AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 49

1. SUBJECT CLASSIFICATION
A. PRIMARY: Food Production and Nutrition — AF00-0150-G520
B. SECONDARY: Plant Production--Cereals--Rice--Ecuador

2. TITLE AND SUBTITLE
Resource allocation and factor substituion in Guayas basin rice production

3. AUTHOR(S)
Glenn,G.S.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	64p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Utah State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Thesis M.S.--Utah State)

9. ABSTRACT

This study, conducted in the Guayas Basin of Ecuador, was designed to examine changes in resource productivity and factor shares as irrigation was introduced on small rice farms managed by traditional methods. The average output on irrigated farms was double that of dry farms, because irrigated farms produced two crops. Examination of the marginal products showed that farmers using irrigation could profitably use more land. The low labor input and high marginal product of labor on dry farms occurs because the farmers are undercapitalized and are obliged to accept off-farm employment at crucial periods of the rice-growing season. On both farm types, irrigated and dry, factor shares of land were high, suggesting that a redistribution of land would also redistribute income. Irrigation does increase output and provides income and employment during slack periods. Supplemental irrigation by pumps appears to be less desirable than more permanent types of irrigation systems.

10. CONTROL NUMBER
PN-AAD-086

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Allocations
Dry farming
Factor analysis
Guayas Basin?
Irrigated land
Production capacity
Rice
Cropping patterns
Ecuador

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-2459 211(d)

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

CSD-2451 211(d)
PN-AAZ-056

RESOURCE ALLOCATION AND FACTOR SUBSTITUTION IN CHAYAS BASIN RICE PRODUCTION

by

Gary Scott Glenn

RESOURCE ALLOCATION AND FACTOR SUBSTITUTION IN GUAYAS BASIN RICE PRODUCTION

by

Gary Scott Glenn

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Agricultural Economics

Approved:

Major Professor

Committee Member

Committee Member

Dean of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

1974

ACKNOWLEDGEMENTS

I wish to express sincere appreciation to Dr. Allen LeBaron, my thesis director, and to Dr. Reed Willis and Dr. Glen Stringham, members of my graduate committee, for their time and consideration throughout my graduate program. Special appreciation is due to the Department of Agricultural and Irrigation Engineering for financial aid made possible through a grant from the United States Agency for International Development (USAID-csd/2459). Collection of the original survey data was partially financed as part of the United States Agency for International Development--Utah State University cooperative program in on-farm water management research (USAID-csd/2167). Appreciation is also extended to the personnel of the National Rice Commission for their support of the field survey upon which this study is based. The opinions expressed do not necessarily represent the views of the Government of Ecuador, USAID or USU.

Gary Scott Glen

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ABSTRACT

Resource Allocation and Factor Substitution in

Guayas Basin Rice Production

by

Gary Scott Glenn, Master of Science

Utah State University, 1974

Thesis Director: Dr. Allen LeBaron

Department: Economics

The primary objective of this study was to examine changes in resource productivity and factor shares as irrigation was introduced on small rice farms using traditional management techniques.

Average output on irrigated farms was double that of dry farms. This was because irrigated farms produced two crops as opposed to one crop on farms without irrigation. Examination of marginal products showed that farmers with irrigation could profitably use more land. Dry farmers could profitably use more labor. The low labor input and high MP of labor on dry farms occurs because these farmers are undercapitalized and are obliged to accept off-farm employment at crucial periods of the rice growing season.

On both farm types, irrigated and dry, factor shares of land were high suggesting that a redistribution of land would also redistribute

income. This information provides criteria for formation of rice production policy in Ecuador.

(64 pages)

RESOURCE ALLOCATION AND FACTOR SUBSTITUTION IN GUAYAS BASIN RICE PRODUCTION

INTRODUCTION

As concern about poverty and the world population growth becomes more prevalent there is an interest in increasing efficiency of resource use and productivity. Evidence to support this interest is found in funds and services provided to assist less developed areas of the world. The grants and loans that are made due to concern about poverty and world population growth have usually been aimed at increasing productivity of existing resource by introducing new technologies. Thus existing production functions are replaced with new ones which lie to the right of an original production function in output space. The hope is for increased output from the same resources or the same output using fewer resources thereby releasing "saved" resources for other economic activity. Only a small portion of international development funds have been designed to increase the efficiency of resource use within the context of a given production function. [6, 585] In the Guayas Basin there are strong indications that output in traditional Agriculture could be increased by increasing traditional inputs such as labor. Thus, while introducing new technologies may shift the production function upward, it is also possible that substantial gains in Guayas Basin rice production can

be made by simply improving the efficiency of resource use within the context of the existing production function. [1, 67]

Problem

The Guayas Basin of Ecuador contains large areas of low lands that are especially suited for rice. During the winter various crops can be grown but substantial areas are left idle because of extensive flooding. As the dry season begins and flood waters recede, water collects in hundreds of natural depressions called pozas. Campesinos utilize these pozas to grow summer rice. Summer rice has become very important in the Guayas Basin and there is an interest in expanding production. Some large scale water management projects are planned on the basis of more modern technology but these do not help the small farmer. Apparently small poza farmers could use some water control too if it were available since the payoffs seem fairly high. Aitken has estimated that net returns on poza farms using supplemental irrigation are more than double what could be obtained on the same type farm without irrigation. [1, 57]

Even if the B/C estimates that were determined by Aitken indicate good returns to relatively small investments in water control, there is no guarantee that all the resources involved will be utilized efficiently relative to other opportunities. There is a chance that marginal value product (VMP) of land and labor will be increased by virtue of an investment in water capital.

There is also a chance that the reverse will be true. In addition, little is known about distribution of factor shares among inputs on rice farms. Which factors really capture a major share of the value of output? Is it labor on dry farms and capital on irrigated? Fitting a Cobb-Douglas production function can provide some insight into the above questions. It can also predict how supply or output would respond to increased quantities of inputs, and it will give some information about what stage of production a general small farm is in.

In addition to Aitken, earlier work on rice production in the Guayas Basin has been done by Tom White. Both White and Aitken described rice production in the Guayas Basin in detail. However, they differ considerably in their conclusions. White concluded that production could be substantially increased only by shifting to completely modern mechanized operations. He admits that rapid change to modern production techniques creates problems in labor adjustment because it fails to make use of the abundant labor resources available in the basin. White argued also that small scale farming was completely irrational because of excessive bird watching costs borne by small farmers.

Aitken has taken issue with White's conclusions, especially the statements about bird control making small scale rice production uneconomical. Aitken discovered that some rice varieties were more susceptible to bird damage because of the structure of the rice head. Small farmers tended to

use the susceptible varieties because they are more valuable and because they had the longer stalks needed to raise rice in pozas. Aitken found that the bird problem could be solved by changing varieties and, in any case, it was only a spotty occurrence and, on average, not as expensive as postulated by White.

Aitken conceded that rice production could best be expanded by helping larger farmers become totally mechanized. Nevertheless, he argued that the smaller producers were also efficient and that they made much better use of an abundant labor resource. He reasoned that it would be logical for the Ecuadorean government to encourage more production at the traditional level of management because it uses labor and requires much less capital, which is scarce. Thus, making inexpensive irrigation or water control available to small farmers would be a realistic policy.

The conflicting results cited provide much of the rationale for this study. It is obvious that large rice farms can be efficient and profitable. However, Aitken is alone in asserting that the small poza farmer is efficient. Aitken bases this assertion on sample budgets that were constructed from the 106 observations obtained in his survey. Most of the observations were taken from small poza farms so that with a farm production function analysis it will be possible to determine whether poza farmers really are allocating resources efficiently. Results from the analyses have been used to make assertions about factor shares and the Value of Marginal Product of the various inputs at traditional management levels.

Objectives

1. To determine if resources are properly allocated at present management levels;
2. To determine through factor share analysis what proportion of output value is received by each input;
3. To determine through comparisons whether irrigation increases output and if so who benefits.

The results will be too general to support specific recommendations to individual farmers. However, they will be useful for policy purposes. They will indicate who stands to benefit from irrigation: landowners, capital suppliers, or labor. If the aim of the Ecuadorean government is to help as many of its people as possible this is the type of information that is required to establish appropriate policies of land reform, capital subsidization, colonization or public investment in new technologies such as irrigation works or equipment.

Socio-Economic Conditions in the Guayas Basin

The Guayas Basin is a large land area stretching between the Andes Mountains and the Pacific Ocean in Ecuador. It is drained by the Guayas and other large rivers. The land is very flat and low; the ocean tides actually make the river run upstream for considerable distances. During the so called winter or rainy season, precipitation is intense and large areas are

flooded. However, this condition lasts only for four or five months leaving the remainder of the year dry with little or no precipitation. This makes irrigation necessary for the cultivation of many crops. According to the Commission for Development Studies in the Guayas Basin (CEDEGE) there are about 485,000 hectares of irrigable land in the central part of the Basin. Of this, about 200,000 hectares could be irrigated with an extensive system of dams, reservoirs and wells. Presently about 80,000 hectares of rice are under cultivation and rice constitutes over one-third of the value of total output in the area. [3, 45] There are good possibilities for expanding rice production. This is because at present many areas produce only one crop whereas with irrigation two crops per year would be possible.

Population

Prospects for increased output have important implications for people in the coastal area. Presently the coastal area, of which the Guayas basin is a major part, contains 32 percent of Ecuador's 4,476,007 people and population is growing at a rate of 3.42 percent per year. [7, 2] Many of the people live in urban areas. Guayaquil, the largest city in the Basin, had a population of 716,600 in 1968. Per capita income in urban areas was $200.00 U.S. but declined to $120.00 in rural areas. This differential could account for much of the rural to urban migration in the area. Apparently there is an active labor market in rural areas but peak demand occurs during certain periods of the rice season and then subsides.

The average small rice producer often leaves his own land to work on the large commercial farms, even when his earnings would be larger in the long run if he did his own work first. This is a factor in the lower yields encountered on small poza farms.

Living conditions are substandard. There is a general absence of culinary water and sanitary facilities. These two factors alone measureably lower the level of health in the rural community. During the rainy season many homes are completely surrounded by water and are kept dry only be building them on stilts. The main form of transportation is by canoe. For this reason most homes are built near the main waterways. Land that is inaccessible by water generally lies idle as the road network in the Basin is inadequate.

Literacy is around 40 to 60 percent in most rural areas. Even those people who are literate are poorly prepared, even by Ecuadorean standards. Ecuador requires all children to attend school for six years. However, lack of schools and teachers in rural areas deprives many people even this minimum. Low educational level in rural Ecuador is a factor in making the adaptation of new technologies difficult. [4, 8]

Problems of small farmers

The typical poza farm is one to two hectares in size and consists of a shallow depression where water is trapped after the rainy season. The

farmer cleans out the aquatic weeds and works up the mud to an extent with his feet. Then as the water recedes he begins transplanting rice around the outer edges gradually working towards the center as water level permits. Rice is weeded and harvested by hand. From this rigorous, backbreaking work a farmer can expect a yield of from 35 to 40 quintales per hectare worth 140 sucres per quintal.[1] In this study the only differences in farming techniques were found among a few farmers who irrigated either with small portable pumps or with water that could be diverted to the fields when the tides raised the water level in the river. These farms were able to raise two crops by using supplemental irrigation water.

There are larger farms in the Basin where yields are considerably higher. However, given the limited capital available relative to that required, a small farmer is restricted in what he can do unless he becomes a member of a co-op and can benefit from a special co-op loan program. [5, 5]

Credit. Banks have limited capital available for loans and limit loans to people who use larger quantities of money because such loans are easier to supervise. Some loans are made by the Banco Cooperativa but its funds are limited and it is unable to meet credit demands in the area. Farmers also have complained that the amount loaned per hectare is insufficient to operate efficiently. Most small farmers depend on the owners of rice mills for their credit needs. Mills loan money to farmers with the understanding that the harvested crops will be offered to the mill at a price slightly lower

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[1]One quintal is equal to 100 pounds of hulled rice or 195 pounds of unhulled rice.

than market value. This causes the small farmer to pay extremely high interest rates, as high as 20 percent for six months. In addition, people called fomentadores or "promoters" operate among small farmers. They provide pumps or irrigation water at crucial periods in return for a share of the crop, usually two to three sacks per hectare. This means that the small farmer is paying 8.5 percent of gross output for the use of a pump for a few days. The fact that a farmer will pay this price is an indication of how valuable supplemental water can be during dry periods.

Land tenure. Originally most of the land in the Guayas Basin was owned by people who had received it as grants from the Spanish kings. Over the years individual holdings have diminished in size somewhat due to the division of estates. However, the general pattern of quite large land owners has continued. Until recently there were large, idle areas in the asin that never came on the land market because their owners were under no pressure to sell. Some owners rented land to campesinos who did the actual work. This situation was inequitable and was resented by small farmers who saw no opportunity to accumulate capital or become independent of the landowners. Because of political pressures the, Ecuadorean government passed a land reform law called the "Ley Precarista" (#1001). This law forbids land rental and takes over rented land for benefit of the renters who are allowed to buy it at declared tax value, usually about 10 percent of what it is worth. [1, 15]

As expected, this law has greatly increased the number of small landowners in the Guayas Basin. It has also had some negative impact because prior to the effective date of the law renters were suddenly evicted and their lands were diverted from rice to less productive uses such as grazing. At present the land tenure situation could best be described as unstable.

Seed, fertilizers, pesticides. Poza farmers generally do not use the new high yielding IR-8 varieties because of their short straw. Instead they use traditional longer straw type varieties that can be planted in deeper water. In addition traditional varieties produce higher quality rice than is the case for the hybrid IR-8. Besides lower yields traditional rice is susceptible to bird damage and, because of the long straw, cannot be heavily fertilized as lodging would result. Very few farmers in this survey use fertilizers and if pesticides are applied it appears they are regarded as worthwhile only if crop failure seems imminent.

Machinery use. Few poza farmers use any kind of machinery in their operations even though tractors could be advantageous in preparation of seed beds. Attempts have been made to make machinery available on a rental basis but the government owned facility organized to meet this need has had serious maintenance problems with its tractors (and service). Custom work is done on a private basis but generally only larger farms or co-ops have enough land to justify paying the cost of transporting machinery by barge.

Description of Rice Cultural Practices

Although all Guayas Basin rice growers share common goals and problems their approach to meeting these goals and overcoming problems varies considerably. Aitken divided rice growers into eight management classes:

Type 1, totally mechanized, planting by plane

According to the National Rice Commission, there is only one farm in Ecuador that practices modern and mechanized production techniques. This farm operates 500 hectares of land that has been leveled to 0 to 5 centimeters by contours, then divided into plots of one to two hectares each. Irrigation water is provided by pumping water from the river into a system of irrigation canals. A system of drainage canals drains the fields and permits some of the water to be recycled.

To prepare a seedbed the land is flooded and plowed. Then, while the water is still standing, fangueadores, which are big basketlike wheels attached to the rear axle of a tractor replacing the rear tires, are used to pulverize and work trash into the soil, where it will decompose. The land is then drained and the pregerminated seed is dropped by plane on the plots. Once the seed has rooted, the land is flooded to a depth of 15 centimeters and irrigation is maintained and varied according to crop need. Airplanes are used for fertilization as well as application of pesticides and herbicides.

Before harvest the water is drained and the plant is allowed to ripen. Once the fields are dry the grain is harvested by combine and packed in sacks weighing 195 pounds (which is equivalent to 100 pounds of hulled rice on average). Estimated production for this type of farm is 110 quintales per hectare (11,000 pounds hulled rice).

Type 2, dry farming mechanized

Non-irrigated (winter) farming is carried on by farmers whose land is higher and better drained. These farmers grow upland rice during the rainy season. Machinery is used in planting and harvesting but the distribution of fertilizers, herbicides and insecticides is done by hand. Farmers generally all use about one quintal of seed per hectare. Yields for this type of farming range from 40 to 60 quintales per hectare. Bird watching cost is reduced because birds are distributed over a wider area (winter planting) and farmers use firecrackers.

Type 3, dry farming, non-mechanized

Upland rice is also cultivated under very rudimentary conditions where the only modern inputs are fertilizer and insecticides. First virgin land is cleared of brush and trees by hand. The wood is burned and the ashes spread. This is the "socola." Rice is planted after the first rain by making 1 inch holes with a stick and dropping in 15 to 20 grains of rice (claveteado). Harvesting is generally done by hand and is often contracted to

other workers for 10 sucres per sack of 195 pounds. Average production is calculated to be 30 quintales per hectare. On average 10 percent of the crop is paid as rent.

Type 4, irrigated mechanized

The difference between irrigated mechanized type 4 and irrigated mechanized type 5 is that uneven terrain prevents complete draining prior to planting. Direct seeding is ruled out because some areas are deeper and the seed would drown. Therefore, the rice is actually transplanted twice, first from the original seedbed to a larger area and finally to the field. Bird control is accomplished with firecrackers and shouting children. Most farmers who operate on this level own the land they farm. Average yield per hectare has been estimated at 80 quintales.

Type 5, irrigated, mechanized

Type 5, irrigated, mechanized differs from type 1 in that mechanization is less complete and no field operations are carried out by plane. Generally, such farms have land which is more level than type 4. Direct seeding is therefore possible. Most farmers at this management level own their own land. Average production is estimated to be about 80 quintales per hectare.

Type 6, poza farming with no additional water

Most poza farmers previously rented their land out, now they are proprietors, according to the Agrarian Reform Law.

Poza farming is practiced in shallow ponds and lakes formed by winter rains. Some of these shallow lakes are as large as 350 hectares and are divided by dikes into individual plots.

Most of the work, if hired, is done by "tareo" or contract (piece work). Fertilizers and insecticides are seldom used, unless there is a danger of losing the crop, and never as a preventive measure.

Most poza farmers do not obtain credit from the banks. Instead they rely on private "fomentadores" who charge 20 percent interest per crop. Average production per hectare for type 6 has been estimated to be 30 quintales, although most farmers recognized that two of every three crops were over 35 quintales. These farmers work only in summer.

Type 7, poza farming with additional water by pump

The physical situation is about the same as type 6 except that these farmers have supplemental irrigation and, therefore, obtain better crops. Average production is estimated to be 40 quintales per hectare.

In this case, some allowance should be made for management costs since many such farmers are entrepreneurs who, if they have money to buy a pump, place the pump on rental. Then they hire occasional overseers while they pursue their pump business.

Many of these farmers have obtained loans from the "Banco de Fomento" at 9 percent per year which is less than one fourth the rate of interest paid by type 6. These farmers may work both summer and winter.

Type 8, poza farming with additional water by tides

Again the physical situation is the same as for types 6 and 7. The difference is that these farmers take additional water from the river when the river is backed up by the tides enough to overflow into a canal and onto the rice field.

Production alternatives for this type are the same as for type 7. Average production is calculated to be 40 quintales per hectare due to the fact that additional water is available and better yields can be obtained.

Two crops per year

The farm types that could potentially produce two crops per year are farmers within:

Type 1. Totally mechanized, irrigated
Type 4. Irrigated mechanized, transplant
Type 5. Irrigated, mechanized, direct planting
Type 7. Poza farming, additional water by pump
Type 8. Poza farming, additional water by tides

Types 1, 4, and 5 have good water control because of extensive water control infrastructure and pumps on the farms. Dikes and drainage canals do more than provide for irrigation, they also protect the fields from flood damage. Types 7 and 8 have infrastructure that is generally less substantial but still sufficient to permit cultivation of two rice crops. Some rice varieties require 135 days to mature, others need only 85. Therefore, there is ample time to obtain two crops and still avoid both the peak flood period of the rainy season

and the end of the dry season. Farmers in management levels 7 and 8 are not always completely sure of obtaining two crops. However, enough farmers in these management levels indicated that they routinely obtained two crops that it seems this is a safe assumption.

Comparison of net benefits among management practices

Table 1. Summary of costs, profits, and man day labor use per hectare, per crop

Type	Cost/ha.	Return/ha.	Profit/ha.	Labor Use/ha.
Type 1	$.10,593.00	$.15,400.00	$.4,807.00	18 days
Type 2	6,184.72	7,000.00	816.00	25 days
Type 3	3,367.80	4,200.00	832.20	74 days
Type 4	8,661.00	11,200.00	2,539.00	69 days
Type 5	9,110.00	11,200.00	2,090.00	32 days
Type 6	3,437.90	4,200.00	762.10	128 days
Type 7	3,565.90	5,600.00	2,034.10	144 days
Type 8	3,653.90	5,600.00	1,946.10	151 days

Table 1 permits a comparison of various farm types. In all cases average farms with supplemental irrigation have higher net returns than those without. Some of the higher costs shown are explained by an allowance for more valuable land. Note the high labor use in types 6, 7, and 8. If labor becomes a limiting factor in the Basin, it appears that a shift to types 4 and 5 would be advisable.

Of the eight management classes defined by Aitken, only three are of interest in this study: 6, poza farming; 7, poza farming with additional water by pumps; and 8, poza farming with additional water by tides. Tables 2, 3, and 4 are representative budgets as developed by Aitken, for each of these general farm types. For comparison Table 5, the budget for management level 1, is included.

Table 2. Budget for farming type 6

Poza (shallow lake) Farming/ha.

	Labor Use Man Day/ha.	Cost per Hectare in Sucres ($)
Cleaning (10 man days)	10	$. 200.00
Seed (100 pounds) ($1.20/pound)		120.00
Labor for Nursery (1 man day)	1	35.70
Nursery Transplant (claveteo)	10	214.30
Transplanting	14	571.40
Weeding	15	107.10

Table 2. Continued

Poza (shallow lake) Farming/ha.

	Labor Use Man Day/ha.	Cost per Hectare in Sucres ($)
Bird Watching	28	571.40
Harvest & Other	40	600.00 (Based on $15 per bag, 40 bags)
Transport	10	120.00 (Based on $3 per bag, 40 bags)
Interest (20% on $.3,000/ha. 6 months)		600.00
Total	128	$.3,139.90
Interest on Capital (1%, 6 months)		148.00
		$.3,287.90
10% Annual Value of Land ($.3,000) (semester)		150.00
		$.3,437.90

Production Alternatives

	20 qq	30 qq	40 qq
Cost per qq	171.89	114.59	85.94
Price per qq	140	140	140
Profit or Loss	-31.89	25.41	54.06

Source [1, 54]

Table 3. Budget for farming type 7

Poza Farming Plus Additional Irrigation by Pump/ha.

	Labor Use Man Day/ha.	Cost Per Hectare in Sucres ($)
Cleaning	10	$. 200.00
Seed (122 pounds)		126.00
Labor for Nursery	2	35.00
First Transplant (claveteo)	10	214.30
Second Transplant	29	571.40
Weeding	15	107.10
Bird Watching	28	571.40
Pump		
3 hours rent, 6" pump		300.00
Installation & other		100.00
Harvest	40	600.00
Transport	10	120.00
Total	144	$.2,945.90
Interest 9% on 3,000/ha. (semester)		270.00
		$.3,215.90
Interest on Capital 1% (semester)		200.00
		$.3,415.90
10% Annual Value on Land (semester) (3,000)		150.00
		$.3,565.90

Production Alternatives

	30 qq	40 qq	50 qq
Cost per qq	116.86	89.14	71.51
Price per qq	140	140	140
Profit or Loss	23.14	50.86	68.39

Source [1, 55]

Table 4. Budget for farming type 8

Poza Farming Plus Additional Irrigation by Tides (Estero)/ha.

	Labor Use Man Day/ha.	Cost Per Hectare in Sucres ($)
Cleaning	10	$. 200.00
Seed		126.00
Labor for Nursery	2	37.70
First Transplant (claveteo)	10	214.30
Second Transplant	29	571.40
Weeding	15	107.10
Bird Watching	28	571.40
Ditch Cleaning	2	40.00
Water Watching	5	100.00
Harvest	40	600.00
Transport	10	120.00
Total	151	$.2,687.90
Interest 20% on $.3,000 (semester)		600.00
		$.3,287.90
Interest on Capital, 1% month (semester)		216.00
		$.3,503.90
10% Annual Value of Land (semester) (3,000 S/ha)		150.00
		$.3,653.90

Production Alternatives

	30 qq	40 qq	50 qq
Cost per qq	121.70	91.30	73.07
Price per qq	140	140	140
Profit or Loss	18.30	48.70	66.93

Source [1, 56]

Table 5. Budget for farming type 1

Totally Mechanized, Direct Planting by Plane/ha.

	Labor Use Man Day/ha.	Cost per Hectare in Sucres ($)
Land Preparation		$. 300.00
Plowing (once)		274.00
Sidewall Repair		167.00
Fangueo		384.00
Seed (150 pounds)		150.00
Fertilizer (N 900 lbs.)		900.00
(P 160 lbs.)		250.00
(K 120 lbs.)		120.00
Planting by Plane (0.80 lb.)		120.00
Fertilizing by Plane (0.60 lb.)		708.00
Irrigation (initial)		130.00
Irrigation (up to harvest)		527.00
Labor for Irrigation (7.5 man days at $40 per day)	7.5	300.00
Herbicides (9 ltrs.)		495.00
Plane Cost for Herbicides		20.00
Hand Weeding and Others (10.5 man days)	10.5	420.00
Insecticides (preventive & operational)		320.00
Plane for Insecticides		50.00
Harvest		1,000.00
Transport		240.00
Land Rent (5% of $.15,000/ha)		750.00
Administration		750.00
Total	18.0	$. 8,375.00
10% Unexpected		837.00
		$. 9,212.00
9% Interest Per Semester		1,381.00
		$.10,593.00

Table 5. Continued

	Production Alternatives		
	100 qq	110 qq	120 qq
Cost per qq	105.90	96.30	88.27
Price per qq	140	140	140
Profit or Loss	34.10	43.70	51.73

Source [1, 49]

In these budgets, Aitken assumed that yields on type 6 were lower, 30 quintals as opposed to 40 quintals on types 7 and 8. This assumption accounted for most of the difference in profit per hectare as his assumed costs per hectare were nearly equal for the three management types.

Differences in reported net returns, as revealed by study of the collected, individual budgets, were not as sharp as shown by Aitken. However, Aitken makes an allowance for average yields over a three-year period because if a survey is conducted in an above average moisture year the yields in farm type 6 would not be too different from types 7 and 8.

For the present study, a somewhat different approach has been followed. Further investigation of Guayas Basin subsequent to Aitken's survey revealed that a more important consideration was that higher net returns to type 7 and 8 management is due to the fact that double cropping is possible. [5, 5]

THE PRODUCTION FUNCTION

A production function expresses a relationship between the quantity of output, inputs required to produce that output and how factors of production interact. Technology embodied in a production process is a constraint on decision making. It defines limits within which production can be adjusted to meet producer's desires as market conditions change availability of inputs. Production functions embody no market variables and can be imposed on economic decisions whereas economic decisions cannot be imposed on how output relates to input [2, 10].

Production functions show maximum output possible for any given combination and level of resource use and a given state of technology. They can be estimated using engineering or business data and enable economists to analyze a wide range of problems including determination of relative income shares, factors affecting economic growth and nature of technological unemployment [2, 11].

Stages of Production

Consider the following function shown in Figure 1.

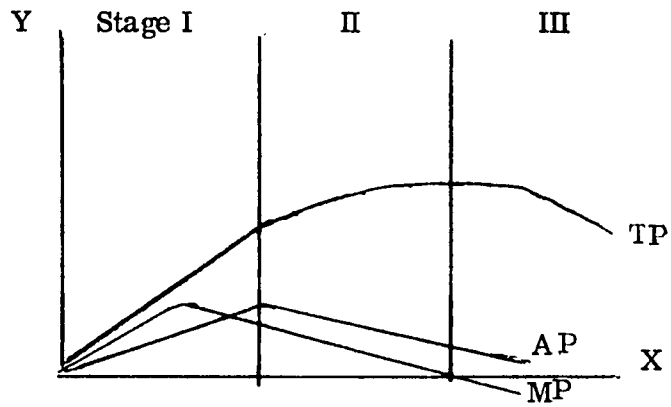

Figure 1. Stages of production function

Since this graph is two dimensional it describes the hypothetical situation where output Y depends on one input X. In stage I total product increases as does average product. Marginal product both increases and decreases but in all cases is positive. Elasticity of production $\frac{MP}{AP}$, which indicates change in output due to change in input is greater than one. In stage I, it is rational to continue increasing input because each additional unit of X creates a more than proportional increase in Y.

Entry into stage II is defined where $\frac{MP}{AP} = 1$. In stage II, average product and marginal product are decreasing and total product is increasing at a decreasing rate. Elasticity of production declines to zero at the beginning of stage III. In stage III, marginal product is negative and total product decreases as input increases. Elasticity of production is negative. Entry into stage III is where total output is at a maximum.

From these relationships it is possible to state unequivocally that stage II is the area of rational production. Regardless of unit costs of

inputs there is no reason to limit production short of stage II because output is increasing more than proportionally compared to inputs. On the other hand, there is no reason to produce beyond entry into stage III because additional inputs actually decrease total possible maximum production. Or, to put it another way, there's no reason to produce in stage III because additional units of output (MP) are negative. Of course, there is an optimum production level within stage II. Just what this optimum (economic) is depends upon the production function. Once the proper Marginal Revenue and Marginal Cost information is available a production level can be set which will maximize profits. If, for example, marginal costs are zero, production will take place exactly at the entry into stage III. This is the only case where the economic optimum and technological maximum production levels are the same.

It is readily apparent that the relationships depicted in Figure 1 are what they are due to the "shape" of the total product (TY) curve and that this shape implies the law of diminishing returns. That is to say, that at some point, successive increments of X will begin to produce successively smaller increments of Y. In this situation economists speak of increasing and decreasing returns to scale.

Although it is difficult to imagine any physical process failing to follow the law of diminishing returns, in some ultimate sense, it is possible to imagine and observe essentially linear relationships over certain ranges

of input-output relations. If output is observed to remain proportional to input for all practical purposes, the production process is said to display constant returns to scale. In this case $\frac{MP}{AP} = K$ for all input levels of X.

Forms of Production Functions

Several possible forms of input-output relationships have been developed. Selection of a form for the function may be based on experience from previous studies of theories of sciences involved. An infinite number of functional forms are possible in productivity studies. [6, 73] Those considered here are the most widely used and best known.

Single variable equation

Many studies are concerned with the effect of one variable on output. In reality if only one input is used output will be zero. However, by assuming all other input factors constant or fixed the effect of the remaining variable may be measured. This information is useful although in real life it is unusual to vary one input without varying the remaining inputs also. [6, 74]

Spillman function

This is an exponential type function where $Y = M - AR^X$. Y measures total output, x total input, M maximum total output using the variable input, A is increase in output attained by increasing x and M-A is level of output

defined by fixed resources and zero input of variable resource. R is a constant defining the ratio of successive increments to total product. Because marginal products are not allowed to become negative this function is not suitable for samples where input magnitudes are such that total product declines. [6, 78]

Quadratic forms

A simple quadratic equation $Y = a + bX - cX^2$, with a negative third term to denote diminishing marginal returns, allows both a declining and negative marginal productivity but not both increasing and decreasing marginal products. A maximum total output is defined where input magnitude or X is equal to $.5bc^{-1}$. Marginal products do not bear a fixed ratio to each other but the quadratic equation does assume that all marginal products decline by a constant absolute amount K were K = 2c. This means the marginal product curve is negative. A constant term (a) represents the amount of product that is produced when only fixed resources are used. If Y is used to measure output due to variable resource only, then we assume (a) is zero. This equation can be modified to relax the restraint that the marginal products decline by a constant amount. [6, 80]

Constant elasticity of substitution function

An important concept in production functions is elasticity of factor substitution. In Marshall's words:

> Every agent of production, land, machinery, skilled labour etc.; tends to be applied in production as far as it profitably can be. If employers, and other businessmen, think they can get a better result by using a little more of one agent they will do so. They estimate the net product, (that is the net increase of the money value of their total output after allowing for incidental expenses) that will be got by a little more outlay in this direction, or a little more outlay in that; and if they can gain by shifting a little of their outlay from one direction to another they will do so. [2, 18]

The elasticity of substitution as developed by John R. Hicks is a measure of this phenomenon; it tells how rapidly diminishing returns set in to one factor of production when its price falls relative to another factor price. [2, 18] For two factors of production, labor (N) and capital (C) the ratio of marginal product of capital to marginal product of labor is the marginal rate of substitution of labor for capital. "Hence elasticity of substitution relates proportional change in relative factor inputs to proportional change in relative factor price ratio. It can be conceived as a measure of similarity of factors of production from a technological point of view." [2, 18]

The CES function assumes that the measure of degree of input substitution is constant but not restricted to any particular value. A constant elasticity of substitution refers to invariance with respect to change in relative factor supplies and not to transformations of the underlying technology. The CES function has positive marginal products whether or not constant returns to scale are present. Marginal products fall over relative ranges of inputs and the function can characterize any degree of returns to scale. [2, 46] Maximum output can be defined when

elasticity of substitution is less than unity. When it exceeds unity there are no limits. The CES function also identifies the characteristics of an abstract technology; efficiency of a technology, technologically determined returns to scale, capital intensity of a technology and ease of substitution of labor for capital. There are four general limitations.

> First an empirical representation of economies of scale may be ambiguous because the function combines in one parameter scale economies attributable to variations in the scale of operations of the firm for a given technology and scale economies that may result from the implementation of a new technology for a given scale of operation. A second difficulty with the function is that it is difficult to generalize for n factors of production. The third limitation noted is that it assumes that the elasticity of substitution between capital and labor is invariant with respect to relative factor inputs; this may be a source of specification error. Finally, the CES function is relatively difficult to fit to data. [2, 12]

Cobb-Douglas function

The Cobb-Douglas function, in the form generally used, is $Y = aX^b$ where X is the variable input, Y is output, a is a constant and b defines the transformation ratio when X is at different magnitudes. The b coefficient is the elasticity of production and can be interpreted directly. (The equation is estimated in logarithmic form.) This function allows either constant, increasing or decreasing marginal productivity but not all three on the same input-output curve. If b = 1, marginal and average product will be constant at the level a. If b is greater than 1, the magnitude of marginal product will increase as X increases. If b is less than 1,

the magnitude of marginal product will decrease as X increases. This function assumes a constant elasticity of production over the entire input-output curve, that is successive equal increments of input add the same percentage to total output. The Cobb-Douglas function cannot be used on data where there are ranges of both increasing and decreasing marginal productivity or both positive and negative marginal products. [6, 75]

Use of Cobb-Douglas Type Functions

Of the algebraic forms mentioned the Cobb-Douglas function of the form $Y = AX_1^aX_2^b$ where Y is output, the X's are inputs and a and b are production elasticities that must always sum to one, has been the most widely used in farm firm analysis and has been selected for use in this study. It provides a compromise between adequate fit of data, computational feasibility and sufficient degrees of freedom to allow for statistical testing.

When data for a Cobb-Douglas analysis are being gathered and analyzed certain procedures should be followed. If aggregation is necessary it should be done on a multiplicative not an additive basis. In addition a Cobb-Douglas function implies that at least some quantity of each input must be used if output is to be non-zero. Therefore, zero inputs should be entered as ones, especially where log tranformations are used since the log of one is zero.

Returns to scale

Historically in Cobb-Douglas analysis the sum of the estimated input coefficients has been taken as an indication of returns to scale. Thus $\sum_{i=1}^{n} b_i < 1$ has been taken as implying decreasing returns to scale. That is as X increases marginal product of X decreases. If $\sum_{i=1}^{n} b_i > 1$ then as X increases marginal product of X increases and increasing returns to scale prevail. If the $\sum_{i=1}^{n} b_i = 1$ then constant returns to scale prevail. A "t" test is usually performed to ascertain whether the Σb_i is significantly different from one at the desired probability level.

Estimates of return to scale will be biased unless all input factors are included in the production function. Scale returns will be underestimated if excluded inputs vary less than proportionately with changes in included factors over the sample of observations. If the opposite situation holds returns to scale will be overestimated. For example, it appears that as scale of firm increases, management does not increase to the same extent as other factors. Exclusion of management could therefore lead to underestimation of returns to scale. Likewise, ignoring quality differences in land and labor will lead to overestimation of returns to capital, underestimation of returns to labor and land and underestimation of returns to scale. If a researcher has strong reason to believe that constant returns to scale exist then it is logical to test the divergence between the sum of the b_i and unity as an indication of importance of omitted input variables and not as an indicator of returns to scale. [6, 23]

The effect of technology

As defined above a production function expresses the relationship between output and input and how inputs cooperate with each other in varying proportions to produce any given output. Relationships between outputs and inputs and among inputs are determined by technology. Technology is embedded in production functions and can be expressed in terms of them.

There are four characteristics of a production function which taken together are called an abstract technology. They are efficiency of technology, economies of scale that are technologically determined, degree of capital intensity of a technology and ease with which capital is substituted for labor.

> The Cobb-Douglas function can represent changes in three of the four characteristics of an abstract technology. If efficiency of a technology is varied, ceteris paribus, a change in A will occur, where $Y=AX_1^aX_2^b$ Variations in A do not affect marginal rate of substitution between labor and capital; hence, changes in the technological efficiency parameter, A, produce a neutral technological change. [2, 42]
>
> A neutral technological change does not affect the marginal rate of substitution of labor for capital. Neither saves nor uses capital. Neither saves nor uses labor but produces a change in the production relation itself. [2, 21]

Assuming that changes in magnitude of returns to scale are produced by modifications in technology, then a Cobb-Douglas production function represents a change in a second characteristic of an abstract technology by a shift in the sum of a and b. This is also a neutral type of technological

change because the ratio of a and b will be unaltered and this means that the marginal ratio of substitution of the factors X_1 and X_2 is unaltered.

> Changes in capital intensity of a technology are depicted by variations in the ratio of two elasticities of production, i.e. a change in a relative to b. This is the only way in which non-neutral technological progress can be represented in Cobb-Douglas production function. If b rises relative to a, than a capital-using technological change is said to occur. Conversely a fall in b relative to a indicates that a less capital intensive technology has been introduced. [2,42]

Elasticity of substitution

In the Cobb-Douglas function, elasticity of substitution is unity for any given factor combination and for any given capital intensity. That is, if relative factor prices change by a certain proportion, relative factor inputs change by the same proportion in the opposite direction and relative income shares remain unchanged. This is a well known property of the Cobb-Douglas function because it provides a rationale for the constancy of relative income shares even when there are significant changes in relative factor supplies. [2, 42]

DATA

Data to be examined and fitted to a Cobb-Douglas function consist of farm budgets obtained by Percy Aitken in August of 1971. The survey was made in the provinces of Los Rios and Guayas which account for 88 percent of Ecuadorean rice production. These provinces were divided into six areas. Each area was assigned to an extension agent who distributed 20 questionnaires at random. This accounted for only 1.3 percent of the areas' farmers. Of the 120 questionnaires distributed 106 were collected and of these 86.7 percent came from small farmers in management levels 6, 7, or 8.

After eliminating budgets where the data was incomplete, conflicting or not applicable to management levels 6, 7, or 8, 66 observations remained. Of these 44 were poza farms, 9 were poza farms with additional water from tides and 13 were poza farms with additional water from pumps. The poza farms with additional water by pump or tides were combined to form the irrigated farm classification. This means comparisons will be made only between dry (poza) and irrigated (poza and pump or tide) farms.

Crop production costs were calculated on a per hectare rather than on a per farm basis. This was considered the most practical approach considering restricted data on farm production, organization and size of sample. Costs, developed on a per hectare basis disregard economies of scale on larger farms and may understate machinery costs on small farms.

The data have some weaknesses. Sample size was small for such a large area. Also because most data came from small farmers there were problems of distrust, illiteracy, lack of written records and fear that they might lose their land. Nonetheless, the data are as good as can be expected from this type of survey and seems sufficiently accurate for the general types of questions being considered in this study.

PROCEDURE

There are several ways to go about examining the data using different forms of the Cobb-Douglas function. The most direct method is to estimate functions for each group of data and make comparisons between the two functions by observing changes in beta coefficients and factor shares as irrigation is introduced. A Cobb-Douglass equation of the following form will be used: $Y = AX_1^{b_1} X_2^{b_2} X_3^{b_3}$ in which

Y = a value of physical production

A = constant

X_1 = value of land input

X_2 = value of capital input

X_3 = value of labor input

b_i, b_2, b_3, = elasticities with respect to each factor input, and the proportionate share of total product (factor share) going to each input.

First partial derivatives are marginal products for specified inputs:

$$\partial Y/\partial X_1 = A\, b_1\, X_1^{b_1-1} X_2^{b_2} X_3^{b_3}$$

$$\frac{A\, b_1 X_1^{b_1} X_2^{b_2} X_3^{b_3}}{X_1}$$

which by substitution reduces to $\frac{b_i Y}{X_1}$

Marginal factor share for any input is defined as marginal product, $(\frac{Y}{X_1} b_1)$ multiplied by the amount of input used (X). Because the marginal

product is shown to be equal to $\frac{Y}{X_1} B_1$ the marginal factor share can be expressed as b_1Y since $(\frac{Y}{X_1} b_1)X_1 = b_1Y$. Marginal productivity theory is based upon conditions that Euler's theorem holds (value of total product matches payments to all factors of production). Also it is assumed that competition exists in all markets. [8, 20]

In a competitive market it is assumed that VMP of an input equals the price of that input.

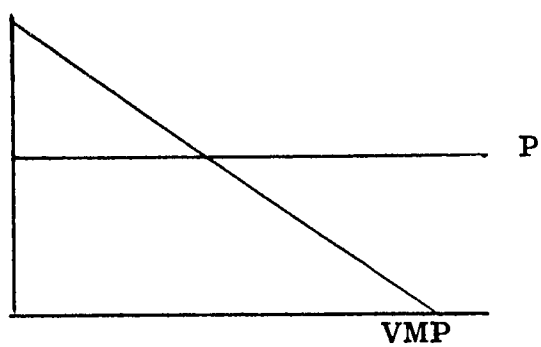

Figure 2. Profit optimizing output in a competitive factor market

Since the price of the input equals (MPP.P) marginal physical product of X times the price of the output, it follows that $MPP = \frac{P_i}{P_o}$ then $\frac{MPP}{P_i} = \frac{1}{P_o}$. For best resource allocation this ratio should be equal for all inputs.

A second alternative is to fit a single Cobb-Douglas equation to the pooled data of the form

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3} + Z$$

where Z is a dummy variable. Z = 1 if the observation is irrigated and zero if it is dry. This method assumes that both dry and irrigated farms have the same production function except for the intercepts. The value attributed to Z is added to A to yield a function

$$Y = (A+Z)X_1^{b1}X_2^{b2}X_3^{b3}$$

for the irrigated farms while the function for dry farms is

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3} \quad .$$

If the production functions are simple one variable models the difference in the two functions could be illustrated as follows in Figure 3.

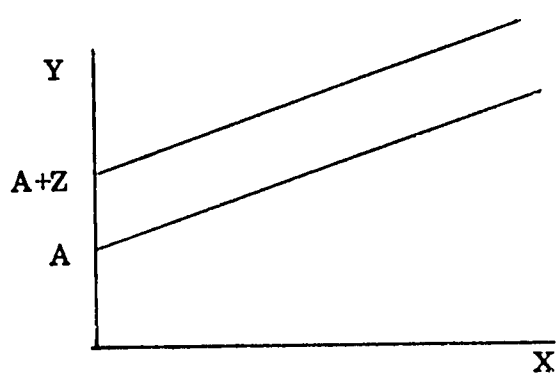

Figure 3. Effect of single dummy variable on intercept

This says that as irrigation is introduced production shifts upward by some constant amount at all levels of input. The function with the highest intercept is more efficient because output is higher at all levels of input.

A third alternative would be to fit all observations (both dry and irrigated) to a Cobb-Douglas type function of the form

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3}Z(ZX_1^{b1})(ZX_2^{b2})(ZX_3^{b3})$$

where Z is a dummy variable. Again the dummy variable has a value of one if the observation is for an irrigated farm and zero if it is dry.

Employing a function of this form allows both slope and intercept to change as irrigation is added. Production functions for both types of farms can be derived from this equation. For dry farms

$$Y = AX_1^{b1}X_2^{b2}X_3^{b3} \quad .$$

For irrigated farms

$$Y = A+Z(X_1^{b1}+ZX_1^{b1})(X_2^{b2}+ZX_2^{b2})(X_3^{b3}+ZX_3^{b3}) \quad .$$

Statistical analysis can be accomplished by testing whether each of the b values is significantly different from zero. If all the beta values for the irrigated dummy variables are significantly different from zero then the production functions for dry and irrigated farms have different slopes. The intercept values may also be tested. If the irrigated intercept dummy is significantly different from zero, then the intercepts of the two production functions are different. Different slopes imply that input relationships in each function are different. Different intercepts imply differences in efficiency of production. The function with the higher intercept is more efficient because output is higher with the same level of original inputs plus the water input.

An interesting situation here is that the least square estimators and beta values for each function are identical to the values obtained from two separate regressions of X on Y. The only difference between running separate regressions and pooling the two sets of data concerns variance of the error term. If, as normally assumed, variance is constant through the test period, then estimates based on all observations will be efficient, whereas estimates obtained from each subset will not be. The two separate regressions are not efficient because each is established from a subset that does not utilize information about variance contained in the other subset.

The main reason for considering the two approaches using dummy variables is because they are more efficient. However, if the two sets of data are substantially different and variance is not homogeneous in the two sets, then they shouldn't be pooled and the approach using two separate equations is the one that should be followed. A covariance analysis can be used to test the hypothesis that the two sets of data come from the same population. It can also show difference in variance between the two sets. In addition covariance analysis provides information necessary to perform an F test for homogeneity of slope of the two regression lines. This is considered necessary because in the case that some of the b_i in the irrigated equation are significantly different from zero and some are not it would be difficult to know whether the regression lines were really different. The F test in covariance analysis does not test whether the

individual b_i are significantly different from zero but it does test whether the sum of the b_i in subset one is significantly different from the sum of the b_i in subset two. If they are significantly different then that is an indication that the slopes are different.

RESULTS

Differences Between Irrigated and Dry Farms

Of the three approaches the one using a single dummy variable was omitted because the second dummy variable approach allows both slope and intercept to change. A production function using the second approach was estimated and yielded the following equations.

The combined equation for this function is

$$Y = 3.898X_1^{.5411}X_2^{.02324}X_3^{.4001}.2628X_1^{-.0465}X_2^{.02128}X_3^{-.3065}.$$

From this equation we derive equations for both dry and irrigated farms.

For dry farms

$$Y = 3.898X_1^{.5411}X_2^{.02324}X_3^{.4001}.$$

For irrigated farms

$$Y = (3.898+.2628)(X_1^{.5411+X_1^{-.0465}})(X_2^{.02324+X_2^{-.0465}})\ (X_3^{.4001+X_3^{-.3065}})$$

or

$$Y = 4.1608X_1^{.4946}X_2^{-.02326}X_3^{.09}$$

The same results should be obtained by means of separate regressions on each set of data. An equation derived for irrigated farms in this manner is

$$Y = 4.176X_1^{.5154}X_2^{.02065}X_3^{.0898}.$$

For dry farms

$$Y = .7903X_1^{.5440}X_2^{.04822}X_3^{.3913}.$$

Generally the results compare favorably except that the constant for dry farms is lower and not significantly different from zero, whereas the opposite was true when the data were combined.

This is cleared up somewhat by examining the results of co-variance analysis. Results obtained from the co-variance analysis suggest that these data are from different populations and cannot be pooled. These conclusions are based on observed values of treatment means for each variable. In some cases the treatment means varied enough to violate the assumption of the covariance analysis.

Therefore the results from the two separate equations are those that should be used in an analysis. In addition if sums of squares due to regression plus mean squares from covariance analysis are employed to perform an F test for homogeneity of slope, results indicate that the slopes of the two equations are not significantly different.

	Degrees of Freedom					
SS Reg trt. 1	3	.2056025				
+SS Reg trt. 2	3	1.112457				
-SS Reg Pooled	-3	3(.3047681)	=	.4037555	= 1.837954	N.S.
	6			.21967583		
Within trt. M.S.		.219676583				

The only statistically significant difference between farm classes is in magnitude of the intercept. This means that irrigated farms have the same production function as dry farms but output is higher at all levels of input, i.e., a neutral technological change.

Constant Returns to Scale

Finally, at the 5 percent confidence level the sum of the b_i for either equation does not differ significantly from one.

$$t = \frac{\Sigma b_i - 1}{S\sqrt{X^{1} X^{-1}}}$$

irrigated $t = \frac{-.374150}{.188809} = 1.981632$ significant at 10 percent confidence level

dry $t = \frac{.016480}{.151509} = .108772$ N.S.

In other words, both functions exhibit constant returns to scale and it can be assumed that no important input variables are omitted.

Factor Shares

Factor shares are determined by the b_i and Y. The share of total product going to each factor is dependent on the MPP of that factor, amount of factor used, market structure and elasticity of factor supply. Table 6 contains relevant values for computing factor shares. For example the factor share for land in irrigated farms is equal to 4861.91 sucres per hectare. The sum of the factor shares will not exactly equal the Y value because the b_i do not sum to one. This is especially true for the irrigated farms. Means show the average value of each input and output used per hectare.

Table 6. Showing b_i values, means, VMP and factor shares of functions for dry and irrigated farms

Irrigated

	b_i	S_b	t	Sig. Level	Mean	OP MP	MP	VMP	Factor Share
Land	.5154	.02227	2.314	.975	2953.36	21.09	34.6	1.64623	4861.91
Capital	.02065	.08040	.02569	N.S.	531.55	3.79	1.38	.33647	194.80
Labor	.0898	.01585	.05665	N.S.	3310.65	23.65	6.05	.25587	847.10
Constant	4.176	1.546	2.701	.975					

*Y = 9433.29 R^2 = .4135

Dry

	b_i	S_b	t	Sig. Level	Mean	OP MP	MP	VMP	Factor Share
Land	.544	.1501	.3623	N.S.	3500.64	25	16	.65507	2293.16
Capital	.04822	.06599	.7307	.75	139.83	1	1.45	1.45367	203.27
Labor	.3913	.12	3.264	.995	1567.76	11.12	11.78	1.05213	1649.48
Constant	.07903	1.474	.536	N.S.					

*Y = 4215.4 R^2 = .4170

Resource Allocation

Optimum resource allocation is achieved when the ratios of marginal physical product to price of input equal one over the price of output ($\frac{MP}{Pi} = \frac{1}{P}$). These optimal marginal products (OP MP) can be compared directly to the existing marginal products (MP) and will indicate whether each of the inputs should be increased or decreased to achieve optimum resource allocation.

On irrigated farms the optimal marginal product for land is 21.09 and the actual marginal product is 34.6. This indicates that the land input should be increased until the actual marginal product is driven down to 21.09. The optimal marginal products for capital and labor are 3.79 and 23.65 as opposed to actual marginal products of 1.38 and 6.05. This indicates that farmers are using too much of these inputs.

The situation is the reverse for dry farms. Actual marginal products are higher than optimal marginal products for both capital and labor suggesting more of these inputs should be used. However comparison of OP MP and MP for land suggest that too much land is being used.

These conclusions are reinforced by observing the value of marginal product (VMP) for each of the inputs. VMP indicates return in sucres per sucre invested in each input. Unless VMP for input is greater than one it is uneconomical to use more of that input. Observing values of VMP in Table 6 we see that they correspond with the conclusions already drawn from comparison of marginal products.

CONCLUSIONS

High b_i values associated with land are a strong indication that the Ecuadorean land reform policy is rational (especially if the land is idle or is presently devoted to enterprises less productive than rice-growing, such as grazing). Since the survey reported land investment anywhere from 3,000 to 10,000 sucres per hectare, investment in irrigation infrastructure tends to be capitalized into land values. It seems the high b_i values for land are a reflection on magnitude of returns to leveling and water control structures.

Low b_i values for capital shouldn't be alarming. Improved inputs such as better seed, more fertilizer, pesticides and credit could significantly raise output. However, these farmers seldom use any of these inputs except credit. Occasionally a farmer will use pesticides but only if his crop is infested and it appears that he'll suffer severe losses otherwise. In this survey there were not enough farmers using modern inputs to justify saying anything about them. MP of capital was high on dry farms. This indicates more capital should be used. It is likely that capital is important on irrigated farms also. Aggregation of capital input may have obscured useful information in both cases.

Reduction in the b_i value for labor when water was introduced is puzzling. A "t" test indicates this value is not significantly different from

zero at the 95 percent significance level. One possible explanation might be that water absorbs a great share of total product when introduced and so decreases labor's share of total product. It is probable that this type of irrigation is expensive in relation to the increase in output it produces. If farmers experience an unusually dry year it appears unlikely that a pump with a one or two inch discharge will supply enough water to make a difference. An alternative here would be to use larger pumps and distribute water either through irrigation companies or co-ops.[2]

R^2 in both cases was low, .41 and .45 respectively. This could be improved substantially by further dividing farms into size categories. However, this made the subsets so small that there were not sufficient degrees of freedom for statistical testing. Also it appeared that the b_i values were not appreciably different when this was done. It can be said with confidence that when farmers own more land, 10 to 20 hectares, and continue trying to farm with traditional methods, output per hectare drops considerably. This is another indication there is a labor shortage during peak demand periods of the rice growing season.

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[2]Referring to the budget for farm type 1, we see that irrigation cost/ha. is 1365 sucres/ha. but 7.5 man days are spent watching the water on one hectare. In contrast, type 7 has a cost of only 300 sucres but the budget suggests water is applied for only three hours. Intuitively type 1 must be getting a lot more water for the money than type 7. Type 8 appears to have water along the same magnitude as type 1.

Despite the high value of marginal product of labor on both poza and irrigated farms it appears that many farmers are leaving their own work at critical periods to work on the larger more commercial rice farms. Some of the larger growers indicated that they sent barges up and down the river to recruit labor at peak perios and during these periods labor was in short supply.

As Aitken noted many small farmers were paying interest rates as high as 40 percent for operating money. This high interest rate reflects both the difficulty in collecting loans and the farmers' need for capital. Nevertheless, it appears that farmers use very few capital inputs. It seems that the money is being used to pay living expenses between rice crops. If farmers are unable to obtain credit they are forced to work off-farm until they have sufficient money to meet expenses. It appears that there would be increases in both output and income among small farmers were more credit available. In the same manner farmers would greatly benefit by being able to grow rice year around.

Summary

1. Poza farmers could profitably use more capital and labor were they available.
2. Poza farmers with supplemental irrigation could profitably use more land.
3. Irrigation does increase output and provides income and employment during slack periods.
4. Supplemental irrigation by pumps appears to be less desirable than more permanent types of irrigation systems.
5. Land reform is a rational policy and should be continued.

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APPENDIX

One alternative to financing small individual farmers would be to concentrate credit and irrigation efforts on co-operatives. At present there are 33 active rice co-ops in the basin. Many of them could make efficient use of long term credit for developing and irrigating their land. It appears that loans to co-ops would be easier to administer than loans to small individual farmers. In addition co-ops can operate much more efficiently on irrigation and leveling projects than can individual poza farmers. There are also important social benefits as co-ops once organized can act to gain many community improvements such as schools, water systems and electricity that would be difficult or impossible to obtain on an individual basis. Table 7 shows the names of rice production co-ops presently operating in the Guayas Basin.

Table 7. The list of rice cooperatives served by FENACOPARR in August 1971, is as follows:

Cooperative	Zone
	I
Los Rios	Babahoyo
Las Mercedes	"
Marcos Bonnetazu	"
El Agosto Bonnetazu	"
	II
La Union	Daule
Narciso de Jesus	"
San Felipe	"
Nueva Esperanza	"
Progreso	"
Las Pampas	"
	III
La Boldaca	Milagro
Jujan	"
Yaquachi	"
Huancauilca	"
La Isla	"
Rio Ruidoso	"
Nueva Fortuna	"
Los Angeles	"
La Carmela	"
Villa Mercedes	"
	IV
Margarita	Sambo Rondon
Nueva Narcisa	"
31 Octubre	"
San Luis	"
Los Juncos	"

Table 7. Continued

Cooperative	Zone
	V
Legua de los Indios	Baba
Santa Isabel	"
Tinoco	"
	VI
22 Octubre	Vinces
El Roblento	"
San Juan	"
Buena Fe	"

Source [1, 16]

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