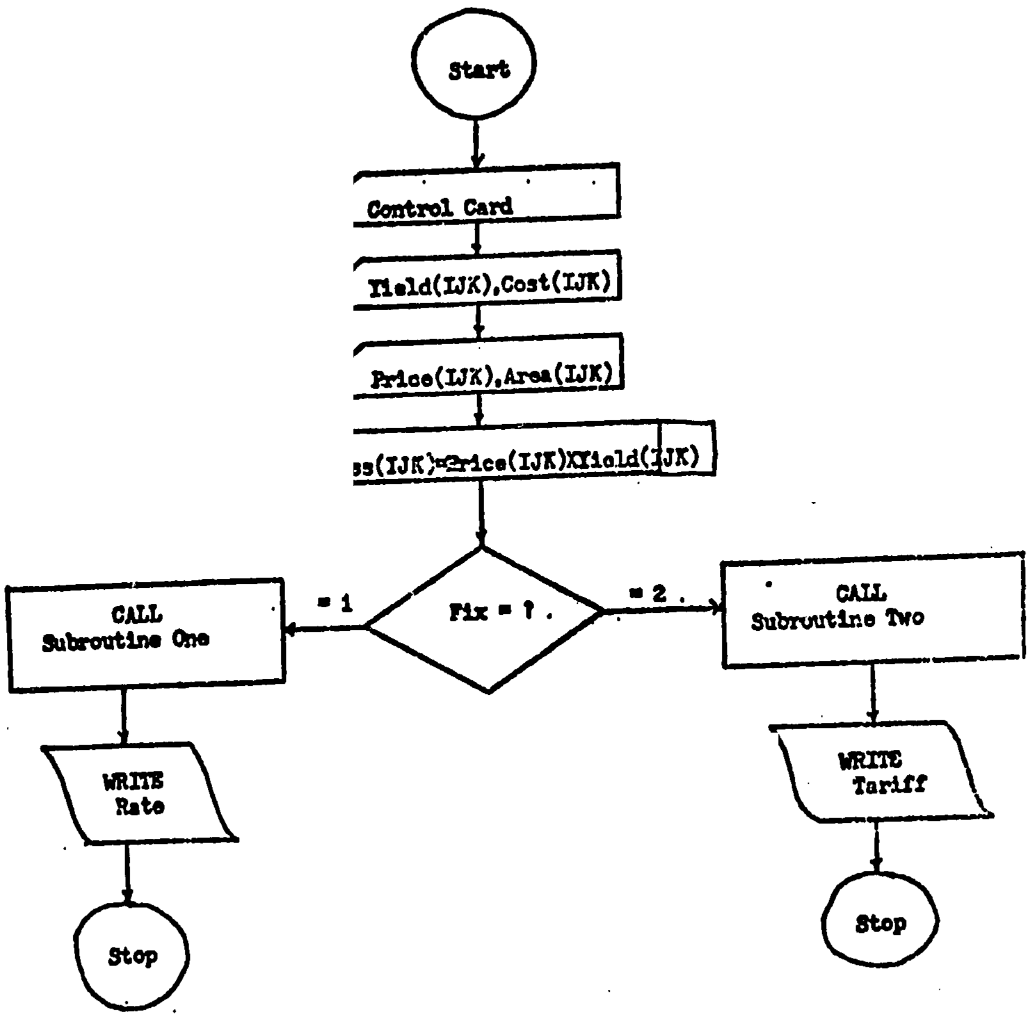
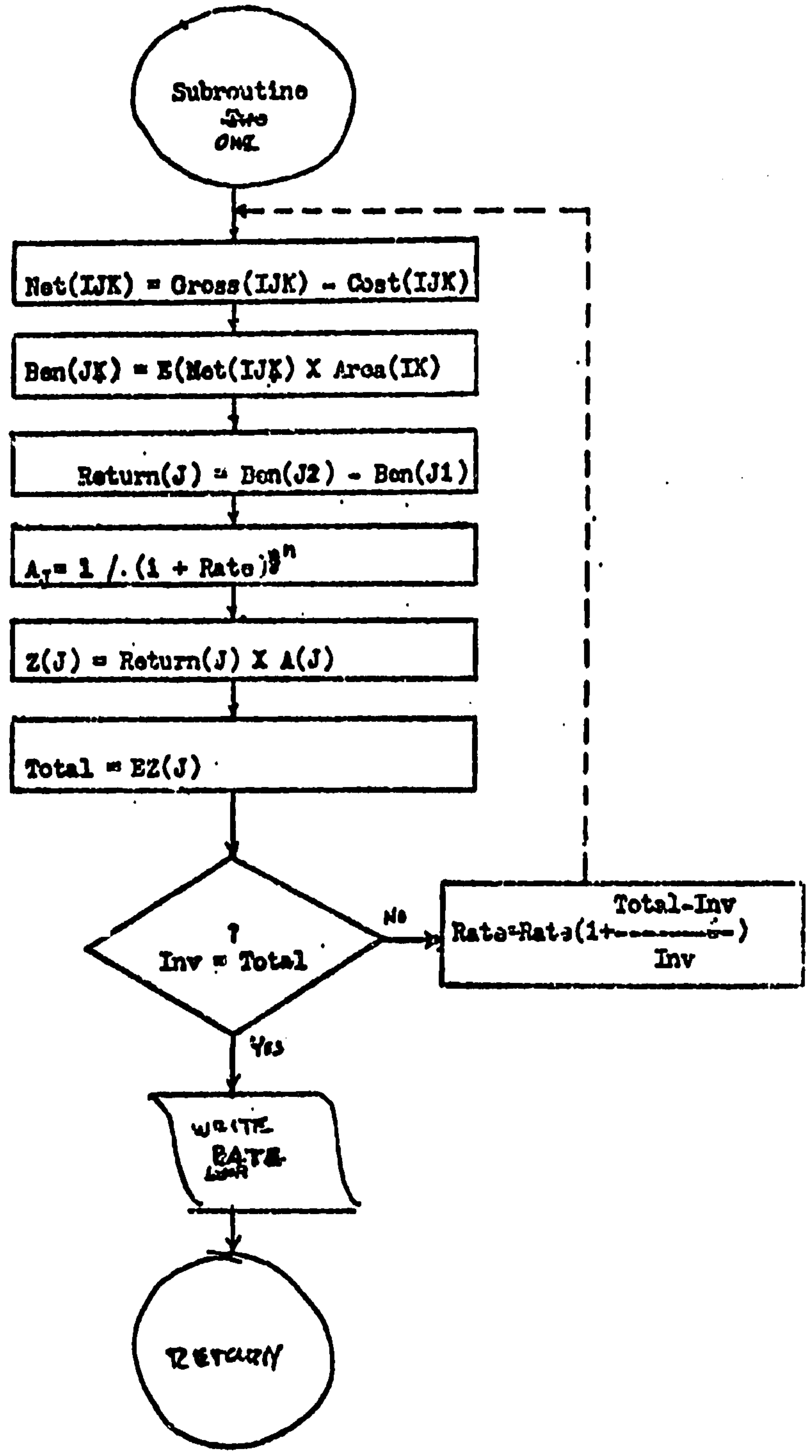
APPENDIX I:

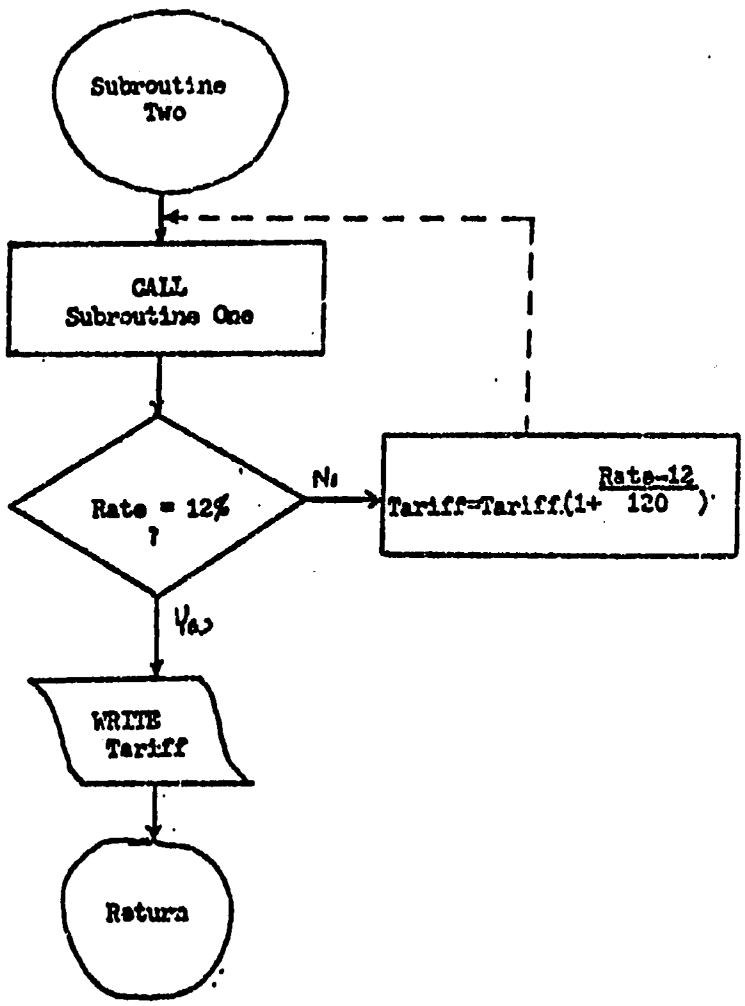
COMPUTER PROGRAMS



Start
Control Card
Yield(IJK),Cost(IJK)
Price(IJK),Area(IJK)
ss(IJK)=Price(IJK)XYield(IJK)
Fix = ?
= 1
= 2
CALL
Subroutine One
CALL
Subroutine Two
WRITE
Rate
WRITE
Tariff
Stop
Stop



Subroutine
ONE
Net(IJK) = Gross(IJK) - Cost(IJK)
Ben(JK) = E(Net(IJK) X Area(IK)
Return(J) = Ben(J2) - Ben(J1)
A = 1 /. (1 + Rate)
Z(J) = Return(J) X A(J)
Total = EZ(J)
?
Inv = Total
No
Total-Inv
Rate=Rate(1+)
Inv
Yes
WRITE
RATE
RETURN



Subroutine Two
CALL Subroutine One
Rate = 12% ?
No
Tariff=Tariff.(1+ Rate-12 / 120)
Yes
WRITE Tariff
Return

CONTROL CARD

1-9	Yields
1-3	Increment
4-6	Lower limit
7-9	Upper limit
10-18	Prices
10-12	Increment
12-15	Lower limit
16-18	Upper limit
19-27	Inputs
19-21	Increment
22-24	Lower limit
25-27	Upper limit
28-37	Subroutines
28-29	Fix
30-33	Tariff value
34-37	Rate value
38-42	Investment Value (per unit area)
43-45	Number of crops
46-48	Number of years

```
C       FORMAT STATEMENTS
C
  301 FORMAT (9F3.2,I2,2F4.0,F6.0,2I3)
  302 FORMAT (3F10.2)
  303 FORMAT (4F10.0)
C
  400 FORMAT (1H1)
  401 FORMAT ('1',3X,9F6.2,I3,2F7.1,F10.1,2I4)
  402 FORMAT ('1',/,15X, 'CROP     PRICE   AREA(1)   AREA(2)',///,
     * 10(I19,3F10.2,//))
  403 FORMAT (10('1','                              CROP =',I3,//,
     * '    YEAR       YIELD(1)  YIELD(2)   COST(1)    COST(2)'
     * //,30(I8,5X,2F10.1,2F10.2,/)))
  409 FORMAT ('1',//////,5X,'INTERNAL RATES OF RETURN (GROSS)'
     *                //,10X,'COST FACTOR = ',F4.2,
     *               ///,17X,11F6.2)
  410 FORMAT (//,11X,11F6.2)
  411 FORMAT ('1',//////,9X,'WATER TARIFF (= MVP)',
     *                //,10X,'COST FACTOR = ',F4.2,
     *               ///,17X,11F8.2)
  412 FORMAT (//,11X,11F8.2)
C
C       MAIN PROGRAM
C
C       DIMENSIONS
C
      REAL YI, YLL, YUL, PI, PLL, PUL, CI, CLL, CUL, TARIFF, RATE, IN,
     *  INV
      INTEGER FIX, C, N
      COMMON PRICE(10), AREA(10,2), YIELD(10,30,2), COST(10,30,2),
     * Y(10,30,2), VC(10,30,2), P(10), GROSS(10,30,2), X(11,11)
C
C       CONTROL CARD
C
      READ (5,301) YI, YLL, YUL, PI, PLL, PUL, CI, CLL, CUL, FIX,
     *TARIFF, RATE, IN, C, N
C
C       YIELDS AND COSTS
C
      READ (5,303) (((YIELD(I,J,K),K=1,2),(COST(I,J,K),K=1,2),J=1,N),
     *  I=1,C)
C
      WRITE(6,401) YI, YLL, YUL, PI, PLL, PUL, CI, CLL, CUL, FIX,
     *TARIFF, RATE, IN, C, N
      WRITE (6,403) (I,(J,(YIELD(I,J,K),K=1,2),(COST(I,J,K),K=1,2),
     * J=1,N),I=1,C)
C
C       PRICES AND AREAS
C
   10 READ (5,302,END=900) (PRICE(I),(AREA(I,K),K=1,2),I=1,C)
C
      WRITE (6,402) (I,PRICE(I), AREA(I,1), AREA(I,2),I=1,C)
C
C       CALCULATE TOTAL INVESTMENT
C
      INV = 0.0
```

```
  030 DO 031 I=1,C
  031 INV = INV + IN * AREA(I,2)
C
C       CALCULATE GROSS RETURNS
C
  011 AA = 1.0 + CLL
      BA = 1.0 + CUL
C
  012 DO 015 I=1,C
  013 DO 015 J=1,N
  014 DO 015 K=1,2
  015 VC(I,J,K) = COST(I,J,K) * AA
C
  016 LB = 2
C
  017 AB = 1.0 + PLL
      BB = 1.0 + PUL
C
  018 DO 019 I=1,C
  019 P(I) = PRICE(I) * AB
C
  020 LC = 2
C
  021 AC = 1.0 + YLL
      BC = 1.0 + YUL
C
  022 DO 025 I=1,C
  023 DO 025 J=1,N
  024 DO 025 K=1,2
  025 Y(I,J,K) = YIELD(I,J,K) * AC
C
  026 DO 029 I=1,C
  027 DO 029 J=1,N
  028 DO 029 K=1,2
  029 GROSS(I,J,K) = P(I) * Y(I,J,K)
C
C       CALL SUBPROGRAMS
C
  032 IF (FIX .EQ. 1) CALL ONE(C,N,AA,AB,AC,LB,LC,INV,TARIFF,FIX)
  033 IF (FIX .EQ. 2) CALL TWO(C,N,AA,AB,AC,LB,LC,INV,RATE,FIX)
C
  101 IF (AC .GE. (BC - (YI * 0.1))) GO TO 105
  102 AC = AC + YI
  103 LC = LC + 1
  104 GO TO 022
C
  105 IF (AB .GE. (BB - (PI * 0.1))) GO TO 109
  106 AB = AB + PI
  107 LB = LB + 1
  108 GO TO 018
C
C       WRITE TABLES
C
  109 X(1,2) = YLL
  110 DO 112 J=3,LC
  111 X(1,J) = X(1,J-1) + YI
```

```
C
  112 X(2,1) = PLL
  113 DO 114 I=3,LB
  114 X(I,1) = X(I-1,1) + PI
C
  117 IF (FIX .EQ. 2) GO TO 12
C
  118 WRITE (6,409) AA, (X(1,J),J=2,LC
  119 DO 120 I=2,LB
  120 WRITE (6,410) (X(I,J),J=1,LC)
      IF (AA .GE. (BA - (CI * 0.1))) GO TO 124
      AA = AA + CI
      GO TO 012
C
  121 WRITE (6,411) AA, (X(1,J),J=2,LC)
  122 DO 123 I=2,LB
  123 WRITE (6,412) (X(I,J),J=1,LC)
      IF (AA .GE. (BA - (CI * 0.1))) GO TO 124
      AA = AA + CI
      GO TO 012
C
  124 GO TO 10
C
  900 WRITE (6,400)
      STOP
      END
```

```
      SUBROUTINE ONE(C,N,AA,AB,AC,LB,LC,INV,TARIFF,FIX)
C
      COMMON PRICE(10), AREA(10,2), YIELD(10,30,2), COST(10,30,2),
     # Y(10,30,2), VC(10,30,2), P(10), GROSS(10,30,2), X(11,11)
      REAL INV, TOTAL, NET(10,30,2), BEN(30,2), Z(30), A(30), RETURN(30)
      INTEGER FIX, C, N
C
  001 DO 004 I=1,C
  002 DO 004 J=1,N
  003 NET(I,J,1) = GROSS(I,J,1) - VC(I,J,1)
  004 NET(I,J,2) = GROSS(I,J,2) - VC(I,J,2) - TARIFF
C
  005 DO 007 K=1,2
  006 DO 007 J=1,N
  007 BEN(J,K) = 0.0
C
  008 DO 011 K=1,2
  009 DO 011 J=1,N
  010 DO 011 I=1,C
  011 BEN(J,K) = BEN(J,K) + NET(I,J,K) * AREA(I,K)
C
  012 DO 013 J=1,N
  013 RETURN(J) = BEN(J,2) - BEN(J,1)
C
  044 RATE = 0.5
  045 NA = 1
  046 TOTAL = 0.0
C
  047 DO 050 J=1,N
  048 A(J) = 1.0 / (1.0 + RATE)**J
  049 Z(J) = RETURN(J) * A(J)
  050 TOTAL = TOTAL + Z(J)
C
C
  051 IF (ABS(TOTAL - INV) .LT. 0.5) GO TO 056
  052 IF (NA .EQ. 20) GO TO 056
C
      RATE = RATE * (1.0 + (ABS(TOTAL) - INV) / INV)
  054 NA = NA + 1
  055 GO TO 046
C
  056 RATE = RATE * 100.0
C
  057 X(LB,LC) = RATE
C
      RETURN
      END
```

```
      SUBROUTINE TWO(C,N,AA,AB,AC,LB,LC,INV,RATE,FIX)
C
      COMMON PRICE(10), AREA(10,2), YIELD(10,30,2), COST(10,30,2),
     * Y(10,30,2), VC(10,30,2), P(10), GROSS(10,30,2), X(11,11)
      REAL INV, RATE, R
      INTEGER FIX, C, N
C
      M = 0
  075 TARIFF = 500.0
C
  076 CALL ONE(C,N,AA,AB,AC,LB,LC,INV,TARIFF,FIX)
C
      R = X(LB,LC)
C
      IF (ABS(R-RATE) .LT. 0.5) GO TO 100
      IF (M .EQ. 30) GO TO 100
C
  098 TARIFF = TARIFF * (1.0 + (R-RATE) / (RATE*10.0))
      M = M + 1
  099 GO TO 076
C
  100 X(LB,LC) = TARIFF
C
      RETURN
      END
```

APPENDIX II:

Examples of Survey

Questionnaires

PROYECTO DE FICHA PARA ENCUESTA DE CARACTER
AGRICOLA A NIVEL DE FINCAS

FICHA DE:
ENCUESTADOR:

1.- GENERALIDADES

-UBICACION________________________________

-ACCESIBILIDAD________________________________

-FISIOGRAFIA GENERAL DE LA FINCA________________________________

____

____

SUPERFICIE DE LA FINCA			
Sup. Total (U.A.L.) Has.	Sup. Cultivable Has.	Sup. Cultivada Has.	Sup. Urbana Has.

CARACTER DE LA TENENCIA Y TIPO DE EMPRESA			
TENENCIA			EMPRESA
Propietario	☐	has.________	Familiar
Arrendatario	☐	has.________	Empresarial
Otros tipos:			
________	☐	has.________	
________	☐	has.________	

Figure 6. Example of 1968 questionnaire (p.1)

CIDULA DE CULTIVO EN EL ULTIMO AÑO					
I Semestre			II Semestre		
Cultivo	has.	Epoca S C°	Cultivo	has.	Epoca S C°

Se han realizado otros cultivos en los años precedentes? si no

Cuales ______________________________

Cuales cultivos han incrementado en los últimos años? ______________

____

Cuales cultivos han disminuido? ______________

Por que razones? ______________

____

S = Siembra

°C = Cosecha

Figure 6. Example of 1968 questionnaire (p.2)

INSTITUTO ECUATORIANO DE RECURSOS HIDRAULICOS

Economía y. Estadist.	Encuesta Socio Economica	Fecha:

DATOS CONFIDENCIALES

IDENTIFICACION		SUPERFICIE	TENENCIA		EXPLOTAC.		
PROVINCIA	Cantón	TOTAL			Agr.	Gan	Mix
PARROQUIA	Sitio	REGADA	Propietario				
NOMBRE DEL PRODUCTOR		CULTIVADA	Arrendat.				
Nombre del Propietario		Cultivable	Partidario				
			Otro				

LINDEROS:

NORTE ORIENTE

SUR OCCIDENTE

VIAS DE COMUNICACION:

PRINCIPAL (S) TIPO

SECUNDARIO (S) TIPO

OTROS PREDIOS DEL MISMO DUEÑO

Nombre del Predio	LOCALIZACION			Superficie	Tenencia
	Cantón	Parroquia	Sitio		

COMPOSICION FAMILIAR

NOMBRE	Parentesco	Sexo		Estado Civil	edad	Ocupación	Instruc.	Lugar de tra-
		M	F					

VIVIENDA Y OTRAS CONSTRUCCIONES

CLASE	ESTADO	Superficie	Material	OBSERVACIONES

MAQUINARIA EQUIPO Y HERRAMIENTAS

CLASE	ESTADO	N° años uso	Valor Est.	OBSERVACIONES

Figure 7. Example of 1971 questionnaire (p.1)

PRODUCCION AGRICOLA

CULTIVOS	Superf. cultiva	COSTOS DE PRODUCCION POR HECTAREA (EN SUCRES)																		Suman	Costo Total
		Semillas			Fertilizantes			Fungicidas			Mano de obra			Maq. o tracc An			Riego				
		unid	cant	Valor	unid	cant	Valor	unid	cant	Valor	unid	cant	Valor	unid	cant	Valor	unid	cant	Valor		
TOTAL																					

COMERCIALIZACION

CULTIVOS	Superf. cultiv.	PRODUCCION		DESTINO DE PRODUCCION				Lugar Venta		A quien vende	OBSERVAC.
		Rendim. por	Total	consumo en finca	VENTAS			dentro finca	fuera de finca		
					cantidad	precio U.	Total				
TOTAL											

Figure 7. Example of 1971 questionnaire (p.2)