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EFFECT OF INCREASED WATER SUPPLY ON NET RETURNS TO DAIRY FARMS IN SONSONATE, EL SALVADOR

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The survey team was composed of an agricultural economics student from Utah State University, a staff economist from DGORD, and enumerators from the local office of Mejoramiento de Ganaderia.

These survey data have been shared by the subgroups. U.S.U. is primarily interested in economic returns to on-farm irrigation and water management. Thirty-one of the 34 dairy farmers were sampled and 27 questionnaires were usable. The dairy farms vary in size from 20 to 950 manzanas and show considerable variation in annual net returns.

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SUMMARY

The pronounced dry season in the Sonsonate-Banderas region of El Salvador has led Direccion General de Obras de Riego y Drenaje to consider implementation of an irrigation project. One important group of users of any supplemental water would be about 34 dairy farmers who rely entirely on pastures in their operations. To better understand the benefits of improved water management on the irrigated pastures in question, a cost/returns survey was made in the Summer and Fall of 1971. This study reports an analysis of the survey results.

The survey team was composed of an agricultural economics student from Utah State University, a staff economist from DGORD, and enumerators from the local office of Mejoramiento de Ganaderia.

These survey data have been shared by the subgroups. U.S.U. is primarily interested in economic returns to on-farm irrigation and water management. Thirty-one of the 34 dairy farmers were sampled and 27 questionnaires were usable. The dairy farms vary in size from 20 to 950 manzanas and show considerable variation in annual net returns.

There are several conclusions to be drawn from the Sonsonate-Banderas area study.

1. The analyses indicate that differences in net returns, (assuming current technology) between farms with adequate, and inadequate water supplies (farms that are otherwise as nearly alike as possible) range from ¢5.01 to ¢461.13 and average ¢186.53 per manzana.[1] If farms are

[1]Throughout this paper, the sign "¢" refers to colones. The exchange rate is 2.4 colones per dollar.

"homogeneous", except for adequate and inadequate water supplies, the difference in earnings is the return to the differential application of water.

2. As a means of adding water to those dairy farms that have marginal supplies, the use of pumps appears more attractive than the proposed surface project development. From the standpoint of the average dairy farmer surveyed the internal rate of return on investment in pumps with a 10 year life is 107% compared to only 7.6% for the benefits of the proposed project. However, the overall feasibility of the proposed surface development is based on more than benefits to just dairy farmers.
3. An alternative or supplement to either pump irrigation or surface project development, is restructuring and improving the management and institutions that control the distribution and use of water. It is estimated that, due to an economically and physically inefficient distribution system, the annual loss to the dairy industry in Sonsonate-Banderas is ¢877,624. Recent changes in irrigation law provide an opportunity for institutional and managerial reform that would have the same effect as creation of additional supplies.
4. Not all farmers with marginal supplies of water will be anxious to invest in pumps or surface project development, and they may only partially benefit from reorganization of institutional control. These are the farms that have such high negative returns that, even though an investment in pumps or a project or institutional reform could reduce their losses, net returns would still be negative.
5. Also noted:
   a. Consideration of other farm operations in addition to dairy-pasture emphasis may alter significantly the general expectations and benefits

from the proposed surface project.

Interaction experiments with water, seed, and fertilizer on improved and commonly used pasture grasses (pangola, estrella elefante, etc.) will provide a much more precise basis for determining increases in net returns due to increased applications of water or other farm inputs

c. Experimental results to determine milk production response of cows to different rations and roughage were not considered. Such experiments would indicate which diets lead to maximum net returns.

Labor requirements for dairy and pasture management is not as intensive as for a crop such as tomatoes. But dairies provide steady year around employment as opposed to the highly seasonal labor demanded by tomatoes. Smaller, well managed dairy farms make the best use of labor.

Outline of the Research

Will increased application of water to pastures lead to increases net returns on dairies in Sonsonate-Banderas, El Salvador? This problem is introduced and its importance stressed, by presenting evidence that demand for animal proteins is outstripping supply in El Salvador. Such evidence includes large increases in the price of animal proteins relative to other foodstuffs.

Background information vital to an understanding of the problem is presented in Chapter II. In the first section, the role of various agencies and institutions concerned with governing the use of water, are discussed. Demographic and physical characteristics of the Sonsonate-Banderas region are presented in the second section. Finally, current management practices on irrigated dairy farms in this region are detailed (based on a survey of such farms), with the role of irrigation being emphasized.

The conceptual approach to be used in the analysis is elaborated in Chapter III. There are two parts to the conceptual approach. The first involves comparison of net returns on farms with and without sufficient water that otherwise had relatively homogeneous production characteristics. The difference in such returns is attributed to the differential applications of water. The second part of the conceptual approach involves calculating the internal rate of return to pump, and surface project irrigation as alternate means of supplying the additional water to farms with marginal supplies. The net benefit of either investment is assumed to be the average differential in net returns between farms with and without adequate water while costs are obtained from independent studies of pumping and an enlarged surface system.

The results of the analysis are discussed in Chapter IV. Net returns to farms with marginal supplies are negative, while they are positive on farms with sufficient water. The internal rate of return is positive for both project and pump irrigation; however, the relative return to pump irrigation is larger than for the proposed surface project. The annualized value of the differential in the value of land with and without irrigation over the life of the project is less than the difference in average net returns between such lands. This suggests that the difference in net returns may be overstated.

I. STUDY PROBLEM BACKGROUND

Introduction

The economic and physical role of irrigation in increasing the supply of meat, milk, fruits and vegetables in the less developed world has not received much attention. Except for cereals, little is known of physical production responses of traditional crops and pastures to differential applications of water and fertilizer. Nevertheless, decisions to invest scarce development resources in irrigation works are being made. Even in cases where production responses are known, the economic viability of investment in irrigation capital must still be assessed.

This study focuses attention on the role of irrigation in the production of pasture forage for dairy cattle in the Sonsonate-Banderas region of El Salvador. The dairy farms of this area vary greatly with respect to available water supply, size, management efficiency, herd quality, and cultural practices. Consequently a suitable analytical technique must be employed in order to obtain valid comparisons.

Statement of the Problem

Irrigation is currently widespread in the dairy industry in the Sonsonate-Banderas region of El Salvador. However, little is known about the economics of present irrigation practices, or the effect on net returns of increased availability of water on dairy farms where irrigation water becomes a limiting factor during the dry season. What is lacking is empirical data.

The task at hand has two facets: the first is to report a benchmark survey documenting the current production milieu on dairy farms in Sonsonate-Banderas with emphasis on the role of irrigation; the second is to determine whether or not there is any indication that increased returns accrue from differential applications of water to pasture, and if so, if any such returns justify the investment necessary to supply the additional water to farms with limited supplies.

Importance of the Problem

There are two reasons for concern. First, there is a need to understand the role and economics of irrigation in increasing the supply of animal proteins (milk and milk products) for the burgeoning population of El Salvador. Second, a feasibility study of a proposed surface irrigation prject for the Sonsonate-Banderas area already exists; its expectations may be over-optimistic.

Need for Increased Food Production

The population of El Salvador increased at an estimated rate of 3.6% to 4% per year in the 1960's.[1] The rate for the earlier period, 1950-61, was 2.8%.[2]

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[1]The 3.6% figure is for 1961-1968 and is from the International Bank for Reconstruction and Development, Atlas: Population, Per Capita Product and Growth Rates, 1970; the 4% figure was the geometric rate of growth between December 31, 1967 and December 31, 1969 as calculated from the population levels estimated in the Ministerio de Economia, Anuario Estadistico, 1969, Vol. II, San Salvador, October 1970. Neither of these estimates for the 1960's consider the influx of Salvadorans expelled from Honduras after the "Football War" in 1969.

[2]See USDA, Projections of Supply and Demand for Selected Agricultural Products in Central America Through 1980, ERS, August 1969, p. 5.

Between 1961 and 1968, real per capita income in El Salvador was estimated to have increased at an average rate of 2.1%.[3] Between 1950 and 1961, real per capita income grew at a slightly greater rate of 2.6%.[4] If we assume an income elasticity of demand for agricultural products (food) of .3 in both periods, then demand for such commodities increased at the rate of at least 4.2% per year between 1961 and 1968, and at 3.6% in the 1950's.[5]

The supply of agricultural commodities has increased much more slowly than has demand. From 1950 to 1961, the value of output (in 1962 prices) of the agricultural sector (including the export crops of coffee, cotton, and sugar) grew at only 2.4%. Between 1962 and 1968, the value of output of agriculture grew at the much slower rate of .9%. However, production of cereal staples grew at the rate of 2.1% (measured in value terms at 1962 prices) between 1962 and 1968. The combined production of rice, corn, and beans as measured in metric tons grew at 5.7% between 1963/64 and 1969/70.[6]

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[3] International Bank for Reconstruction and Development, Atlas.

[4] See USDA, Projections, p. 14.

[5] The assumption of an income elasticity of demand for food is based on estimates made of that elasticity in other LDC's by FAO. See FAO, Agricultural Commodity Projections, 1970-1980, Vol. II, Rome: 1971, p. 209.

[6] The rates of growth presented in the section are calculated from data presented in Robert Nathan Associates, Agricultural Sector Analysis for El Salvador, Vol. I, Dec. 1969, p. 49, and CONAPLAN, Indicadores Economicas, pp. 48 and 56. The growth rate in cereals is according to data from CONAPLAN p. 48. Unfortunately, CONAPLAN does not define what constitutes cereals. This may partly explain the great differences in the rate of growth of cereals in constant prices between 1962-68 (2.1%) and that of beans, rice, and corn (the most important cereals) in metric tons between 1963/64 - 1969/70 (5.7%). However, this differential may also reflect a conceptual problem in the calculation of agricultural production at constant prices (see text below). Also, it calls to mind the very poor base upon which production and price data are reported.

The increase in demand for agricultural commodities, relative to supply, tends to have a negative impact on economic development as prices for such products rise. All consumers will spend a larger proportion of income on food than if prices remain constant or fall. But the poorer classes will be relatively worse off since they spend a larger proportion of their income on food. Demand for commodities of the non-farm sector will be diminished, along with real income, and the incentive to save is lessened.

Available data suggest that the overall price of food products in El Salvador rose during the decade of the sixties. The index of consumer prices for foodstuffs in the city of San Salvador rose from 100 in 1954 to 110 in 1965 and to 117 by 1969.[7] The rise in prices in the four years between 1965 and 1969 was almost as great as in the 11 years from 1954 to 1965. This is consistent with our rough approximations of growth in demand and supply which indicated a greater gap in the sixties than the fifties.[8]

However, the index of prices for bread and cereals rose from 100 in 1954 to 102 in 1965, and then fell to 94 in 1969. This is consistent with the relatively greater increase in cereal production than in total agricultural production in the 1960's, although the degree of consistency

[7] All price data reported in this section are from Ministerio de Economía, Anuario Estadístico 1969, Volumen IV, December 1970, p. 26.

[8] Agricultural production grew at 2.4% in the period 1950-61, while demand is estimated to have grown at 3.5% in the 1950's. In the latter period the rate of growth in demand increased to 4.2% while growth in agricultural production fell to 1%. Thus, one would expect greater pressure on price of food in the latter period.

depends on whether the 2.1% or 5.7% rate of growth in cereal production is correct.[9] The slight fall in the price of cereals in the latter 1960's suggests a possible redistribution of income in favor of the poor. Not only is a larger proportion of their income spent on food relative to the more well-to-do classes but a much larger proportion of their diet is composed of cereals relative to the wealthier group.

The price indexes for meats and fish, milks and eggs, and fruits and vegetables all rose. The index for meat and fish rose from 100 to 150 between 1954 and 1965 and to 168 by 1968. Thus, this index grew at about the same rate in both periods. The index for milk and egg products fell from 100 to 94 between 1954 and 1965. By 1969, it had risen to 110, a rise of almost 4% per year after 1965. Likewise, the price index for fruits and vegetables rose from 100 in 1954 to 123 in 1965 and to 140 in 1969. Thus, there was greater pressure on food prices during the latter period.

These data demonstrate that there has been upward pressure on the overall price of food, and that the pressure was relatively greater in the 1960's than in the 1950's. Also, they suggest that there has been relatively greater pressure on meat and fish, milk and eggs, and vegetables and fruits, than on basic cereals.[10] There is a definite need to increase

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[9]That is, change in the index of prices for bread and cereals supports the rate of increase in production of cereals as calculated from metric tons of rice, corn and beans (5.7%) as compared to that calculated from the value of cereals in 1962 prices (2.1%). The latter is less than the rate of growth in demand (4.2%) and would suggest a rise in prices of cereals. Price data, however, suggest that prices fell.

[10]The income elasticity of demand in El Salvador for pulses is .40 and for corn is .10 and rice .60. In contrast, the elasticity is .80 for beef, .50 for pork, 1.00 for poultry, and 1.00 for milk. Thus, we would expect greater demand pressure on the animal protein than cereals. See FAO, Agricultural Commodity Projections 1970-1980, Vol. II, Rome: 1971, p. 209.

the supply of animal proteins in El Salvador. This is one justification for studying the role of irrigation in the dairy industry of Sonsonate-Banderas.

<u>Existing Study of Proposed Sonsonate-Banderas Irrigation Project</u>

The government of El Salvador has considered developing a surface irrigation/drainage project in Sonsonate-Banderas. A feasibility study by a Mexican consulting firm (ICATEC-Consultares) has estimated the total cost of the project to be ¢11.9 million ($4.8 million) with additional water to be supplied from surface diversion.[11] The ICATEC study indicates that there is sufficient water in the Sensunapan (Sonsonate) and Banderas River watersheds to fully irrigate the proposed project areas. Further, the study finds that the benefit-cost ratio is 1.82 in Sonsonate and 2.27 in Banderas using a discount rate of 10% and a life of 50 years.

The study reports that, although the project areas could be easily irrigated, available water is underutilized, wastage is prevalent, and drainage problems limit yields.

The ICATEC study assumed that the project would lead to an increase in effective land area by 15% in Sonsonate, and 24% in Banderas. The engineers assumed that yields would increase not only through the improved usage of water, but also through <u>improved techniques of production</u>. Even though projected costs rise, projected returns rise even more.

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[11] ICATEC, S. A., "Estudio de Factibilidad de Riego, Sonsonate-Banderas," prepared for DGORD in 1967.

The increase in net benefits are predicted to be ¢742/ha. in Sonsonate and ¢1023/ha. in Banderas.

It is possible that the ICATEC study is over-optimistic in assuming rapid technical change associated with implementation of the proposed project. Many farms within the project area are fully irrigated at present. Some suffer partial loss of water during the dry season, and if water supplies suddenly became available the managers of such farms might be expected to at least copy known dry season practices. But this is not the same as saying that generally better techniques will materialize very rapidly. Improved pasture management and improved water management techniques are still the subject of research emphasis. Thus, it seems useful to try to estimate returns to current irrigation and production practices on dairy farms in Sonsonate-Banderas. These dairy farm net returns, with land area and techniques of pasture production assumed constant, may indicate that the proposed project will "pay" in any case.

Limits of the Study

Based on empirical observation, the management of water on individual farms in the study area is assumed constant across all farms. (The study area is the same as the proposed project area in the ICATEC study.) Focus is on the costs and returns of providing supplemental water. However, the results are only indicative of the general economic magnitudes. Lack of experimental data on forage response to additional water precludes statements about precise levels of return. Nevertheless, the results do provide evidence whether the rate of return on investment in irrigation facilities is great enough to indicate economic viability of that investment.

The study is only concerned with the on-farm profitability of providing additional water for dairy pasture irrigation; secondary benefits and costs are not considered. No attempt is made to assess the profitability of investment in irrigation for dairy pastures in El Salvador vis-a-vis the cost of production in other regions of the world or the cost of producing other crops in El Salvador. That is, whether El Salvador has an absolute or comparative advantage in producing milk is not considered.

Finally, the study is only concerned with dairy farms in the proposed project areas. Other crops or farming operations are ignored. Consequently, it is not a benefit-cost analysis of the proposed project area and our results cannot be compared directly with the ICATEC study.

Objectives and Procedures

Objectives

The main objective of this study is to assess the economic viability of investment in irrigation capital on dairy farms where water is a limiting factor during the dry season.

The main objective will be met by attaining the following sub-objectives:

1. Benchmark current cultural practices in irrigation and production on dairy farms in the Sonsonate region;

2. Develop a conceptual approach to determine if additional water applied to Sonsonate dairy farms (where water is a constraint), increases output enough to justify the investment. (Such an approach is to only be concerned with costs and returns at the farm level);
3. Test the approach with production cost data from a sample of irrigated dairy farms in the Sonsonate area;
4. Provide an economic interpretation of the empirical tests;
5. Draw policy conclusions and make recommendations from the analysis.

Procedures

Information on activities and philosophy of agencies that govern th use of water resources is based on secondary sources and upon interviews with personnel from the Ministry of Agriculture and Dirección General de Obras de Riego y Drenaje. This information is utilized in the introduction and background chapter.

An on-farm survey is the basis for details of current production practices on Sonsonate dairy farms, and for assessing the costs and returns associated with additional water. The collected data cover cultivation/cow-herd practices, management techniques, the resource base, availability of water, herd quality, size, costs of production, and returns.

DGORD personnel cooperated with Utah State University student in gathering the basic survey data necessary to complete the study. DGORD provided transportation and other support where possible. Survey questionnaires were devised on a cooperative basis to incorporate DGORD and USU needs.

II. WATER MANAGEMENT INSTITUTIONS AND CHARACTERISTICS OF THE SONSONATE-BANDERAS AREA

The purpose of this section is to provide background information on the study area. The role of key agencies governing the use of water is reviewed, and the legal constraints affecting water rights, delineated. Then demographic and physical characteristics of the study area are set forth. Finally, production practices on the dairy farms of the study area are described.

Agencies Governing the Use of Water

Ministry of Agriculture (MAG)

The Ministry of Agriculture and Livestock is the official organ of the central administration and has charge of organizing, comprehending and executing agricultural policy. This branch of government was first created in 1946 as the Ministry of Agriculture and Industry. In 1959, Industry was assigned to the Ministry of Economics and the Ministry of Agriculture and Livestock was left in its present form.

As the chief organization of the agricultural sector, the Ministry of Agriculture and Livestock is related to all institutions; public, autonomous, semi-autonomous and private, that serve the agricultural sector. Close relations are also maintained with international and foreign organizations offering technical or economic assistance and with similar organizations throughout the Central American area. The Minister of Agriculture also acts as/or appoints the heads of numerous commissions and boards of directors in El Salvador.

In the development of its objectives the Ministry of Agriculture has the following functions:

1. Planning, directing and supervisin... ..e development of agricultural activities in the country;
2. Stimulating agricultural production by utilizing idle or under-utilized lands and the recovery of marsh lands;
3. Planning, directing and supervising the development of conservation practices, increasing forests, and the encouragement of se... exploitation of the country's forest resources;
Conserving and propagating beneficial wild animals and fresh water fish, and regulating hunting and fishing;
. Promoting establishment of irrigation systems and regulating the use of rivers and springs in the public domain for agricultural use and to promote the expansion of agricultural production;
6. Encouraging the raising of animals useful to man and adapted to the conditions of the country;
7. Promoting the conservation of agricultural products and livestock;
8. Preventing and combating plagues and sicknessess that affect the agricultural resources of the country;
9. Promoting in cooperation with the Ministry of Economics, the establishment and development of new industries th... utilize the country's agricultural products.
Collaborating with the Ministry of Economics to promote the establishment and development of associations of farmers and cattlemen, especially cooperatives, and to see that they function according to their statutes.

11. Collaborating with the Ministry of Economics to recopy and elaborate agricultural statistics.

Direccion General de Obras de Riego y Drenaje (DGORD)

DGORD is an appendage of the Ministry of Agriculture. It has its official headquarters in the city of San Salvador and dedicates its time to the study, design, and construction of medium and large scale irrigatio and drainage projects.

The office was established in January 1966 by the Ministry of Agriculture, to be in charge of the technical and administrative part of the investment programs of the Zapotitan Valley Project and the Rio Grande de San Miguel Project. Its personnel were assembled through contracts. The office consists of the Department of Preliminary Studies, the Department of Design, and the Department of Administration and Bookkeeping.

The Department of Preliminary Studies has a head who coordinates the work of the Sections of Promulgation of Agricultural Technology and Agricultural Economic Studies, and Hydrology and Geology. The department head elaborates and revises final reports of the work of this department and directs the field work and drafting which is under the department's jurisdiction. The leaders of each sub-section organize their own specialized work and participate directly in the elaboration of studies, ıction of basic data, etc.[1]

[1] This department under the direction of Mario Garcia gave invaluable assistance in the preparation of this report.

Relation to other Agencies--In executing its function DGORD maintains close relations with practically all the offices in the Ministry of Agriculture in order to acquire the basic information for the formulation of the projects. It also works closely with the "Instituto de Colonización Rural" (ICR), "Administración de Bienestar Campesino" (ABC), and other credit institutions, with international credit institutions to obtain financing for the works to be executed, with the Administración Nacional de Aqueductos y Alcantarillados (ANDA) and the Comisión Ejecutiva del Río Limpa (CEL) and other electrical companies which provide energy to the projects.

Philosophy of DGORD--The main objective of DGORD is the integral development of agricultural projects through utilization of soil and water resources. This objective is reached through the formulation of irrigation and drainage projects at the zone level. In these projects financing is the responsibility of the government through use of its own funds and foreign resources in the form of development loans.

Development of an irrigation project includes preliminary studies, feasibility studies, work design, contractual documents and construction specifications. Actual construction may be done through construction companies on a bid basis or by DGORD through an administrative system.

DGORD has a head office composed of a director general and a sub-director general, who are directly responsible to MAG for the programs under their authority and who must supervise the administrative affairs of the same. They propose to MAG plans and programs, biweekly, biannually and annually, covering the irrigation and drainage projects at hand. The director is also president of the National Committee for the Coordination of Hydraulic Resources.

Legal Constraints Surrounding Water Rights

Old brick aqueducts and ditches on some farms show that irrigation has been practiced in the Sonsonate area for many years. Under the old water law municipalities governed water rights. These encompassed a system for distribution and measurement of water, but it was not always equally applied to all users. Water judges were appointed and charged with "keeping everyone happy." The appointees were generally uneducated and poorly paid, and more often than not they contributed to the confusion. The distribution system gave top water priority to farms nearest the source or stream bed. Prior use is not considered; consequently farmers far from the water source, who might have enjoyed a particular supply for years, are known to experience severe or complete shortages as their neighbors become more progressive and start irrigating.

On November 17, 1970, El Salvador enacted a new water law which is a radical change from the old one. Under the new provisions the Ministry of Agriculture assumes supreme power in questions of water rights. This law gives the National Government the right to determine water use priorities, organize and finance irrigation districts, and expropriate private property for use in irrigation installations. It also provides for the expropriation (and fair renumeration) of lands benefiting from public irrigation and drainage districts when such benefits are in excess of a maximum set by government authorities. However, farms nearest the source or stream bed still have priority claims on water. Thus customary users may still have distribution difficulties.

The law is very detailed and provides for measurement, policing and proper use of the country's water resources. Violators may find themselves faced with a stiff fine or a jail sentence and in extreme cases water rights may be rescinded. The state accepts responsibility for any damages which may be caused by malfunctioning of government built irrigation and drainage facilities.

Characteristics of the Study Area

The study area is located in the department of Sonsonate, and has the same boundaries as reported in the ICATEC study of the Sonsonate-Banderas project.

Climate

Sonsonate department lies in a torrid zone between 40 and 500 meters above sea level. The average temperature varies between 24.6°c and 28.2°c in the lower elevations and 23.4°c to 28.2°c in the higher. Annual precipitation varies from 1750 mm. to 2000 mm. in the more elevated areas and there is a distinct dry season which lasts from November through April.

Hydrologic Resources

The area of study is located in the Sonsonate (Sensunapan) and Banderas River watersheds. Although the precise flow of water from the watersheds is unknown, it is evident that they are only being partially used for irrigation. The flows of the rivers below the study area plus that diverted for use within it suggest that there is more than enough water to fully irrigate all of the area. It is also likely that reliable sources of underground water exist.

Land Use

That part of the study area closest to the city of Sonsonate is mainly devoted to dairying. About 56% of the land is in pastures, with dairy products accounting for about 73% and sugar cane about 24% of the value of production. About 37% of the land is in cane, and the rest in fruit and coconut. The area nearest the Pacific Ocean (Banderas) is about equally divided between dairying and cotton production, with maize being raised on cotton land during the dry season.

As indicated, pastures are mainly used for dairy cattle, and to a much lesser extent for beef. The level of technology on the dairy farms is the highest in the country with reference to cattle breeds, installations and equipment. Efficiency varies greatly from farm to farm, but generally there is room for improvement, especially in administration, pasture management, irrigation, supplementary feeding, stocking rates, and livestock quality. A stable market exists for milk for it is all purchased by a co-op processor in Sonsonate for distribution and sale as fresh milk in the urban areas of San Salvador some 35 km. to the east.

Population

The most important city is Sonsonate, capital of the department, with 30,000 people. The other major city is the Pacific Ocean port of Acajutla with 4,500 inhabitants. It is the most important port in the country and the principal exit for exports. Its port installations are modern.

In the area of the project are 7,900 inhabitants (1,360 families) that provide much of the labor force on farms in the area.

Land Tenancy

Data are presented in Table 1 on land tenancy in the study area.

Table 1. Land tenancy in the Sonsonate-Banderas study area

Size of holding in Ha.	Owners		Area	
	No.	%	Ha.	%
0 - 3	255	62.0%	218	2.7%
3.1 - 20	70	17.0%	482	6.1%
20.1 - 100	64	15.5%	2657	33.1%
100.1 and over	23	5.5%	4683	58.1%
Total	412	100.0%	8040	100.0%

The ownership of available land is concentrated in the hands of relatively few people.

Irrigated Dairy Farming in Sonsonate-Banderas

The dairy farmers or managers interviewed for this study all operate within the heretofore described study area. Thirty-four of thirty-six dairy farms in the area were surveyed in August, September, and October of 1971 to obtain production costs and returns, and thirty-one gave the desired information.[2] A larger sample would have been desirable but as there were no more farms in the project area it was decided to do the analysis with these data rather than to extend the study to farms outside the project area. In the final analysis, four of the 31 farms are

[2]See Appendix I for a sample of the questionnaire used in the study, and Appendix II for a table showing the number of farms, and land use.

omitted because of contradictory or incomplete information obtained in the interview. This leaves a total of twenty-seven.

Description of the Farms

Size--Farm size ranges from 20-900 manzanas. The farms that were limited as to water supplies tended to be somewhat larger on the average than the irrigated farms. Within each size range there was considerable variation in management efficiency.

Cow Herd Quality--Cow herd quality varies from farm to farm but generally the cows are at least 1/2 blood Holstein or Brown Swiss. One farm was using cows that were 1/2-3/4 Jersey with the dams being native or creole cows and the sires Jersey. Another farm had cows that were 1/2 Brahman and 1/2 Brown Swiss. These cows were exceptionally good. Their production was higher than many herds that were 3/4-7/8 Holstein. Much of the increased production was undoubtedly due to their greater vigor and disease resistance. The Holstein cows seemed especially weak and disease prone.

Availability of Water--Farms in the study area divert water from the Sonsonate (Sensunapan), and Banderas river watersheds. All farmers in the survey had invested in irrigation infrastructure in the form of dams and ditches; however, some had only marginal supplies of water during the dry season. Diversion from the river or its tributary is currently controlled by the municipality through which the river passes, although the new law transfers jurisdiction to the Ministry of Agriculture. In most cases, each farmer makes his own diversion dam but in a few cases farmers cooperatively own and maintain a diversion dam and delivery ditch. In addition, a few farms benefit from springs and small streams that originate within th(

While some farmers lack sufficient irrigation water and seem unable to alleviate the problem, others have plans to make new diversions and seem completely confident of obtaining the necessary water. This situation strongly suggests that there is sufficient water in the area during the dry season but that shortages are caused by an unsatisfactory distribution system.

According to custom, farms closest to the water source have preferential rights over farms more disadvantageously located. Because of this system, farmers who have relied upon irrigation water for years may suddenly find themselves dry, as their neighbors upstream decide that irrigation is profitable. The new water rights law does not appear to deal specifically with this issue. However, broad powers are given to the Ministry of Agriculture in water control, and this could alleviate some of the uncertainty.

As indicated, water previously was controlled by the municipal governments. When a farmer needed irrigation water he would negotiate with municipal officials on the quantity of water required and its price. The farmer or group of farmers would then proceed to build the ditches and diversion structures necessary to bring water to their farms. Annually, thereafter, farmers would renegotiate with the city government for the amount of water agreed on and the fee. Under this system farmers were responsible for maintenance of the ditches. When a large group of farmers jointly used a ditch the municipality would appoint and pay a water judge, who was responsible for insuring that everyone got his legal share. In actual practice, the water was poorly measured so the water judge's job became one of keeping everyone happy.

For the present this continues to be the situation in the Sonsonate-Banderas area. The proposed DGORD project aims to improve distribution by scientific regulation of water measured to individual farms and an improved delivery system. Land owners would be forced to irrigate more efficiently and dikes and light leveling or planing operations might become necessary. The quantity of water saved in this manner would likely be sufficient to meet the needs of those farmers with inadequate supplies during the dry season.

Management--Milking is done by hand on all farms except one. Most herdsmen can take care of from 20-25 cows milking twice a day. Hand milking provides more jobs and apparently induces fewer mastitis problems than would the use of milking machines. Also it appears that under present labor prices this is more efficient.

A few farmers practice on archaic system that wastes time and is very unsanitary. A calf is allowed to nurse the cow until the udder is stimulated and milk begins to flow. Then, the calf is forcefully pulled from the udder and snubbed securely to the cow's front leg. The milker then finishes the milking secure in the knowledge that the cow thinks the calf is still sucking. Moreover, the calf's saliva makes a lubricant for the milker's hands and speeds up milking.

Milk handling leaves much to be desired. Farmers often neglect to use strainers, and many wash milk cans in streams without the benefit of soap. At present, all milk is handled in cans. Many farms have tanks of cold water to cool the milk. Two farms had refrigerated cold rooms and two had bulk tanks. However, the milk in bulk tanks had to be emptied into cans to be taken to market. Many farmers took their milk to market in open trucks and some even used horse or oxcarts. Given the hot climate, it is obvious this practice hurts milk quality.

Cows are given very little concentrate. Most farms rely on a pasture intensive program. Labor is used lavishly. Every cow's production is recorded daily on some farms. On some farms pastures are clipped by hand after every grazing with small wide scythes shapped much like brush axes.

Herd health is especially important under the adverse climatic conditions in Sonsonate. Although most farms have received a regular veterinary service, health problems are still common. Many herds have breeding problems which cause them to support a disproportionate number of dry cows. Hoof rot is a serious problem and anaplasmosis, septicemia, and anthrax will quickly take their toll if the vaccination schedule is neglected. Brucellosis and tuberculosis are quite common in some herds but MEGA has started a program to eliminate these diseases and progress is being made.[3]

Calf mortality, on some farms, is very high but generally they are very well cared for. Most farms have individual calf pens with slotted floors. However, very few people use milk replacer and most give heifer calves whole milk until they are 6 months old. Raising bull calves with milk replacer has been quite unprofitable due to lack of a market. However, with the new packing plant, "Quality Meats" (located near San Salvador) in operation, raising bull calves might become more profitable.

Pasture management is generally very good. Almost all use pasture rotation, improved grass varieties and surprisingly large amounts of

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[3] MEGA is the acronym for Mejoramiento de Ganadería.

fertilizer (up to 1320#/manzana--generally ammonium sulfate). Some farmers clip their pastures and fertilize after every grazing. This helps to control invading weeds and woody plants yet does not destroy the native legumes which may exist. The most serious problem in the pastures is invasion by a type of grass called <u>zacate amargo</u> (bitter grass). While not bitter as the name suggests it has very poor nutritive qualities and produces no milk. This grass invades the improved pastures and eventually necessitates complete renovation.

On-farm water management seems to be the most backward part of total management. Farmers flood irrigate without benefit of rills or ditches through the fields. Pastures of 5-10 manzanas are completely covered with water and the process is repeated at intervals of a week to 15 days. Undoubtedly, much water is wasted and this system reduces the amount of water available for use by other farmers. Although the land is almost flat most farms could benefit from a simple planing or leveling project. This would appreciably reduce the volume of water needed to push across the field. Concrete ditches are rare and although the soil is very heavy, they could probably reduce water loss and washing in certain areas.

<u>Labor</u>--Labor in the Sonsonate area is relatively cheap but its low cost has apparently misled some farmers. One farmer milking 305 cows was spending ¢1,432 per cow per year on labor. This contrasts with ¢62 labor cost per cow per year on another ranch that was milking just 85 cows. Some of the larger land owners are so socially conscious that they are apparently spending exorbitant amounts on labor. Although labor is abundant, the level of skills is very low. Most farm workers are

very poorly educated and lack adequate incomes. Many of the dairy workers have an "I don't care" attitude and are very rough, almost cruel in the way they handle livestock.

MEGA

A bright spot for the dairy industry in Sonsonate is the technical assistance given by the livestock improvement agency (MEGA) there. MEGA is a national agency created to help modernize the livestock industry. They do all basic record keeping, encourage upbreeding, provide inexpensive semen from government owned bulls, instruct farm hands in insemination methods, and supervise herd health on farms that will accept their help. This organization is constantly on the move from farm to farm and their presence in the area encourages farmers to be more progressive.

Existing Irrigation Works

Existing irrigation works are a series of small diversion dams usually owned and maintained by an individual farmer or in some cases, groups of farmers. Some of these dams are little more than rocks thrown in the river while others are quite elaborate and costly. The present system givea everybody some water. The main problem is that it is unsystematic, and water supply is sometimes erratic during critical periods of the dry season. If a suitable area could be found for a reservoir it would greatly alleviate any possibility of a water shortage in March and April, the final months of the dry season.

Other Crops

The Sonsonate-Banderas area is not exclusively a dairy region. One dairy farmer was raising rice and almost all had a few manzanas of coconuts.

Sugar cane provides strong competition for pasture lands in Sonsonate and cotton is a profitable alternative in Banderas. Both have some advantage over cattle in that they require less fixed investment. However, cotton is risky and rice also is risky because of the danger of drought and bird problems. Technically, rice, cotton, and cane can fit in quite well with a dairy enterprise. One farmer used crop residue and the volunteer grass in his cotton fields to carry his herd through the dry season. This arrangement enabled him to sell his cull cows and steers at higher prices during the dry season. Another dairy farm had been in cane several years prior to being seeded to pasture. This farm had unusually good pastures probably because of the organic matter left by the cane. The rice straw also was a valuable asset to the dairy herd on the same farm.

Nevertheless a well managed dairy farm is apparently as profitable as any crop alternative and in the future will probably be more profitable. Most of the farms are absorbing the cost of raising all heifer calves in an effort to improve their herds as rapidly as possible. Once the herds are established, this extra cost will no longer be necessary and many of these good heifers will be available for sale to other farmers.

III. CONCEPTUAL APPROACH

The purpose of this chapter is to set forth the analytical procedure to: a) determine the economic return to differential applications of water to pastures on dairy farms in the Sonsonate-Banderas area of El Salvador; and, b) to determine if the magnitude of the returns justifies the cost of adding water. Ideally one would want experimental data on pasture response to irrigation, and on milk production responses of dairy cows to the irrigated forage, as well as per manzana costs of alternative methods of adding water. However, there seems to be no data on production responses,[1] while cost data are sparse.

Trying to determine exact amounts of water used by individual farms was impossible with the resources available for this study. However, the results of the survey indicated that farms could be easily divided into two sharply defined groups, according to general abundance or availability of water. The farms that irrigated with reasonable frequency and consistency throughout the dry season were defined as having an adequate water supply. Included in this group are some farms that use excessive amounts of water. Farms with limited water were defined as those which were unable to irrigate with the desired regularity due to complete or partial loss of their water supply in February, March and April.

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[1]The original work plan called for the gathering of experimental data. We attempted to gather data on forage response to irrigation, and milk production to forage in El Salvador, but such data does not seem to be available.

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It should be emphasized that survey results also indicated <u>all</u> farms apparently had adequate distribution facilities. Lack of investment in such infrastructure is not a limiting factor on any of the farms; rather the constraint on some farms is a shortage of water

The rest of this chapter is organized as follows. First, the procedure for calculating the return to water as the difference in net returns between farms with adequate, and inadequate supplies is discussed, along with the assumption of homogeneity necessary to make such a comparison. The second section presents the methodology for calculating the internal rate of return to investment necessary to add water to farms with inadequate supplies, with both pump and DGORD project irrigation considered as alternatives. The final section discusses the possibility of improving administrative control and management of water as a basis for increasing the supply of water to farms with marginal supplies.

Differential in Net Returns for Farms With Adequate and Inadequate Water Supplies

The approach taken is to first calculate the net return per manzana[2] on farms with adequate water, and on those with inadequate (limited) water. The difference in net returns between such farms is assumed to be the return to additional water and is hypothesized to be positive. The procedure for calculating the return to differential applications of water is presented in the first subsection.

In order for this difference to be the economic return to differential applications of water, we must assume that all other production practices

[2]About .7 of a hectare.

are homogeneous on the two kinds of farms being compared, including adequacy of the distribution systems. This homogeneity assumption limits the number of comparisons that can be made between farms with adequate and inadequate water supplies. Its role in the analysis is discussed in the second subsection.

Calculation of the Return to Differential Applications of Water

Net returns on each type of farm (with adequate and inadequate water supplies) are calculated by subtracting annual total costs from gross receipts. This net return is the return to management after all costs are accounted for, and represents profits in some sense. Then net returns are divided by the number of manzanas in each farm so as to allow comparisons of profitability between farms.

It is expected that net returns per manzana on farms with adequate water are larger than on farms with inadequate supplies, and that under the homogeneity assumption the difference represents the return to the differential water.[3]

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[3] One might ask why net returns are calculated in this manner if interest is in the return to differential applications of water. It might seem more appropriate to cost everything (including some cost for management) excluding the investment in irrigation capital. Then the return would be that to the investment in irrigation capital on each farm type. However, we are not interested in the return to irrigation capital per se, since both farm types have adequate irrigation capital, but the return to differential applications of water between such farms. Also, it is impossible to get reliable cost data on the investment in irrigation capital on most of the farms. However, we do know the value of land with irrigation capital and adequate water is higher than that without irrigation capital or water. This provides evidence that there is a return to differential applications of water, and can be used to calculate the value of the stream of benefits flowing from such returns. This permits a cross-check on the size of the difference in net returns (see below).

The return to water is calculated as follows. Let GR = annual gross returns, TC = annual total costs, and GR - TC = NR = annual net returns, with GR and TC expressed on a per manzana basis. Let the subscript 1 refer to farms with adequate water and the subscript 2 refer to farms with inadequate water. Then:

$$GR_1 - TC_1 = NR_1 \text{ and}$$

$$GR_2 - TC_2 = NR_2.$$

The return to water is

$NR_1 - NR_2 = R_w$, where R_w is hypothesized to be > 0 under the assumption of homogeneity.

Gross Returns--Gross returns are the sum of milk sales, calf and cull cow sales, and additions of heifers at market value to the cow herd. Milk prices were the same for both groups of farms since all sell their milk to the same cooperative in Sonsonate. The same prices have to be assumed for cows. A beginning and year end inventory of heifer calves, one year old heifers, and two year old heifers was obtained for each farm. The increase in the market value of such heifers at the end of the year was added to gross receipts.

Fixed Costs--Fixed costs are defined as costs associated with factors of production which lasted more than one production period (one year). Such factors include land, irrigation systems, installations and buildings, and machinery and equipment. Straight line depreciation is used to determine part of the annual cost for installations and buildings, and machinery and equipment, with the former group having a 20 year life span, and the latter group a ten year span. Interest is charged at the rate of 6% on the undepreciated balance in each case,[4] to determine the other part of annual costs. This approach is equivalent to amortizing the value of the fixed factors over their life span.

Determining the annual costs for land and irrigation systems presents a difficult problem. Most farms in the survey (both with adequate and inadequate water) had very old irrigation systems. It was impossible to determine the cost of such systems due to their antiquity. It may be assumed that the market value of the land parcels reflects the capitalized value of the benefits to be realized from the irrigation of the land as well as the initial value of the land. But, the land market is very poorly developed and it was impossible to get differential land values between farms with adequate irrigation systems and water supplies, and farms with adequate irrigation systems but inadequate supplies of water. Land is worth about ¢3,000 per manzana (the current market price of land with adequate systems and supplies of water) and ¢500/2,000 without irrigation systems. Since with proper maintenance and management, benefits could be expected to be derived from the land in perpetuity it is costed at 6% interest (the opportunity cost of the investment). We assume land is valued at ¢3,000/manzana since all farms in the survey had adequate distribution systems. This leads to an overstatement of land costs for farms without adequate water.

The survey revealed that a few farms had recently installed simple irrigation systems (diversions dams and ditches). Their land was valued

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[4]This is the rediscount rate changed by the Central Bank in 1970. It is not known if this rate is close to the rate charged on long term capital for agriculture.

at ¢300-¢2000 (value before addition of irrigation systems) which was charged at 6%. The cost of the systems was depreciated on a straight line basis with a 50 year life, and the undepreciated value charged at 6%. The owners are in a position to reap a windfall gain from the increase in the value of their land, as the expected benefits from irrigation are capitalized into it. In the cases of land with very old systems, it is likely that such windfalls have already been tapped through sale of the improved land by the original owner.

Variable Costs--Variable costs include labor, on-farm management, feed concentrates, veterinarian service, fertilizers, repair and maintenance costs, and some gas, oil and electricity costs. Labor was the biggest single cost on most farms. Wages are low with little variation from farm to farm. The minimum wage is ¢2.25 or $.90 U.S. per day. This is what most of the workers earned although some were paid an extra day every week and there were some year end bonuses. One land owner had an incentive plan and paid some workers up to ¢4.00 per day. Salaries of foremen or managers ranged from ¢90 to ¢400 per month with ¢150 being most common.

The next greatest variable cost was feed concentrate. Although very little is used by United States standards, some concentrate was always used to supplement the rather coarse pasture grasses. A common mixture is 25# cottonseed meal, 20# ground sorghum, 27 1/2# ground corn, 2 1/2# salt and mineral and 25# molasses. This mixture costs ¢5.00 per 100# or $2.00 U.S. This feed is not expensive; no complete feed was over U.S. $3.40/100# or about the same cost as in the U.S. At the same time, Salvadoran farms received about U.S. $4.00/100# for milk, or about the same level as their U.S. counterparts. This suggests a need for more research on feeds in El Salvador. Some feeds such as cottonseed meal and molasses are very abundant and it is possible that by mixing these feeds with a filler, cows could be kept cheaply under confinement away from the heat. Indeed, one farmer was doing this. Because of poor pastures he was giving his cows a mixture of cottonseed hull, molasses and chopped grass. He had a very profitable operation.

Powdered milk replacer for calves is about as expensive as in the United States. Nevertheless, few farmers used it because the supply is too erratic. Only three farmers were using milk replacer and their costs of raising calves appeared to be considerably less than for those farms who used nurse cows for up to 6 months.

Most farms visited were serviced regularly by veterinarians. Veterinarian bills were high, as was the cost of medicines. Many farms paid a flat fee of ¢150 to ¢200 per month for this service plus the costs of any medicine.

Fertilizer is a big cost on some of the more intensively managed farms. It is not unusual to find farmers using up to 1320# of ammonium sulfate per manzana per year in 5-6 applications. Fertilizer is spread exclusively by hand, contributing to high application rates. Occasionally farmers supplemented the ammonium sulfate with formula 20-20-0, and more rarely, urea. Some fertilized according to soil tests but most just put it on and hoped for the best.

Other costs were generally insignificant. Gas, oil, and electricity costs were important on some farms but others used none of these. The latter carried out all farm operations with hand labor and oxcarts, without even having the benefit of can coolers for their milk. A few farms used minor amounts of soap and insecticides.

Actual repair costs on fixed assets were difficult to obtain as very few of the farms kept accurate records. However, the few farmers who did keep such records experienced repair costs of 2 1/2% - 5% of actual cost. In the budgets which follow it is assumed that all repairs on assets with a 10 year life are 5% of acquisition cost, and on assets with a 20 year life, 2 1/2%.

Net Returns--Total costs on an annual basis (the annualized value of fixed costs and the variable costs) were subtracted from the annual gross returns to yield net returns for each farm in the survey. Division by the number of manzanas yields net returns per manzana and permits comparison of profitability of farms with adequate and inadequate supplies of water. The comparison will have to be made between farms that are the same in every respect, except for the differential water application.[5] The process for assuring this homogeneity is discussed in the next section.

Homogeneity Assumption

For the differential in net returns between farms with and without adequate water to be attributed completely to the different levels of water applied per manzana, all other production factors would have to be homogeneous. Inspection of the survey data suggest that this is not likely to be the case for comparisons between average net returns of the two groups of farms.

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[5]This assumes that the differential net return is due to differences in water application, and not to other factors.

Consequently, it is necessary to make comparisons between net returns of individual or small groups of farms with adequate and inadequate water supplies, at a more disaggregated level. The approach utilized is the following. First, a table listing key production characteristics include: type of cow herd, kind of pasture grass, how calves are raised, rotation system used, whether or not artificial insemination is used, labor costs per cow, calf mortality, and veterinarian costs per cow. Each farm with adequate water is compared with farms having limited water according to this set of characteristics. Farms that have the same production practices, are deemed comparable. That is, differences in net returns per manzana between comparable farms are due to the only factor that is different (availability of water). By making this comparison for each farm with adequate water, sets of farms that can be compared are delineated. If such a group within the set contains more than one farm, the average net return for that group is calculated with weighting by farm size. The difference in net returns between farms with and without adequate water generates for each set of comparisons an estimate of returns of water. From this an overall average net annual return is calculated as a basis for determining the internal rate of return to water investments.[6]

Some characteristics not included in the criteria for comparison include: on-farm water management, competence of manager, soils, rainfall, efficiency of veterinary service, and knowledge of prices and

[6] See Appendix III for details of the specific comparisons, and for an explanation of the notation used below.

best practices. However, empirical observation suggests that these factors are relatively homogeneous across all farms. Thus, the assumption of homogeneity is approximated by comparing farms that are as much alike as possible with respect to every production characteristic, except the availability of water.

Still the assumptions are approximate. Soils, rainfall, management, etc., do have nuances of difference even among sets of farms deemed comparable. In some cases, such differences serve to widen the differential in net returns; in other cases they tend to narrow the differential. Consequently, the results from using this approach are not precise; at best, they only indicate the direction, and possibly the magnitude of benefits from supplemental irrigation.

Internal Rate of Return on Investment Necessary to Add Water to Dairy Farms With Inadequate Supplies

How do we determine if the magnitude of the difference in net returns between farms with adequate and inadequate supplies justifies the investment necessary to add supplemental water? If we assume the income stream from such an investment would be equal to existing differences in net returns between the two types of farms, the internal rate of return on the investment can be calculated for the different technical possibilities of obtaining the supplemental water. Calculation is made for two alternative methods of adding water; one is on-farm investment in pump irrigation, and the other is total DGORD project development. Neither of the alternatives contemplates costs of adding ditches, head gates, etc., due to the existence of distribution infrastructure on most farms.

The internal rate of return is that rate which makes the ratio of the present value of all net benefits (to be derived from some investment), to the initial cost of the investment, equal to 1.[7] In this analysis we assume that the average of the single farm comparisons ($\bar{R}_{w_s}$, Appendix III) is the most conservative indicator of the stream of benefits per manzana to be derived from adding irrigation water (via pump or project). The internal rate of return is defined as i when: $\sum_{t=0}^{T} \frac{\bar{R}_{w_s}}{(1+i)^t}$ = cost of pump or project (per manzana) where,

$\sum_{t=0}^{T} \frac{\bar{R}_{w_s}}{(1+i)^t}$ = PV = present value of $\bar{R}_{w_s}$

$\bar{R}_{w_s}$ = the annual return to water per manzana assumed to be constant over the life of the pump or project (average for single group comparisons)

T = total life of pump or project

t = actual year.

In practice, the rate i is calculated by an iterative process usually employing an electronic computer.

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[7]A caveat needs to be given at this point. In interpreting the internal rates of return, the reader needs to keep two things in mind. First, the difference in net returns cannot be clearly identified as accruing purely from additional water. In fact, in most comparisons the differential return to water (R_w) may be over or understated due to the influence of factors which cannot be held constant between farms in a comparison. Second, the data on costs of adding water (to be discussed) in this section) are at best, inadequate. Consequently, the internal rates of return only indicate magnitudes of return, rather than precise measurement.

There are at least two alternative ways of adding water on farms where it is a constraint. The first is to drill wells on the farm, with all investment being made by the farmer. The second is for complete project development by the government with the farmers or society bearing the costs.[8]

Internal Rate of Return to Pumps

To arrive at the internal rate of return to pump irrigation for farms without sufficient water both the costs and the benefits of adding such water, are required. Benefits will be assumed to be the present value of the differential in net returns per manzana between farms with and without sufficient water, over the life of the pump. Costs of wells and pumps for different size farms are those reported by DGORD.

The fixed cost of irrigating up to 25 manzanas by pump has been estimated at ¢450 per manzana, 26-50 manzanas at ¢400 per manzana, and over 50 manzanas at ¢381 per manzana. The annual maintenance as estimated by DGORD is ¢81, ¢72, and ¢67, respectively.

These data are used to calculate the cost per manzana on farms with inadequate water to obtain supplementary irrigation from tube wells. First, the number of manzanas that required extra water is determined

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[8]This has been proposed by DGORD. In this case, under the new law all water rights would be given out by DGORD and the entire project would receive water from DGORD (including farms that already have all the water they need via water rights from municipios and their own investment).

for each farm.[9] Then the fixed cost of adding water via pump per manzana (¢450, ¢400, or ¢381 depending on the amount of land requiring extra water) is multiplied by the number of manzanas requiring the extra water, to yield total fixed cost by farm. The total fixed cost for all such farms is found by summing over fixed costs for the individual farms. Then the total acreage of all farms was divided into the total cost for all farms to get the average fixed cost of pumping additional water per manzana. For example, a 55 manzana farm might need water for 30 manzanas. The cost would then be ¢400 per manzana and total cost would be ¢12,000. A second farm of 150 manzanas might need only 21 manzanas of water and its cost would be ¢9,450 (21 x ¢450). The total cost for both farms is ¢21,450 (¢12,000 ± 9,450) and total acreage is 205 (55 ± 150). Fixed cost per manzana in this example is ¢105 (¢21,450 divided by 205). The maintenance costs are calculated in the same manner.

The fixed cost per manzana is estimated to be ¢149 and maintenance costs are estimated at ¢27 per year over the life of the typical pump (10 years). The annual maintenance costs were subtracted from the annual differential in net returns (R_{w_s} - maintenance costs) and the internal rate of return calculated on the net differntial. That is, the internal rate

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[9]Some farms reported the number of manzanas that actually went without irrigation during the dry season. However, other farms with inadequate water irrigated the whole farm during the dru season, but suffered from overall water shortages, so that optimal irrigation was not possible. On these farms, it was assumed that a pump and well sufficiently large to irrigate approximately half the acreage would supply enough water to alleviate the shortage. In the first case only the reported "dry" acreages entered into the calculations.

of return is i when $$\sum_{\substack{t\ 20\\ t=0}}^{T} \frac{\bar{R}_{w_s} - ¢27}{(1+i)^t} = ¢149.$$

Since we are concerned with differential in net returns between farms with and without adequate water, and any such differential has been attributed to water, the only costs we are concerned with are those due to adding the necessary water. It is obvious that any farmer with marginal water supplies who wants to realize the increase in net returns from added water, would also have to invest in extra cows and other inputs which would lead to higher gross returns. Comparison of typical net returns per manzana has the feature that such costs and higher yields are automatically taken into account (excepting water).

Internal Rate of Return to Project Irrigation

The internal rate of return per manzana due to implementation of a proposed irrigation project may be determined if costs and benefits of adding such water, are known. Benefits to dairy farmers will be assumed to be $\bar{R}_{w_s}$ per manzana just as for adding water via pump irrigation. Project related costs are those reported in a set of feasibility studies prepared for DGORD by ICATEC, S.A., a Mexican consulting firm.[11]

ICATEC's estimates cover the irrigation works, and also additional investment in cattle and livestock installations.[12] Such costs include

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[11] ICATEC, Consultares, "Estudio de Factibilidad de Riego: Sonsonate-Banderas," 1967.

[12] Costs for additional cattle, etc., have been accounted for in calculating the differential in net returns. Since we are only concerned with the cost of adding water, the fixed costs are somewhat overstated for our purpose.

fixed and annual maintenance costs. Fixed costs include a 20% figure for unforeseen costs, and 10% for management of the project during construction.

Total project costs reflect the investment necessary to fully irrigate the study area. However, we are interested only in the portion of the project devoted to dairy enterprises. It is assumed that the share in question is directly proportional to the area classed as dairy farms to receive supplemental irrigation.

The fixed cost of the proposed Sonsonate project is ¢9,424,800 and the annual maintenance cost is ¢171,360 while the same costs for the proposed Banderas project are ¢5,055,600, and ¢91,920, respectively. Since 57% of the Sonsonate project (4,304 manzanas) and 48% of the Banderas project (1895 manzanas) were devoted to pasture for dairy cattle in 1967, under the assumption made above, the proportional costs to dairy enterprises are ¢5,372,136 (fixed cost) and ¢92,675 (annual maintenance costs) for Sonsonate, and ¢2,426,688 (fixed cost) and ¢49,122 (annual maintenance cost) for Banderas.

It will be recalled that eighteen of the twenty-seven dairy farmers in the sample survey of the project area are currently fully irrigated through private investment in irrigation infrastructure and water rights granted by the municipios.[13] Often such farms utilize more water than actually is required to optimally irrigate the pastures. The proposed

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[13] There were only 36 dairy farms in the entire Sonsonate-Banderas area.

project may be viewed as redistributing water to farmers that currently only have marginal supplies through control of water rights and improvement of the general area distribution system. In short, the project will confer little or no benefits to farmers who currently have enough water. At the same time, there will be no losses inflicted on farmers who use too much water since there is no decrease in production when that excess water is redistributed.

Consequently, in order to assess the costs per manzana from supplying additional water, via project development, we have to determine the number of manzanas of land belonging to farmers who have inadequate water supplies, and apply the proportion of the cost of the project attributed to dairy farms to just that land.

The ICATEC study suggests that there were 6,199 manzanas of land in pastures in Sonsonate-Banderas in 1967. Our surveys suggest that there were 7,235 manzanas in 1971. Approximately 65% (4,705 manzanas) of this land belonged to farmers who had marginal supplies of water in the dry season in 1971. Since costs were computed for the project as of 1967, we assume that 65% of the 6,199 manzanas in pasture in 1967 also belonged to farmers who had marginal supplies of water, or 4,029 manzanas.[14]

The total fixed cost to dairy enterprises for both project areas is ¢7,798,824, and the annual maintenance cost is ¢141,797. The fixed cost per manzana of land belonging to farmers with marginal supplies is ¢1,935.67 and the maintenance cost is ¢35.19. The annual maintenance

[14] This implies that any new farms since 1967 maintained the same proportion with inadequate supplies of water.

costs are subtracted from the difference in net returns ($\bar{R}_w$ - maintenance costs) and the internal rate of return is i when:

$$\sum_{t=0}^{T} \frac{\bar{R}_{w_s} - ¢35.19}{(1+i)^t} = ¢1,935.67.$$

Improved Administration and Increased Farm Income

It is our judgement, that a considerable amount of water is wasted each year because of a very inefficient measurement and distribution system. Our survey revealed that many farmers applied excessive amounts of water to pasture lands during the dry season. They had either rights to the surplus water or obtained it through illegal appropriation. Their neighbors often are short of water, either due to the lack of a water right or to improper measurement. This is true up and down the rivers in Sonsonate department.

While we do not have diversion measurement figures at our disposal, it is very likely that there currently exists enough water to irrigate all of the dairy farms in the survey area without additional investment in dams, pumps or ditches. In other words, with a reassignment of water rights, based on proper measurement, and with changes in the institutions that manage the distribution of water, there may well be enough water to meet optimum pasture needs given current cultural practices.

Based upon this hypothesis, the current annual foregone benefits to the dairy industry (and society) because of the poor distribution system, would be the number of manzanas of land in dairy farms that lack adequate water supplies, multiplied by the differential in net returns between farms with and without adequate water.[15] This product would equal the additional net returns if farms without adequate water had all they needed.[16] At the same time, there would be an increase in the supply of milk to society.

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[15]We multiply by the total number of manzanas of land belonging to dairy farmers who lack adequate supplies of water, not by the number of manzanas of marginal land on such farms. This is because the net returns per manzana to water is based on total manzanas on farms with and without adequate supplies.

[16]Assumes milk prices are not affected by the increased production. Also assumes that additional cows are available to the farmer from his own herd, or that there is not a capital constraint to purchase additional animals that could be nourished by the additional forage.

IV. RESULTS OF THE ANALYSIS

This chapter presents the results of the analysis while the next chapter is concerned with the implications of those results. The first section presents the differences in net returns ($R_{w_{ij}}$) among farms with and without adequate water supplies, and the averages of those differences ($\bar{R}_{w_{ij}}$). Then the internal rates of return for pump and project irrigation are presented assuming the lowest average difference in net returns is the annual benefit from investment in pump or project irrigation. The final section calculates the loss to the dairy industry from an inefficient water institution and management.

Differences in Net Returns

The set of differences in net returns ($R_{w_{ij}}$) between farms with and without adequate water are presented in Table 2 for 31 different comparisons. Such comparisons were made between net returns on dairy farms with adequate and inadequate water, but are homogeneous with respect to other cultural practices. Thus, the differentials are mainly due to differences in the application of water.

Differential net returns ($R_{w_{i.j}}$) are all positive and range from ¢5.01 per manzana to ¢461.13 per manzana. Three average differential net returns ($\bar{R}_{w..}$) are calculated from the $R_{w_{i.j}}$. These include:

Table 2. Difference in net returns per manzana ($R_{w_{ij}}$) for comparisons between farms with adequate and inadequate water for irrigation, and average differences ($\bar{R}_{w_{ij}}$).

Comparison number[a]	Farms with adequate water (i)		Farms with inadequate water (j)		Difference in net return for the comparison $R_{w_{ij}} = N_{1.i} - N_{2.j}$
	Survey observation number[b]	Net return[c] $N_{1.i}$	Survey observation number[b]	Net return[b] $N_{2.j}$	
1	14	¢ 52.05	18	¢ 42.12	9.93
2	32	13.78	2	- 1.09	14.87
3	32	13.78	12	- 1.88	15.66
4	26	35.06	12	- 1.88	36.94
5	17	48.25	12	- 1.88	50.13
6	19	- 30.75	13	- 90.48	59.73
7	9	108.59	18	42.12	66.47
8	17	48.25	5	- 65.49	113.74
9	25	113.34	12	- 1.88	115.22
10	6	137.09	12	- 1.88	138.97
11	31	126.23	5	- 65.49	191.72
12	30	216.05	12	- 1.88	217.93
13	30	216.05	13	- 90.48	306.53
14	32	13.78	8	-293.78	307.56
15	22	312.18	12	- 1.88	314.06
16	19	- 30.75	8	-293.78	324.53
17	4	395.64	2	- 1.09	396.73

Table 2. (continued)

Comparison number[a]	Farms with adequate water (i): Survey observation number[b]	Farms with adequate water (i): Net return[c] $N_{1.i}$	Farms with inadequate water (j): Survey observation number[b]	Farms with inadequate water (j): Net return[b] $N_{2.j}$	Difference in net return for the comparison $R_{w_{i.j}} = N_{1.i} - N_{2.j}$
18	9	¢ 108.59	8	¢-293.78	¢ 402.37
19	4	395.65	5	- 65.49	461.13

$$\bar{R}_{w_{i.j_s}} = \frac{\sum_{h=1}^{19} R_{w_{i.j_s}}}{19} = \frac{\text{¢}3544.22}{19} = \text{¢}186.53; \quad \sum R_{w_{i.j_s}} = \text{¢}3544.22$$

Comparison number	Survey observation number (i)	Net return $N_{1.i}$	Survey observation number (j)	Net return $N_{2.j}$	$R_{w_{i.j}}$
20	9,24	47.13	18	42.12	5.01
21	17	48.25	12,5	- 30.56	78.27
22	32,4	114.27	2	- 1.09	115.36
23	32,30,26,25,22 17,6	150.09	12	- 1.88	151.97
24	31,17,14,4	102.96	5	- 65.49	168.45
25	32	13.78	2,8,12	-154.72	168.50
26	19,30	82.16	13	- 90.48	172.64
27	19	- 30.75	8,13	-253.12	272.37
28	30	216.05	12,13	- 55.24	271.29
29	9	108.59	8,18	-206.69	315.28
30	32,19,9	34.44	8	-293.78	328.22
31	4	395.64	2,5	- 14.79	410.43

$$\bar{R}_{w_{i.j_m}} = \frac{\sum_{h=20}^{31} R_{w_{i.j_m}}}{12} = \frac{\text{¢}2407.74}{12} = \text{¢}200.64 \cdot \quad \sum R_{w_{i.j_m}} = \text{¢}2407.79$$

Table 2. (Continued)

Comparison number[a]	Farms with adequate water (i)		Farms with inadequate water (j)		Difference in net return for the comparison
	Survey observation number[b]	Net return[c] $N_{1.i}$	Survey observation number[b]	Net return[b] $N_{2.j}$	$R_{w_{ij}} = N_{1.i} - N_{2.j}$

$$\bar{R}_{w_{i.j_t}} = \frac{\sum_{h=1}^{31} R_{w_{i.j_{(s+m=t)}}}}{31} = \frac{¢5952.20}{31} = ¢192.00$$

[a]Comparisons 1 - 19 are simple paired comparisons. In the notation introduced in Appendix III for comparison #1, $N_{1.14} - N_{2.18} = R_{w14.18}$. Comparisons 20 - 31 are multi-group comparisons. In the notation of Appendix III for comparison 20, $N_{1.9,24} - N_{2.18} = R_{w9.24,18}$.

[b]Each survey of individual farms is referred to by number to preserve the confidential nature of the data.

[c]Net returns for more than one farm are the average of such returns weighted by the size of the farm. All returns are stated in colones (¢) per manzana.

1. $\bar{R}_{w_s} = \sum_{h=1}^{n} \frac{R_{w_{i.j_s}}}{n}$ where s suggests that this is a simple paired comparison or that there is one farm i and one farm j; n = the number of single group comparisons.

In this case there are 19 paired comparisons and $\bar{R}_{w_s} = \frac{¢3,544.22}{19} =$ ¢186.53;

2. $\bar{R}_{w_m} = \sum_{h=1}^{n} \frac{R_{w_{i.j_m}}}{n}$ where m suggests that i or j (or both) are weighted average multi-group comparisons; n = the number of multi group comparisons.

In this case there are 12 multi-group comparisons and $\bar{R}_{w_m} = \frac{¢2407.79}{12} =$ ¢200.64;

3. $\bar{R}_{w_t} = \sum^{n} R_{w_{i.j_t}}$ where t suggests that the average is all 31 comparisons; n = number of paired and multi-group comparisons.

In this case there are 31 such comparisons and $\bar{R}_{w_t} = \frac{¢5952.20}{31} =$ ¢192.00.

In calculating the internal rate of return reported in the next section, the lowest of these three averages ($\bar{R}_{w_s}$ = ¢186.53) will be used as the annual benefits from the investment in irrigation capital. If the internal rate of return as calculated with this lowest average is higher than the best alternative for investment capital, then it would also be greater for $\bar{R}_{w_{i.j_t}}$ and $\bar{R}_{w_{i.j_m}}$. The lowest average sets a conservative lower boundary on the analysis.

A striking result is that the net returns to dairy farms without sufficient water are all negative except for one case; in contrast the net returns to farms with sufficient water are all positive except in one case. Evidently, water is a limiting factor of production. In the long run farmers with inadequate water supplies will tend to go out of business, unless they can gain access to additional water (see the final section of this chapter).

Internal Rate of Return

The internal rate of return for project and pump irrigation was calculated via an iterative process on an IBM - 360/40 computer. The lowest average difference in net returns between farms with and without sufficient water is assumed to be the annual gross return stream. This is ¢186.53, the average difference in net returns for single group comparisons.[2] Annual maintenance costs were subtracted from this gross return stream for both project, and pump irrigation, and the internal rate of return calculated on the fixed investment in each case.

Pump Irrigation

The average fixed cost of investment in pump irrigation per manzana is ¢149.00, and annual maintenance costs were ¢27.00.[3] The return stream is assumed to be ¢186.53. Maintenance costs are subtracted from this to yield at net annual return stream of ¢159.53. The life of the pump is assumed to be 10 years. The internal rate of return is calculated by solving the following equation for i: $\sum_{t=1}^{10} \frac{¢159.53}{(1+i)^t} = ¢149.00.$ This rate i is calculated to be 107%. At this rate the present value of ¢159.53 over 10 years is equal to ¢149.00. If it is assumed that gross

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[2]See Table 2.

[3]See pages 41-43 above.

returns (¢186.53) have been over-estimated by 20%, the internal rate of return would still be 82%.

Project Irrigation

The internal rate of return from proposed project irrigation is much lower than on pumps. The fixed cost of project investment per manzana requiring supplemental irrigation is ¢1935.67 and annual maintenance costs are ¢35.19. The net annual return stream is thus ¢151.34 (¢186.53 - ¢35.19). The calculated internal rate of return is 7.62%, assuming a 50 year life span on the capital. If the gross return stream has been overstated by 20%, the net return stream would be ¢114.03 (¢149.22 - ¢35.19), and the internal rate of return would be 5.48%.

Differential Land Values

Differences in land values were observed in the survey area. These differences may be used as a cross check to assess whether or not our chosen estimate of the average return to water ($\bar{R}_{w_{i.j_s}}$ = ¢186.53) is reasonable.

Land that was fully irrigated and had sufficient irrigation capital sold for ¢3,000/manzana. Land without irrigation facilities or water sold for ¢300 to $2,000 per manzana depending on soil quality, gradient, location, etc. Thus, the range in the difference in value of these two kinds of land was from ¢1,000 to ¢2,700/manzana. No market value was observed on land that was fully invested in irrigation capital, but with inadequate water supplies. However, one would expect that such land would have a value between ¢3,000 and ¢2,000 per manzana (assuming its quality was the same as land that is now fully irrigated).

The differentials in observed land values are the present value of the difference in expected annual net benefits between fully irrigated and unirrigated land. The difference in net benefits on the two types of land must flow from both the irrigation capital and sufficient water if land quality is constant. If the capital lasts 50 years and the rate of interest is 6% the annualized value of the ¢1,000 differential is ¢63.44, and ¢171.29 on the ¢2,700 differential.

One would expect the difference in the value of land that had sufficient water and adequate distribution system and land that lacked water but had an adequate distribution system to be less than ¢1,000. Consequently, the annualized value of the difference in the market price of these two kinds of land might be expected to be less than ¢63.44. Since the average difference in net returns between these two types of farms is calculated to be at least ¢186.53, it is likely that comparison process employed has led to some overestimation of the net return flowing from a differential application of water as well as an imperfectly operating land market. Nevertheless the differential in observed land values does suggest a positive return to increased applications of water.

Relative Importance of Alternative Investment

The internal rate of return is positive for both investment in pumps on the farm, and in proposed total project development. While the size of the return may be questioned in each case, the relationship between the rates of return suggests that pump irrigation for supplemental water is more efficient for the farms

This conclusion is based on an assessment of the worth of the surface project as seen through the eyes of the present dairy farmers who are "short" of water and need supplemental supplies. This means that we have assumed that all of the project costs that could be assigned to the dairy pasture area (about 7,200 mz.) are to be borne by a subset of about 4,700 manzanas. This assumption does not make the benefits to dairy farmers from the surface project seem as attractive as the original ICATEC report.

That report shows returns of about 82% on average. This figure includes allowance for extension of irrigation to new lands and from benefits assumed to be captured due to drainage. Our estimate of 7% benefit is based on the gains from supplemental water for what we have called inadequately irrigated farms, farms having the least need for more water. Wholly new farms will show much higher returns and will increase the total average estimated by ICATEC.

Cost data may not be reliable. While we have no reason to doubt the pumping costs used, it was necessary to make several assumptions in order to estimate project costs just for the dairy lands, (however, it is our opinion that any bias here would be on the low side). The most likely error is the assumption that pumping can be associated with present on-farm irrigation systems that are serviceable. Some farms have extensive investments in irrigation structures while others do not. If too much of the system is antiquated, then it is possible that renovation (and higher costs) will be necessary and that the proposed surface project will be the most efficient way to carry it out.

Foregone Benefits Due to Inefficiencies in the Current Water Distribution System

The internal rate of return could not be calculated for improved management of the present distribution system through altered institutions, since the costs of making changes are not known. However, the annual direct losses to the dairy industry in Sonsonate-Banderas, because of the inefficiencies in the current system, can be estimated.

If we assume that the price of milk would not be affected by increases in production, then the annual loss to the dairy industry because of inefficient distribution in the project area is the differential in net returns per manzana between farms with and without sufficient water (¢186.53), times the number of manzanas of land on farms with marginal supplies of water. There is no cost of adding distributional systems since survey data suggest all farms are fully invested in such capital and only lack adequate supplies of water in some cases. The increase in net returns to farms with marginal supplies would be the value of the differential, if water were distributed more efficiently.

Those that lacked adequate water accounted for 4,705 manzanas of land of the farms surveyed. Thus, there is an annual foregone benefit of ¢877,624 to the dairy industry in Sonsonate-Banderas (4,705 x ¢186.53).[4] This loss is in net returns, after all other factors of production are costed out. In addition, milk production is lower, labor, fertilizer and dairy cow requirements are less, and there is a generally lower level of

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[4]This is also a rough measure of annual direct social costs to all El Salvadoran society if enough water is actually available from the watersheds and changing management practices could be brought about "with the stroke of a pen."

economic activity than there would be if water were more efficiently allocated. While we have no way of assessing the multiplier impacts on the rest of society of such improvements in the inefficient distribution system, they may be sizeable.

The new water law provides the opportunity for institutional change. The National Government has the right to determine water use priorities and to expropriate private property for use in irrigation installations. Under this broad authority the government could redistribute water merely by measuring water accurately to users and by preventing higher deliveries than are optimal.

Labor Efficiency and Intensity

Most dairy farms surveyed had an abundant supply of labor. Managers and owners know some of this is excess, but they appear to desire to provide rural employment as much as possible. However, even if somewhat reduced labor inputs were to become the rule, thereby increasing production per man, dairy farming and controlled pasture management would still be fairly labor intensive.

The comparisons in table 3 show that irrigated farms presently utilize more labor per manzana, per animal, and have higher incomes per worker. When farms are divided into two management levels, good and poor, irrigated farms still use the most labor.* The poorer managed farms also are associated with larger quantities of labor. This explains part of the reason for the

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*Divided on the basis of net returns/manzana.

Table 3. Selected measures of labor intensity between dry and irrigated dairy farms, Sonsonate

Categories	Number Farms	Number Manzanas	Av. Workers per Farm	Measures of Labor Intensity: Workers/ Manzanas	Cows/ Worker	Gross Income/ Worker
Part irrigated	9	2085	25.22	.11	7.58	3799.88
Full irrigated	17	2088	19.71	.13	9.43	6056.06
Full irrigated						
Good mgt.	10	1362	16.1	.12	12.01	7603.95
Poor mgt.	7	726	15.57	.15	10.84	3869.61
Part irrigated						
Good mgt.	9	1353	12.67	.08	9.39	4978.00
Poor mgt.	10	1413	19.0	.13	7.66	4346.43

difference in net returns between management levels. Obviously other factors play important roles. For example, the greater investment in fixed assets at the lower irrigated management level reduces returns below what average lower level dry-farms are able to achieve.

When the farms are categorized by size as well as management level, in all cases but one (dry, size 2, management 2*), the poorly managed farms used the most labor (Table 4).

The poorest farms in terms of gross/worker and cows/worker are in the under 80 manzana class. Such farms are often owned by urban residents who maintain them as weekend retreats and who do not have the capital to operate them efficiently.

The three survey farms with the highest net returns were also in the small size class. They use a lot of labor (.28 workers/mz) while the

*In this category very little labor is used.

Table 4. Selected measures of labor intensity within size and irrigation categories, Sonsonate

Categories	Number Farms	Number Manzanas	Av. Workers per Farm	Measures of Labor Productivity: Workers/ Manzanas	Cows/ Worker	Gross Income/ Worker
Full irrigated						
0-80 mzs.						
Good mgt.	6	315	8.83	.17	9.38	6092.24
Poor mgt.	3	120	11	.28	5.21	2246.65
80- + mzs.						
Good mgt.	4	1047	27	.10	13.31	9871.52
Poor mgt.	3	466	20.67	.13	12.9	5888.32
Part irrigated						
0-80 mzs.						
Good mgt.	2	120	9	.08	7.33	3720.16
Poor mgt.	2	108	18.5	.34	4.62	2630.42
80- + mzs.						
Good mgt.	2	410	18.5	.09	8.35	5133.50
Poor mgt.	3	1450	45	.03	8.21	4437.74
Av. of 3 best net returns/mz.	3	100	9.33	.28	7.86	6191.57
1 large dairy	1	300	14	.05	37	23016.07

number of cows/worker is only average. The big boost to net returns on these farms comes through successful herd and pasture management. These farms have good cows and keep them milking. One large farm had net returns equivalent to three best small farms. This farm had substituted capital for labor wherever possible. It appears that reasonably productive labor employment can be expanded most through encouraging smaller intensively managed dairies.

This conclusion is reinforced by an observation about use of some capital equipment. Most dairy farms surveyed had one or more tractors. These are quite useful, especially for pasture renovation and subsoiling. But in practice they are under-utilized in their designed purposes and operations such as subsoiling are ignored even though area soils are quite heavy and prone to compaction. On many smaller farms tractor services could be rented; those farms close to towns could do all their ordinary work with oxen. Indeed low labor costs make many hand operations attractive.

Some perspective on labor intensity vs. other crops can be obtained by considering the kinds of potential that have been estimated for tomatoes grown under improved practices.* In 4 months a manzana in tomatoes would absorb about .56 of a man (1408 total hours), whereas an efficient dairy, relying heavily on pastures, would absorb about .10 during the same period. On a yearly basis this may look a little better. Tomatoes are undoubtedly in the high range of labor required, but they would be a supporting crop on a lot of farms and they represent a different set of risks than do dairy cows.

*Based on estimates provided by the U.S.U. Water Management Team.

APPENDIXES

Appendix I: Survey Questionnaire

Appendix II: Miscellaneous Survey Data

Appendix III: Notation for Computation of Net Return Differentials

APPENDIX I. SURVEY QUESTIONNAIRE

DIRECCION GENERAL DE OBRAS DE RIEGO Y DRENAJE
DEPARTAMENTO DE ESTUDIOS - SECCION DE AGROECONOMIA

ENCUESTA AGROECONOMICA DE EXPLOTACIONES GANADERAS
ZONA: SONSONATE-BANDERAS

IDENTIFICACION: ____________________

NOMBRE DEL INFORMANTE: ____________________

DIRECCION: ____________________

NOMBRE DE LA FINCA: ____________________

UBICACION: ____________________

Caserío __________ Cantón __________

Municipio __________ Departamento __________

NUMERO DE FAMILIAS RESIDENTES EN LA EXPLOTACION (FINCA) __________

EXTENSION DE LA EXPLOTACION (FINCA) ______ Has. %L ______ %F ______ %otros ______

TIPO DE TENENCIA ____________________

VALOR DE LA TIERRA POR HECTAREA ____________________

CONDICIONES DE TENENCIA

DESCRIPCION GENERAL ____________________

____

HECTAREAS ____________________

NUMERO DE VACAS ____________________

____

NOTAS ZOOTECNICAS

NUMERO DE BECERROS NACIDOS ____________________

NUMERO DE BECERROS MUERTOS ____________________

NOTAS AGRONOMICAS

NUMERO DE POTREROS____

AREA DE CADA POTRERO______________________________________

CULTIVOS____

ROTACION____

C O S T O S   F I J O S

INVENTARIO DE MAQUINARIA Y HERRAMIENTAS
COSTOS FIJOS - LECHERIA Y FORRAJE

DESCRIPCION	COSTO INICIAL	VIDA ESTIMADA	AÑO COMPRADO	VALOR A PRINCIPIO DEL AÑO	REPARACION	DEPRECIACION	VALOR A FIN DEL AÑO	CARGADO A LA LECHERIA				CARGADO AL FORRAJE			
								%	REP.	DEP.	VALOR	%	REP.	DEP.	VALO
AUTOMOVIL															
CAMION															
TRACTOR 1/															
ARADO DISCOS															
RASTRA DIENTES															
SEMBRADORA															
CULTIVADORA															
DESCARGADORA															
EQUIPO FUMIGACION															
CARRETAS															
REMOLQUES															
CHAPODADORAS															
PARIHUELA															
BOMBA MOCHILA															
PULVERIZADORA															
MOTORES															
ORDENADORA															
DESNATADORA															

DESCRIPCION	COSTO INICIAL	VIDA ESTIMADA	AÑO COMPRADO	VALOR A PRINCIPIO DEL AÑO	REPARACION	DEPRECIACION	VALOR A FIN DEL AÑO	CARGADO A LA LECHERIA				CARGADO AL FORRAJE			
								%	REP.	DEP.	VALOR	%	REP.	DEP.	VALC
BALDES															
TARROS/LECHE															
TANQUE P/AGUA															
ENVASES (Sacos)															
LAZOS (Pitas)															
YUGOS Y ACCESORIOS															
ARADOS DE MADERA															
OTROS															
DESCRIPCION															
DRENAJE															
ZANJAS															
BEBEDEROS															
CASA PATRONAL															
CASA DE PEONES															
BODEGAS															
ESTABLOS															
SILOS															
PILAS DE ENFRIAR															
GALLINEROS															
TANQUE AGUA POTABLE															
OBRAS AVENAMIENTO															

DESCRIPCION	COSTO INICIAL	VIDA ESTIMADA	AÑO COMPRADO	VALOR A PRINCIPIO DEL AÑO	REPARACION	DEPRECIACION	VALOR A FIN DEL AÑO	CARGADO A LA LECHERIA				CARGADO AL FORRAJE			
								%	REP.	DEP.	VALOR	%	REP.	DEP.	VALO
OBRAS RIEGO															
OTROS															
CERCOS															
TIERRA															
TORAL															

1/ Indicar tipo de tractor

COSTOS VARIABLES - LECHERIA

DESCRIPCION	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	CARGADO A LA LECHERIA		CARGADO AL FORRAJE	
	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C		%	COSTO	%	COSTO
1 COMBUSTIBLE																	
LEÑA																	
DIESEL																	
GASOLINA																	
ACEITE																	
GRASA																	
KEROSENE																	
OTROS																	
2 FLETES																	
SEMILLAS																	
ABONOS																	
INSECTICIDAS																	
COSECHAS																	
GANADO																	
3 BIENSTAR																	
ALIMENTACION																	
VESTIDOS																	
EDUCACION																	
DIVERSION																	

	COSTOS VARIABLES - LECHERIA 1	2	3	4	5	6	7	8	9	10	11	12		CARGADO A LA LECHERIA		CARGADO AL FORRAJE	
DESCRIPCION	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C	U C	TOTAL	%	COSTO	%	COSTO
MEDICINAS																	
INSEMINACION																	
VETERINARIO																	
MEDICINAS																	
DETERGENTES																	
PESTICIDAS																	
SAL Y MINERALES																	
ALIMENTOS																	
TOTAL																	

C O S T O   V A R I A B L E

MANO DE OBRA

E M P L E A D O							
				CARGADO A LA LECHERIA		CARDADO AL FORRAJE	
HOMBRE	COSTO/DIA	DIAS/AÑO	COSTO/AÑO	%	COSTO	%	COSTO
ADMINISTRADOR							
CAPORAL O MANDADOR							
BODEGUEROS							
VIGILANTES							
MECANICOS							
MOTORISTAS							
VAQUEROS							
ORDE ÑADORES							
CORRALEROS							
PEONES							
FAMILIA DEL PROPIETARIO							
ESPOSO							
ESPOSA							
HIJOS							
HIJAS							
TOTAL							

RANCHO UNICA FUENTE DE INGRESO   SI ☐   NO ☐

I N V E N T A R I O D E G A N A D O

EDAD VACAS - TOROS GRUPO DE VACAS	PRINCIPIO DE AÑO			COMPRAS (Crías)				VENTAS				PERDIDAS			FIN DE AÑO		
	NO.	PRECIO POR CABEZA	VALOR	NO.	FECHA	PRECIO POR CABEZA	VALOR	NO.	FECHA	PRECIO POR VACA	VALOR	NO.	FECHA	VALOR	NO.	PRECIO POR CABEZA	VALOR
TOTAL																	

PESO PROMEDIO DE LAS VACAS

CONTROL DE INGRESOS DE LA EXPLOTACION

RENTAS OBTENIDAS POR CONCEPTOS DE ALQUILERES

DESCRIPCION	NO.	CANTIDAD ALQUILADA	CLASE DE ALQUILER	TRIBAJO EFECTUADO	UNIDAD TRABAJO	VALOR UNIDAD	VALOR INGRESO ANUAL
CLASE EQUIPO							
TIERRAS Y EDIFICIOS							
OTROS							
TOTAL							

INGRESO POR PRODUCTOS PECUARIOS

MES	LECHE			FORRAJE			TERNEROS Y OTROS	INGRESO TOTAL
	PRODUCCION	PRECIO	VALOR	PRODUCCION	PRECIO	VALOR		
AGOSTO								
SEPTIEMBRE								
OCTUBRE								
NOVIEMBRE								
DICIEMBRE								
ENERO								
FEBRERO								
MARZO								
ABRIL								
MAYO								
JUNIO								
JULIO								
TOTAL								

	DESTINO DE LA PRODCCION									
	FINCA			CASA			VENTAS			
SCRIPCION	CANTIDAD	VALOR UNITARIO	VALOR TOTAL	CANTIDAD	VALOR UNITARIO	VALOR TOTAL	CANTIDAD	VALOR UNITARIO	VALOR TOTAL	TIPO. COMPRAD.

DATOS DE CULTIVOS FORRAJEROS

TIPO DE PASTO

MBRADO Has. No. de Cortes

TURALES Has. " " "

STROJOS Has. " " "

AREA DE LA PROPIEDAD Has.

N RIEGO Has.

N RIEGO Has.

FUENTES DE AGUA:

BOMBAS No.

MANANTIAL No.

TOMAS No.

ACEQUIAS

INGRESO No.

NGITUD DE CANALES Mts.

SES AL AÑO EN QUE DISPONE DE AGUA No.

USO DEL AGUA:

FORRAJES No. Riegos

CULTIVOS No. Riegos

DRIA USAR MAS RIEGO EN SU PROPIEDAD IRRIGADA SI /_7 NO /_7

E VENTAJAS OBTENDRIA:

DE OBRA

REGADORES/Mz.

REGADORES/POTRERO DE Mzs.

TOTAL/ANO

COSTO

RESUMEN DEL PRESUPUESTO DEL RANCHO

Análisis de Beneficio de Irrigación

Tipo de Ranche____________ Clase de Tierra____________ Condición____________ Hectáreas bajo reigo______

Cultivos y Ganado	Hectáreas o Numero	Días de Labor de Hombre	Produccion			Disposición de Productos Producidos			
						Vendido			Uso Propio
			Unidad	Rendimiento o peso	Total de Producción	Cantidad	Precio	Valor	
Total									

GASTOS DEL RANCHO	
Propiedad	
Seguros - Rancho	
Reparación y Depreciación sobre Mejoras	
Reparación y Depreciación sobre Equipo	
Combustible, aeite, grasa	
Interés	
Utilidades	
Costo y Operación del auto y camión	
Fertilizantes	
Otros gastos de cultivos	
Labor empleado	
Labor de rutina	
Alimentos comprados	
Otro gastos del ganado	
Costo de venta	
Cultivos	
Ganado	

INVERSION

Tierras	Pastos	Lecheria	
	$	$	
Edificios y Mejoras			
Sistema de agua doméstico			
Casa			

INVERSION

Tierras	Pastos	Lecheria
	$	$
Maquinaria y equipo		
Automóvil		
Ganado		
Alimentos y provisiones		
Total		

LABOR DEL RANCHO

Item	Dias	Valor
Cultivos		
Ganado		
Otro		
Total		
Trabajo de		
Operador		
Familia		
Empleado		

GASTOS DEL RANCHO

Leche	
Otros gastos del rancho	
Total de gastos	

RESUMEN FINANCIERO

Dinero recibido	
Privilegios del rancho	
Ganancia bruta	
Total de gastos	
Ganancia neta	

JAPS/ efc
10 - 8 - 1971

APPENDIX II. MISCELLANEOUS SURVEY DATA

Appendix Table II - 1. Number and area of farms surveyed, farms used in analysis, and farms not surveyed.

Class	With water # of manzanas	With water # of farms	Without water # of manzanas	Without water # of farms	Total # of manzanas	Total # of farms
Class I[a]	2088	18	2085	9	4173	27
Class II[b]	32	1	1270	3	1302	4
Class III[c]	410	2	1350	3	1760	5
Total	2530	21	4705	15	7235	36

[a] Class I are farms interviewed and used in the analysis.

[b] Class II are farms interviewed but not used in the analysis.

[c] Class III are farms not interviewed, but estimated area is known.

Appendix Table II – 2 Costs and returns on dairy farms with inadequate water in the Sonsonate-Banderas area.

(Current Colones)

Questionnaire	Number manzana	Repairs[a]	Depreciation[b]	Variable costs[c]	Labor[d]	Interest[e]
1	55	4,151	8,303	31,796	27,231	21,620.45
2	53	621.30	1,242.60	8,481.71	4,771.40	6,978.09
5	230	1,169.63	2,339.30	18,830.25	17,751.00	44,733.76
8	200	9,770.15	19,540.50	59,877.50	43,689.33	38,068.29
10	950	7,970	15,930.50	165,364.83	90,972.52	95,326.68
12	180	1,859	3,718	33,671.66	10,771.20	32,117.70
13	50	532.25	1,075.50	8,203	6,576.56	12,265.80
18	70	2,395.65	1,788.30	14,271.40	7,452.00	13,311.02
29	300	7,154	14,308	49,878.00	49,674.90	63,615.00
Total	2,085	35,622.98	68,245.70	390,374.35	258,889.91	328,036.79
Cost per manzana		17.08	32.73	187.22	124.16	157.33

[a]Repairs - Repairs were estimated at half the depreciation cost or 2 1/2% for buildings and installations and 5% for equipment.

[b]Depreciation - Depreciation was figured on a straight line basis. Machinery was depreciated over ten years and buildings twenty years. In some case, irrigation facilities were depreciated over an estimated fifty year life.

[c]Variable Costs - Actual costs were obtained from interviewees. If exact costs were not available an estimate was made based on approximate amount of a product used and cost per unit. Unit costs varied little from farm to farm. In some cases, transportation costs were varied significantly because of farm location.

[d]Labor - Labor costs varied widely from farm to farm because of variation in amounts used. Unit costs were very uniform at 2.25 per day for laborers and 150-200 colones permonth for managers. There were incentive payments in some cases and a few farmers gave year end bonuses.

[e]Interest - The opportunity cost to capital was figured at 6%. This covered all investment in undepreciated equipment and installations plus the value of the cow herd and the land.

Appendix Table II - 2. (continued)

Questionnaire	Irrigation cost[f]	Total cost[g]	Gross return[h]	Net return[i]	Net/manzana[j]
1	414	93,515.45	84,385.70	- 9,129.75	-165.99
2	588	22,683.10	22,624.94	- 58.10	- 1.09
5	2,932.50	87,756.44	72,692.14	- 4,128.21	- 65.49
8	225	171,170.77	112,413.35	- 58,757.42	-293.78
10	20,720	396,284.53	365,030.67	- 31,253.86	- 32.89
12	330	82,467.56	82,128.66	- 8,183.50	- 1.88
13	421	29,074.11	24,550.00	- 4,524.11	- 90.48
18	1,098	40,316.37	43,264.90	2,948.53	42.12
29	111	184,740.90	94,117.00	- 90,623.90	-302.07
Total	26,839.50	1,108,009.23	901,207.36	-203,708.38	- 97.70
Cost per manzana		531.41	432.23		

[f] Irrigation Costs - These costs include the fee paid the city for the use of the water and on the larger farms the extra labor required to irrigate. On a few farms that built and maintained their own irrigation systems the irrigation cost also includes depreciation repairs and interest on their investment in #10.

[g] Total Cost - Found by adding columns A thru E.

[h] Returns - Returns include the value of milk sold plus the sale of cull cows and an estimated value of the herd increases.

[i] Net Return - Found by subtracintg G (total cost) from H (gross return).

[j] Net/manzana - Found by dividing net return by the total number of manzanas in the farm.

Appendix Table II - 3 Costs and returns on dairy farms with adequate water in the Sonsonate-Bandera Area.

(Currrnt Colones)

Question-naire	Number manzana	Repairs[a]	Depreciation[b]	Variable[c]	Labor[d]	Interest[e]
3	80	1,117	1,189	37,759.50	9,106.08	11,791.68
4	50	1,593.00	1,988.00	6,726.66	3,788.25	9,539.72
6	65	2,193	4,386	26,491	11,026.50	11,848.50
9	112	4,577	9,154	39,990	28,652.75	27,350.94
11						
14	225	2,880	8,260	88,707.15	58,390.02	73,581.60
15	32	2,308.50	2,367	1,757.50	5,166.00	6,276.06
17	158	3,333.65	6,439.55	22,329.10	15,282.00	16,374.02
19	83	4,105	5,602.50	17,402.10	10,324.40	21,224
21	20	920.50	943.50	9,052	2,168.40	4,263.75
22	300	10,870	21,740	96,733.00	26,915.00	61,711.20
23	30	570.50	1,151.00	20,335	5,329.80	9,449.10
24	28	1,802.50	637	3,865	6,366	6,583.20
25	400	14,476.00	19,423.00	39,486.00	30,324.00	99,473.64
26	60	442.70	885.40	11,283.00	10,688	15,198
30	70	2,594	5,188	9,989	8,427	18,153.66
31	235	3,205.75	6,411	39,025.05	26,095.95	36,076.83
32	140	1,527	2,994	15,166.09	17,506.00	28,072.38
Total	2,088	58,516.10	98,758.95	486,097.15	275,556.15	456,908.28
Cost per manzana		27.54	47.29	232.80	131.97	218.82

[a] Repairs - Repairs were estimated at half the depreciation cost or 2 1/2% for buildings and installations and 5% for equipment.

[b] Depreciation - Depreciation was figured on a straight line basis. Machinery was depreciated over ten years and buildings twenty years. In some case, irrigation facilities were depreciated over an estimated fifty year life.

Appendix Table II - 3. (continued)

Question-naire	Irrigation cost[f]	Total cost[g]	Gross return[h]	Net return[i]	Net/manzana[j]
3	1,094	62,057.26	70,799	8,741.74	109.27
4	893,25	24,528.88	44,311.08	19,782.20	395.64
6	135	56,080.00	69,373	13,293.00	137.09
9	915	110,639.69	122,802.76	12,163.07	108.59
11					
14	225	232,043.77	243,755.25	11,711.48	52.05
15	928	18,803.06	12,036.00	- 6,767.06	-211.47
17	2,677.50	66,375.82	74,000	7,624.18	48.25
19	1,410	60,068.00	57,515.00	- 2,553.00	30.75
21	553.50	17,901.65	23,478.33	5,576.68	278.83
22	10,600	228,569.20	322,225.00	93,655.80	312.18
23	549	37,384.40	51,000.00	13,715.60	457.18
24	352.40	19,606.10	14,043.00	- 5,563.10	-198.68
25	8,391	211,573.64	256,910.00	45,336.36	113.34
26	1,099	39,096.10	41,700	2,103.90	35.06
30	3,354.75	47,706.41	62,830.00	15,123.59	216.05
31	4,570.75	115,385.33	145,051.40	29,666.07	126.23
32	869	66,134.47	68,065.00	1,930.53	13.78
Total	38,617.15	1,414,453.82	1,679,994.82	265,541.04	127.17
Cost per manzana		675.65	804.59		

[c]Variable costs - Actual costs were obtained from interviewees. If exact costs were not available an estimate was made based on approximate amount of a product used and cost per unit. Unit costs varied little from farm to farm. In some cases, transportation costs were varied significantly because of farm location.

[d]Labor - Labor costs varied widely from farm to farm because of variation in amounts used. Unit costs were very uniform at 2.25 per day for laborers and 150-200 colones permonth for managers. There were incentive payments in some cases and a few farmers gave year end bonuses.

Appendix Table II - 3. (continued)

[e]Interest - The opportunity cost to capital was figured at 6%. This covered all investment in undepreciated equipment and installations plus the value of the cow herd and the land.

[f]Irrigation costs - These costs include the fee paid the city for the use of the water and on the larger farms the extra labor required to irrigate. On a few farms that built and maintained their own irrigation systems the irrigation cost also includes depreciation repairs and interest on their investment in #10.

[g]Total cost - Found by adding columns A through E.

[h]Returns - Returns include the value of milk sold plus the sale of cull cows and an estimated value of the herd increases.

[i]Net return - Found by subtracting G (total cost) from H (gross return).

[j]Net/manzana - Found by dividing net return by the total number of manzanas in the farm.

APPENDIX III. NOTATION FOR COMPUTATION OF NET RETURN DIFFERENTIALS

We have specified that

$NR_1 - NR_2 = R_w$ where

NR = net return to management

1 = farms with adequate water

2 = farms with inadequate water, and

R_w = return to water (hypothesized to be > 0) under the homogenity assumption.

The homogeneity assumption dictates that R_w can only be calculated by subtracting NR_1 from NR_2 when all production factors are the same except the differential application of water. Otherwise, the difference R_w may be due to other factors besides water.

To illustrate, introduce a second subscript i (on farms with adequate water), and j (on farms with inadequate water) that refers to the survey number of farms in a group. Thus:

$NR_{1.i} - NR_{2.j} = R_{w_{i.j}}$, where:

$i = 1 \ldots m$, the survey number of a farm with adequate water

$j = 1 \ldots n$, the survey number of a farm with inadequate water, and

$m = 18$, $n = 9$.

Thus, net returns ($NR_{1.i}$ and $NR_{2.j}$) are calculated for 18 farms with adequate water and 9 farms with inadequate water. But $R_{w_{ij}}$ is only calculated where production practices are similar between farms with and without adequate water. For example, such a calculation would be: $NR_{1.7} - NR_{2.6} = R_{w_{7.6}}$. This indicates that farm #7 (adequate water) is comparable with farm #6 (inadequate water). Or such a calculation might be: $NR_{1.7} - NR_{2.8} = R_{w_{7.8}}$. Farm #7 (adequate water) is comparable to farm #8 (inadequate water). Comparisons between farms 7 and 6, and farms 7 and 8 are known as single group comparisons. Note that farm #7 (adequate water) is comparable to both farms #6 and #8 (inadequate water). This comparison is:

$$NR_{1.7} - NR_{2.8,6} = R_{w_{7.8,6}}, \text{ where}$$

$NR_{2.8,6}$ is the average net return on farms 8 and6 weighted by the farm size. This comparison is defined as a multi-group comparison.

This process of comparison yields a set of $R_{w_{ij}}$. At least three average returns to water $\left[\frac{\sum R_{w_{i.j}}}{n} = \bar{R}_w\right]$ can be calculated from this set. These include a) the average for all single group comparisons, $(\bar{R}_{w_s})$, b) the average for all multi group comparisons, $(\bar{R}_{w_m})$, and c) an overall average, $(\bar{R}_{w_t})$. The lowest average is used to calculate the internal rate of return.[1] This is done because if such a return is greater than with alternative investment, it would also be greater with the other averages. The lowest average is the lower boundary of an income stream flowing from an investment to add water.

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[1]As it turns out this is $\bar{R}_{w_s}$, the average for the single group comparisons. See pages 49-51.