

AN INVESTIGATION OF FACTORS AFFECTING THE INTENSITY OF WATER USE
IN THE LAJAS VALLEY IRRIGATION PROJECT

Project A-036 -PR

By

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ABSTRACT

This study was conducted in the Irrigation District of Lajas Valley located in the southwestern part of Puerto Rico. Data used were obtained from the irrigation system during the fiscal years 1971-72, and 1972-73. A sample of ninety (90) farms with irrigation facilities encompassing a total area of 7,035 acres were selected for investigation. The primary productive activity of these farms is centered on the cultivation of sugar cane.

The fundamental objective of the study relates to an analysis of a series of socio-economic factors which were assumed to affect the intensity of irrigation water use in Lajas Valley. These factors are:

- 1- Size of farms
- 2- Ownership of farms
- 3- Available labor
- 4- Cost of irrigation
- 5- Employment of farmers in non-agricultural activities
- 6- Administration of irrigation services
- 7- Topography of the farms
- 8- Soil permeability

Other variables which appear to affect the use of irrigation water were the farmer's age and his level of education. Analysis revealed that although there is no definite relationship between the ownership of farms and intensity of irrigation water use, there is a tendency among farms of 100 acres or more to utilize water more intensively.

Data collected revealed that the majority of farms in the Lajas Valley are operated under rental contracts. Nevertheless, in the study the factor of ownership demonstrated that no significant relationship existed with the intensity of irrigation water use.

A factor of considerable influence on the intensity of water use was the availability of labor for the operation of irrigation systems. The data indicated that with increased labor availability the intensity of water used for irrigation was greater.

Irrigation costs are also a determining factor in the intensity of water use for irrigation. Analysis of data showed that a direct relationship exists between these two variables.

The employment of the farmer in non-agricultural tasks hold no significant relationship to the intensity of water use according to the results of the study. Nevertheless, one-third of the farmers studied pursued non-agricultural occupations in addition to farming. Within this group was noted that a higher index of water consumption on their farms was a common tendency.

The administration of irrigation services as a factor showed no relationship to the intensity of water use for irrigation. A large majority of the farmers found the services of the Water Resources Authority good or excellent.

Regarding the topography of farms, a significant relationship existed between this factor and the intensity of irrigation water use. The farms with a rolling topography showed a greater index of water consumption than those on the flat lands and the owners with both, flat and rolling topography.

Although the soil permeability of most farms is low, there was a significant relationship between this factor and the intensity of water use for irrigation in the farms of the valley.

The factors of age and education of the farmer had no significant relationship with the intensity of water use, despite, the fact that the majority of farmers of Lajas Valley were advanced in age and possessed a high level of education.

Data obtained in this study can serve as a basis for implementing a series of government measures and programs that may tend to stimulate the utilization of adequate quantities of irrigation water and as a result succeed in producing substantial increases in agricultural output.

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CHAPTER I

INTRODUCTION

The Irrigation Project of Lajas Valley is the most recent irrigation scheme among the three public irrigation projects which operate in Puerto Rico. In the second phase of the comprehensive Southwest Project being constructed by the Puerto Rico Water Resources Authority its primary objectives are to increase the electrical capacity of the island through the development of water resources for the production of energy, the provision of irrigation and drainage for a surface area of 20,000 acres of land in the Lajas Valley, the supply of water for domestic and industrial uses, and the flood control of the Añasco, Superior, Yauco, and Loco rivers.

The first phase of the southwest project was centered on the development of engineering works for the retention of water and the production of electricity. These engineering works include the Guayo, Yahuecas, Prieto and Toro dams in the northern slope of the Cordillera Central, the Lucchetti dam in the Yauco River in the southern slope and 13 miles of connecting tunnels. The hydroelectric aspect consists of "Centrals" No. 1 and No. 2 of Yauco which has a combined generation capacity of 35,000 kilowatts.

As was mentioned before, the second phase of the southwest project is composed of the irrigation and drainage system of Lajas Valley. This phase includes the dam of the Loco River which acts as a regulator reservoir, a main irrigation canal 23 miles long together with 43 miles of secondary lateral canals. The system also has 339 turn-out structures to allow the irrigation water into the farms. The drainage system is composed of 68 miles of principal and secondary canals that provides drainage to the farms. It also collects excess water of rainfall and surplus irrigation waters and conveys them to the sea through the Bays of Guánica and Boquerón. Table No. 1 shows the capacity of the reservoirs that

supply water for irrigation in Lajas Valley.

Table No. 1

Capacity of the Reservoirs of the Irrigation System of
Lajas Valley, May, 1973

Reservoir	Capacity in Acre-Feet
Prieto and Toro	97
Loco	639
Yahuecas	778
Lucchetti	11,875
Guayo	13,546
Total	26,935

The irrigation operations of Lajas Valley began in August of 1955, when for the first time deliveries of water were made to the farmers. Through legal provisions the Irrigation District of Lajas Valley should have been established permanently by July 1, 1971. However, for reasons mostly of an economic nature that face the system and the inability of the farms to generate sufficient incomes to recuperate the costs of services, the establishment of the permanent district was postponed until 1975.

Purchase and Distribution of Irrigation Water

The Irrigation District of Lajas Valley is controlled by the Water Resources Authority of Puerto Rico which stores, directs, delivers, measures, and bills water for irrigation to the properties authorized to receive it.

Water is generally delivered by gravity (the gravity system) in the higher elevations of the farms. In cases where the water cannot be supplied by gravity, the farmer resorts to pumping by the installation of his own pumps (pumping system). A 50 percent discount to compensate for the additional costs associated with pumping is generally conceded to the farmers.

The Department of Agriculture has assigned a water allotment of 3.0 acre-feet per acre per year, for every farm. An additional acre-feet of water is provided to those farms that exhaust their monthly allotment. Every farmer who consumed 0.25 acre-feet per acre during one month will receive 0.08 acre-feet of additional water for each acre, free of charge, provided that water is available. A farmer can receive, if he uses all of his allotment, a total of 6.0 acre-feet of water per acre per year providing that water is available and the ground water levels of the Valley are not affected. The price of the last two (2) acre feet is the same as the first three.

The direction and distribution of water within the farm is the responsibility of each farmer. The canals that the farmer constructs in a rudimentary form to distribute water within his farm affect the efficiency of irrigation. These canals are susceptible to overflows and filtrations which result in considerable losses of water occasionally. Construction of irrigation canals of adequate size and slope is required so that water can be moved uniformly to all lands of the farm without being lost or diverted from the planned course.

The Agricultural Pattern

In 1973 the number of plots receiving irrigation water was 249 covering a total area of 18,858 acres. Of this area, 14,403 acres were irrigated by the gravity system and 4,455 through the pumping system. In addition to the 2,000 acres of land reclaimed in the Guánica and Anegado area, some 700 acres have been developed to date.

The development work was made possible through the construction of a network of drainage canals, interception of ravines, and control of the irrigation which have contributed to the maintenance of land fertility of the Valley in the first 24 to 36 inches of soil.

Before 1955, cattle raising for milk as well as for meat was the chief industry of the Lajas Valley. Cane and edible fruits were cultivated in those areas where some water supplies could be obtained. With the advent of irrigation, the agricultural panorama changed completely. Table No. 2 shows the use of the lands by crops in the Lajas Valley.

Table No. 2

Distribution of the Area under Irrigation by Crop in
Lajas Valley, May, 1973

Crop	Area (acres)	Percent of Total
Sugar cane	15,986.0	84.8
Pastures	2,778.0	14.7
Vegetables	58.0	.3
Others	36.0	.2
Total	18,858.0	100.0

As is shown in the above table sugar cane replaced cattle raising as the most important industry in the Lajas Valley. This crop occupies approximately 85 percent of the total area under irrigation.

Problems Confronted by the Project

In the past, development the Lajas Valley Irrigation Project was affected by different kinds of problems. Of major importance were the salinity and drainage problems and those relating to the high freatic levels and artesian pressures. A program of action was adopted to find an immediate solution to these problems.

Through research and studies at the Agricultural Experimental Station, the Water Resources Authority, and the Department of Agriculture of Puerto Rico and through the recommendations of local and foreign scientists and engineers, together with the experiences obtained, the corrective measures were realized.

In spite of the effort described above, the system faces at present functional and economic problems. These can be described as the high costs of maintenance and operation and the low water consumption by farmers. In recent years the system has been operating with deficits which are liquidated by government subsidies. Table No. 3 shows the outlays and incomes and the government contributions to the system in the last 14 years.

Table No. 3

Operational Expenditures, Income, and Government Contributions to the
Irrigation System of the Lajas Valley, 1959-60 and 1972-73*.

Years	Income from water sales	Operational and Mainte- nance outlays	Government Contributions
1959-60	\$ 64,719	\$ 136,685	\$ 92,398
1960-61	75,793	141,196	49,600
1961-62	74,708	184,782	85,700
1962-63	98,605	204,347	48,532
1963-64	109,224	251,278	112,024
1964-65	123,413	307,140	183,800
1965-66	128,629	262,955	134,600
1966-67	168,200	286,272	159,300
1967-68	148,754	371,162	211,375
1968-69	114,006	437,504	260,747
1969-70	78,312	523,514	409,868
1970-71	99,799	568,914	459,400
1971-72	105,880	558,070	506,400
1972-73	157,540	634,040	538,000
Totals	\$1,547,582	\$ 4,867,859	\$3,251,744

As show in the above table the government contributions to keep the system operating have been increasing considerably in the last years.

*Information provided by the Puerto Rico Water Resources Authority (PRWRA).

Importance and Objectives of the Study

The limited amount of rain, high temperatures, and winds that accelerate the evapotranspiration of plants are factors that make the use of irrigation imperative for the commercial development of farm crops in Lajas Valley. Nevertheless, the amount of irrigation water utilized by the landowners of the Valley at present averages 1.5 acre-foot per acre per year. This is considered very low if we note that the principal crop of the Valley is sugar cane. The water requirements of this crop are extremely high.

Table No. 4 presents in comparative form the average water use per year for a period of 10 years among the private landowners and the Land Authority of Puerto Rico. As noted, the Land Authority uses greater amounts of irrigation water than the private landowners. It should also be observed that water use has decreased considerably during recent years.

Table No. 4

Comparative Average Use of Irrigation Water Among Landowners
and the Land Authority in the Lajas Valley
1962-63 to 1971-72*

Users of the System	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72
Landowners	1.30**	1.40	1.25	1.24	1.65	1.46	1.02	0.64	0.78	0.74
Land Authority	4.20	4.43	2.58	5.22	5.20	4.66	3.18	2.28	2.33	3.90
Land Authority and Landowners	1.57	1.71	1.39	1.64	2.02	1.85	1.27	0.83	0.98	1.14

* Data provided by the Water Resources Authority of Puerto Rico.
Average use in acre-feet of water per acre per year.

The low use of water on the part of the farmers needs to be studied for the following reasons:

- 1- In Southwest Puerto Rico a continuous demand for water use for other purposes exists, apart from agriculture. The demand for domestic use as well as for industrial use has greatly increased.
- 2- Water resources for this zone are limited and the established irrigation system involves high costs of operation.
- 3- Maximum output in sugar cane is not being achieved in the region of Lajas Valley due chiefly to the fact that the amounts of irrigation water being used do not meet the normal requirements of this crop.
- 4- Not all the water that enters the main irrigation canal is used completely by the farmers; a great part is lost into the sea.
- 5- A maximum utilization of irrigation water is required so that maximum yields of the crops can be obtained. This would make the farms produce enough incomes so that taxes can be paid for the use of irrigation that will eventually be imposed on the users of the system. The farm lands of the Valley that will constitute the permanent district will be subject to the payment of a tax to cover the expenses of the operation of the system and of another tax classified as a construction tax, for the amortization of the capital.

Originally the law that created the Irrigation and Drainage District of Lajas Valley provided that all capital invested in the system be collected, together with interest. The law, however, underwent an amendment eliminating the collection of interest and limiting the capital to be collected to the amount originally assigned, i.e \$6,400,000 and not the total amount invested which was \$10,000,000.

This study has as its main objective the provision of relevant information on the manner in which a series of factors are influencing the intensity with which irrigation water is utilized by the farmers. These factors are as follows:

- 1- Size of the farm
- 2- Ownership of the farm
- 3- Available labor
- 4- Irrigation costs
- 5- Non-agricultural economic activities that the farmer pursues on a part-time basis.
- 6- The administration of the system
- 7- The topography of the farms
- 8- The amount of water available
- 9- The permeability of the soil

In this study, an attempt is made to find the existing relationship among the above mentioned factors which leads to a low water consumption by the agricultural users of the system.

Another aim pursued is that of obtaining pertinent data regarding the irrigation and drainage practices carried out by farmers of the Valley in order to ascertain to what point it causes the inefficient use of irrigation water.

The data obtained can be used by the Department of Agriculture of Puerto Rico as well as by other agencies that are also struggling with the farm problem in the Lajas Valley. These data will also be of meaningful value in establishing the necessary measures to stimulate the intensity of use of irrigation water which would result in larger outputs and greater incomes for the farmer.

REVIEW OF THE LITERATURE

The problems encountered in the development of the Irrigation District of Lajas Valley relate to different areas which have been the object of study and analysis by local and foreign scientists and engineers. The studies reviewed below relate in one way or another to the main problem analyzed in the present study, i. e., the low intensity of water use for irrigation by farmers.

Miguel A. Quiñones in a study sponsored by the Water Resources Authority of Puerto Rico determined the amount of available water for irrigation based on an allocation of 3.0 acre-feet of water per acre per year. In this study, it was established that by controlling the operation of reservoirs in a systematic way, stored water would be enough to meet the needs of 20,000 acres. An analysis was made of the quantities of water stored in the reservoirs taking the period 1961-65 as a base. Table No. 5 presents the quantities of water available for irrigation in these years and the percent of allocation based on 3.0 acre-feet per acre per year for 20,000 acres. That is, in accordance with the data of this study, it was determined that the capacity of the system would be enough to serve 3.0 acre-feet of water annually when the 20,000 acres projected to be developed by the system had authorization to receive irrigation water.

Although at certain times the system has to limit the deliveries of water, it is noted on the other hand, that the system has in the majority of the years the quantities of water necessary to cover the farm needs.

Studies conducted in the cultivation of sugar cane in the zone of Lajas Valley, as well as other related studies, confirm the fact that the use of irrigation is indispensable to secure maximum yields of this crop.

Table No. 5

Comparative Summary of the Possible Annual Deliveries and Actual Sales
of Irrigation Water, Lajas Valley, 1956 to 1961

Years	Available Allotment (percent)*	Available Water (acre-feet)	Sales (acre-feet)
1956	108	65,101	7,945
1957	92	55,334	10,334
1958	126	75,667	14,894
1959	94	56,167	16,999
1960	95	56,751	12,884
1961	115	69,068	18,121
Annual Average	105	63,015	13,530

Roberto Vázquez in a study conducted during the years or 1965-1968 at the Agricultural Experiment Substation in Lajas, found that sugar cane is a crop that consumes great quantities of water during its growing period. In this study the consumption of water was investigated with a plant cane and two ratoons. The tests made included plots that were frequently irrigated and plots that were less frequently irrigated during the entire period of plant growth (3). Treatments also included plots that were irrigated frequently up to three months prior to harvest and plots that were irrigated frequently up to five months before harvest. His data show that the highest consumption of water in both, the plant cane and the ratoons occurred in the period of August to October. During the first months of the growth period, cane uses smaller quantities of water.

* 100 percent - 60,000 acre feet annually (20,000 acres x 3.00 acre feet).

The total consumptive use of water by a 13-month plant cane was 64.72, 57.18, 59.69, and 54.78 inches under the frequently irrigated and less frequently irrigated plots during the entire growth period and those that were irrigated frequently until 3 and 5 months prior to harvest without irrigation thereafter, respectively. The total water consumption by the first ratoon, 12 months old was 56.14, 47.90, 53.09, and 44.77 inches for each respective treatment. The respective total water consumption for a second 12-month ratoon was 55.97, 44.91, 50.36 and 43.70 inches.

The frequent application of irrigation during the growth period of the cane produces a positive effect on yields. In this study the largest yields of sugar cane were obtained under conditions of high soil moisture throughout the entire period of plant growth. On those plots that were frequently irrigated, yields up to 96.96 tons of cane per acre were obtained. In those lands where irrigation was suspended 5 months before the harvest, the yield fell to 64.3 tons of cane per acre.

The average yield per acre of a plant cane and two ratoons was 73.67 tons of cane and a yield of 7.80 tons of sugar per acre. This was obtained in the treatment that included frequent irrigation during the entire growing period of the plants.

On plots where irrigation was less frequent, the average yield of a plant cane and two ratoons was 59.37 tons of cane and 6.4 tons of sugar.

The results of this study demonstrate the need which exists in the Lajas Valley of increasing the use of irrigation water in order to increase the yields of the sugar cane fields.

Between 1966 to 1968 the Agricultural Experiment Station of Puerto Rico carried out an economic study of the sugar cane farms in the Irrigation District of Lajas Valley (4). The chief aim of this study was to obtain data on expenditures and incomes of cane farms with the hope of determining the economic factors which contributed mostly to the rate of payment of the farms under irrigation which could be charged when the Irrigation District

begins to operate permanently.

In the above mentioned study it was found is that:

- 1- The farms under irrigation used an average of 1.24 acre-feet of water in 1966 and 1.76 acre-feet during 1967.

In Table 6 the distribution of the farms studied on the basis of the use of irrigation water is presented. The data of the table show that in the 1967 harvest, the yield of cane per acre varied from 15.30 tons in the group that did not use irrigation water to 28.36 tons in those which used 1.51 acre-feet or more. In the 1968 harvest, the variation ranges from 18.20 tons in the group that did not use water to 27.68 tons in those which consumed 0.75 acre-feet or less.

The data also revealed a highly significant difference on comparing the yield of cane per acre in the group of farms that were not irrigated with those that were irrigated in both years.

- 2- Economic analysis on non-irrigated farms showed incurred costs amounting to \$219.49 against an income of \$188.56, resulting in a loss of \$30.93 per acre. On irrigated farms, however, income totalled \$373.02 and costs \$332.97 with a resulting profit of \$40.05 per acre. Based on per unit output of cane, income generated on non-irrigated farms was \$12.40 while costs incurred were \$14.42. This resulted in a net loss of \$2.02 per ton of cane produced. On irrigated farms a net income of \$1.35 per ton was obtained since costs incurred were \$11.29 and income generated \$12.64.
- 3- The quantity of irrigation water used had a significant effect on the costs and incomes of the farms studied. Data for the 1967 harvest revealed that the income of one group of farms which used 0.75 acre-foot or less of

Table No. 6

Distribution of the Farms by the Amount of Irrigation Water Used per Acre
Area Sown, and Cane Produced, Lajas Valley, Puerto Rico, 1966-67 and 1967-68.

Years of Harvest	Water Used per Acre (acre-feet)	Number of Farms	Acres of Cane Harvest	Water Used (acre-feet)	Water Used per Acre (acre-feet)	Cane Produced (Tons)	Cane Produced per Acre (Tons)
1966-67	None	11		---	---	9,568.26	15.20
	Less than						
	0.75	11	654.80	232.46	0.36	16,715.83	25.52
	0.76-1.50	16	1,877.95	2,132.85	1.14	52,329.16	27.86
	More than						
	1.51	9	689.25	1,693.23	2.45	19,547.15	28.36
1967-68	None	10	310.50	---	---	5,651.19	18.20
	Less than						
	0.75	10	531.95	162.28	.30	14,725.53	27.68
	0.76-1.50	6	399.84	394.57	.99	10,680.22	26.71
	More than						
	1.51	12	2,138.32	5,565.65	2.60	58,106.64	27.17

water were \$330.98 and the costs incurred \$288.18 with a net profit of \$42.80 per acre. On the other hand, farms that used 1.51 acre-feet or more had incomes of \$374.68 and incurred costs of \$312.42 with a net profit of \$62.26 per acre.

In the 1968 harvest, the first group of farms that used 0.75 acre-foot or less of water obtained \$359.72 in income and incurred costs of \$310.42 with a net profit of \$49.30 per acre, while those that used 1.51 acre-feet or more had incomes of \$353.58 and incurred costs of \$304.52, with a net profit of \$49.06 per acre. The data of the study revealed highly significant differences when net profit per acre is compared between irrigated and non-irrigated farms. These differences are obviously due to the use of irrigation during the years of study.

Hugo Irizarry, in an economic study of the factors that determine water use in Lajas Valley in 1968, found that the average yield of cane in plots that were irrigated was 29 tons per acre (5). He also found that farms that did not use irrigation the average yield was 23 tons per acre.

The study, apart from being made during a dry year, showed low intensity of use of irrigation water by the farmers of the Lajas Valley. Table No. 7 presents the annual water use and distribution of 51 farms studied during 1967-68. Based on this table 21 farms used an average of 0.64 acre-foot of water per acre per year and 17 farms used 1.44 acre-feet per acre per year. Most of these farms, therefore, can be considered as having a low use of water since the average level of use was less than 2.0 acre-foot per acre per year.

This study further revealed that as the use of irrigation water per acre increases, the price per unit of water as well as labor, decrease.

Table No. 7

Annual Use and Distribution of Irrigation Water on 51 Farms of Lajas Valley,
Puerto Rico, 1969-70. (5)

Distribution of Annual Use (Acre-feet/acre	Annual Use Acre-feet/acre	Distribution of Water			
		Number of Farms	Acres Irrigated	Percent	Total Acre-Feet
0.00 - 1.00	0.64	21	756.96	19	487
1.01 - 2.00	1.44	17	1908.97	47	2754
2.01 - 3.00	2.38	11	1003.04	25	2387
3.01 - 4.00	3.36	2	361.38	9	1215

The Water Resources Research Institute of the University of Puerto Rico made a study during the year 1969-70 of the costs and effects of irrigation in the planning and implementation of the Agricultural Development Program of the Lajas Valley (6). It was found that cane grown on farms under irrigation, the output was 27.14 tons per acre. This output was very low when compared with farms under irrigation in the District of the South Coast, where average output is about 40 tons per acre. Similar yields are obtained by irrigated farms administered by the Puerto Rico Land Authority in the Lajas Valley.

Based on this information it can be concluded that the greater tonnage obtained in these farms is mainly due to the greater amount of irrigation water used.

The study also showed that in those farms where irrigation was not used, lower yields, averaging 22.8 tons of cane per acre were obtained. These data are similar to those obtained by Hugo Irizarry in his study described previously. It is significant to point out that according to the data of this study, the farmers that used irrigation on their farms received \$55.25 more per acre of cane cultivated than those who did no irrigation on their farms. The data presented in table No. 8 show that the income per acre of all the items is greater in farms that used irrigation. Consequently a higher total income per acre was obtained.

It is relevant to point out that the farmer's income in this enterprise depends to a great extent on the volume of cane produced and harvested. Lands under irrigation in the zone are in fact more productive and because of this, incomes are larger. Included in such study were some socio-economic factors related to the farmer. Among these were age, education, type of ownership, and size of farms.

In the group of farmers studied, it was found that 63 percent of them were 50 years of age or older. Sixty-seven percent of the farmers had nine years or more of schooling.

Table No. 8

Gross Income per Acre and per Ton of Sugar Cane With and Without Irrigation
in Lajas Valley, 77 Farms, Lajas Valley, Puerto Rico, 1969-70.

Source of Income	Cane Without Irrigation			Cane With Irrigation		
	Total Income	Income per Acre	Income per Ton	Total Income	Income per Acre	Income per Ton
Sugar Sales	\$224,877.29	\$172.32	\$ 7.55	\$ 890,550.33	\$204.86	\$ 7.55
Molasses	14,889.00	11.40	.50	58,937.54	13.56	.50
Insular Govern- ment Incentives	21,463.38	16.44	.72	111,581.04	25.66	.95
Federal Compensa- tion	38,169.53	29.24	1.28	149,207.21	34.32	1.26
Freight	32,457.94	24.87	1.09	124,596.99	28.66	1.06
Other Income	10,315.48	7.93	.35	45,397.09	10.44	.38
Total	\$342,172.62	\$262.25	\$11.49	\$1,380,270.20	\$317.50	\$11.70

Most of the farms were not operated by their own proprietors accounting for 71 percent being rented or administered. About half of those farms were 100 acres or less in size.

Jorge López Zapata, in a study of the factors that affect the technological level of the farmers of Lajas Valley obtained similar results regarding the factors mentioned above (7). López Zapata found the age of the farmers whose farms had irrigation facilities ranged from 28 to 86 years. Fifty-six percent of the age group were between 46-65 years. The average education among these farmers was 9.7 school-years.

CHAPTER III

METHODOLOGY

A total of 268 farms in the Lajas Valley with established facilities for irrigation constituted the universe of the study. A list of farms was obtained from the official register of farms with irrigation facilities in the Office of Development of Lajas Valley.

The farms pertaining to the Agricultural Experimental Station and the Land Authority were excluded from the study.

Farms operated under rental by the Land Authority and the Land Administration were included in the study as individual farms. These represent 23.13 percent of the total of farms and 53.07 percent of the total area. Farms studied were operated by 140 farmers.

The sample of the study constituted 33 percent of the selected sugar cane farms. In order to facilitate a representative sample, farms were classified in 12 groups according to size.

To choose a random sample a number from one to three was sorted. The number selected was one, which corresponded to the first farm selected for inclusion in the study. From thereon, one in every three farms were selected. On this basis the resulting sample was composed of 90 farms with irrigation facilities covering an area of 7,035 acres.

As an instrument for implementing the study a questionnaire was used that included the necessary and relevant questions to the study in relation to the objectives formulated. Initially a basic questionnaire was prepared for consultation with technicians and experts acquainted with the subject, in methodology as well as in technical matters. Consultations were arranged with professors of the Mayaguez Campus of the University of Puerto Rico, the technical staff of the Agricultural Experimental Station, the Commonwealth Department of

Agriculture, the Agricultural Extension Service, the Water Resources Authority, and the Federal Soil Conservation Service.

The suggestions received were incorporated into the questionnaire. Field tests were conducted among five selected farms of the population to be studied in order to make any necessary adjustments to the questionnaire. Based on these tests, modifications of a few questions were made to facilitate easier interpretation on the part of the farmers. An additional page was also prepared to permit tabulation of the information at the Computer Center of the University of Puerto Rico in the Mayaguez Campus.

The questionnaire was administered through personal interviews. The questionnaire sought information on specific questions relating to farm, agricultural conditions, and those factors affecting the intensity of the water used for irrigation.

During the study, visits were made to the irrigation structures and facilities established by farmers on their farms and those of the Water Resources Authority. Supplemental information about the farms and water consumption were provided by some of the government agencies outlined previously.

A series of tables were prepared to compile data and other information obtained from the questionnaires. The same was processed and analyzed at the Computer Center in order to facilitate the final interpretation.

Statistical measures employed in the analysis of data include measures of central tendency such as the arithmetic mean, median, mode and percentages. Chi-square was used to measure the degree of association among the different factors and the intensity of water used by irrigation.

Definition of Terms:

- 1- Permeability is a specific property of a soil of which is a measure of the readiness with which the soil transmits water; usually expressed in inches per hour or in centimeters per hour.
- 2- Acre-foot of water is a measure equivalent to one foot or 12 inches of water over a surface of one acre of land; it is equivalent to 325,851 gallons of water.
- 3- An acre is a piece of land covering an area of 43,560 square feet, or 4,047 square meters, or 1.03 "cuerdas".
- 4- Evaluation of services rendered or structures of the irrigation systems:
 - a) Excellent = when the system or service is perfect and needs no improvements.
 - b) Good = when the system or the service is almost excellent but needs minor improvements.
 - c) Regular = when the system or service meets the minimum requirements but needs many improvements.
 - d) Deficient = when the system or the service is below the minimum requirements and needs great improvements.
- 5- The irrigation canal of the Puerto Rico Water Resources Authority (PRWRA) of their own property made of concrete to transport water to the individual farms.
- 6- Irrigation outlet is the structure used by the PRWRA to deliver and meter the water to the different farms.
- 7- Irrigation ponds of the farm used to receive and distribute the water

categories:

- a) Owners = when a farmer runs his own farms.
- b) Tenant = a farmer who operates a farm through a contract that meets certain conditions of use and payment to the owner of the farm.
- c) Administrator = when the operator receives payment from the owner of the farm so that he may operate or exploit it.

9- Formulas:

- a) Arithmetic mean = the sum total of all the items divided by the number of farmers or,
$$\bar{X} = \frac{\sum_{i=1}^n X_i}{N}$$
- b) Median = is the middle position of all the items placed in order of magnitude.
- c) Mode = is the class that occurs most frequently within the values.
- d) Percent =
$$\frac{\text{Number of farmers in a class}}{\text{Total number of farmers}} \times 100$$
- e) Chi square = χ^2 F_o = observed frequency

F_c = calculated frequency

$$F_c = \frac{(\text{total columns}) (\text{total rows})}{\text{Number of cases}}$$

$$\chi^2 = \frac{(F_o - F_c)^2}{F_c}$$

10- Payment conveyance = a system through which the farmer binds himself to effectuate a payment for a service received for using the incentives and other government subsidies to be subsequently received.

CHAPTER IV

RESULTS

This chapter describes the results of the present study which seeks to determine the relationship of factors affecting the use of irrigation water by farmers in the Lajas Valley. First, the population is described based on the selected socio-economic factors studied. Secondly, the relationship between these factors and the use of irrigation water is analyzed. Finally, the observations of technicians with respect to the farmers efficiency in the application of irrigation and drainage practices are described.

Description of the Population

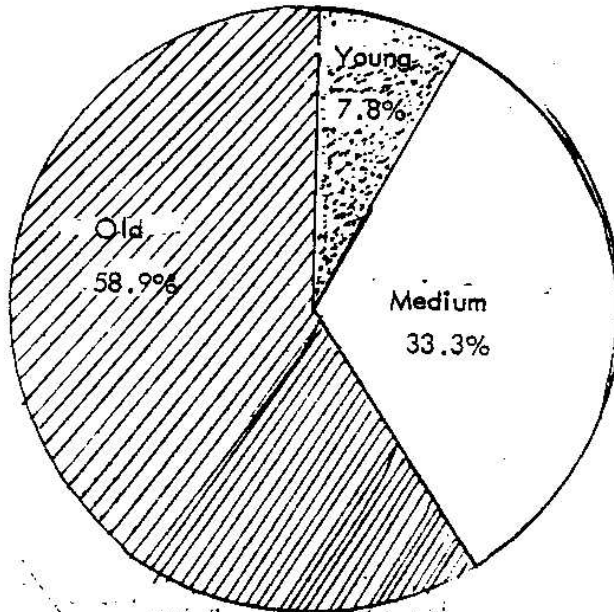
Age

The age of the farmers ranges from 30 to 84 years. Within this age span, 58.9 percent is 51 years or more of age, while only 7.8 percent is between the ages of 18 to 36. Most farmers are relatively advanced in age since the average is 57.7 years. The distribution of the farmers according to their ages is shown on figure No. 1.

The results of this study regarding age are similar to those reported by Busquests (8), Oliver Padilla (10), González Casillas (40), Collazo Collazo and Calero (15), López Zapata (7), Avilés Cordero (6), and the Commonwealth Department of Agriculture (13).

Figure No. 1

Distribution of Farmers of 90 Farms Studied in Lajas Valley According to Age
1971-72



The farmers' age is a point of great relevance for the agricultural development of the country. Traditionally, agriculture is of great economic importance in the Lajas Valley and in Puerto Rico. Knowledge regarding the relative high age of farmers is a cause for concern. Agriculture in the hands of people advanced in age may be an important reason why younger members has demonstrated little interest in it.

Education:

Figure 2 shows the education of the population studied. The level of education varied from fourth grade to professionals having 17 years of formal education. The average education was 11.7 years. Ten percent of the farmers had 6 or less years of schooling and 37.8 percent had completed one or more years at the college level.