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AN ECONOMIC APPRAISAL OF ON-FARM WATER MANAGEMENT PRACTICES IN DEVELOPING COUNTRIES: A STUDY OF SUMMER PADDY RICE PRODUCTION IN GUAYAS RIVER BASIN, ECUADOR

by

Thomas Lloyd White

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

of

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in

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Thomas Lloyd White

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii

LIST OF TABLES vi

LIST OF FIGURES ix

ABSTRACT x

INTRODUCTION 1

OBJECTIVES 5

REVIEW OF LITERATURE 9

Agricultural Development 9
Internal Rate of Return 16

THEORETICAL BASIS FOR ANALYSIS 23

Definition of Internal Rate of Return 23
Requirements for Calculation of the Internal Rate of Return . . . 24
Maximization of the Internal Rate of Return 25
Calculation of the Internal Rate of Return 29

PROCEDURES AND SOURCES OF DATA 31

LIMITS OF RICE PRODUCING AREA 34

Soil Type 34
Quality of Irrigation Water 36

PRESENTATION AND ANALYSIS OF DATA 41

Evapotranspiration and Efficiency of Irrigation Water Use 41
Description of Management Levels and Presentation of Costs
and Returns Budgets 51
Management Level I 54
Land preparation. 59
Planting 59

TABLE OF CONTENTS (Continued)

Page

Fertilization 61
Weed and pest control. 61
Water 61
Harvesting 62
Other costs 62
Interest on operating capital 63
Amortization of land 63
Returns 64
Management Level II 64
Land preparation 65
Planting 65
Fertilization 65
Weed and pest control 65
Water 68
Harvesting 68
Other costs 69
Interest on operating capital 69
Amortization of land 69
Returns 70
Management Level III 71
Land preparation 71
Planting 71
Fertilization 74
Weed and pest control 74
Water 74
Harvesting 75
Interest on operating capital 75
Amortization of land 75
Returns 76
Management Level IV 76
Land preparation 79
Weed and pest control 79
Water 79
Harvesting 80
Interest on operating capital 80
Amortization of land 80
Returns 80
Calculation of the Internal Rates of Return 81
Management level I 83
Management level II 85
Management level III 89
Management level IV 89

TABLE OF CONTENTS (Continued)

Page

HYPOTHETICAL AGGREGATE IMPLICATIONS 91

SUMMARY 96

CONCLUSIONS AND NEED FOR FURTHER RESEARCH 101

LITERATURE CITED 104

APPENDIXES 108

Appendix A. Questionnaire Used in Making Farm Survey 109

Appendix B. Production, Yield, Consumption and Price Data for Rice, Ecuador 115

Appendix C. Response of Rice to Fertilizer 121

Appendix D. Comparison of Internal Rates of Return to Other Rates of Return 124

Appendix E. Factors Limiting Rice Producing Region 125

Appendix F. Machinery Requirements 129

Appendix G. Miscellaneous Tables 131

LIST OF TABLES

Table | Page

1. Population growth rate, Ecuador, 1950 to 1968 1
2. Population distribution and density by regions, Ecuador . . 2
3. Standards for irrigation waters 39
4. Comparison of Piche and Weather Bureau Pan evaporation . . data by month, Milagro Weather Station, Ecuador, 1969 . . . 45
5. Potential evapotranspiration and net water needs for summer rice, stated in millimeters, 1969 48
6. Estimates of water-use efficiency 49
7. Differences among management levels 52
8. Average size production unit and rice paddy in hectares . . 55
9. Investment per hectare in land development and machinery stated in sucres 56
10. Land development investment as a percent of total investment per hectare 56
11. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level I 57
12. Number of operations completed by machine and by hand . . .58
13. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level II 66
14. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level III 72
15. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level IV 78
16. Net benefits and investments schedule for one production unit. Management level I 84

LIST OF TABLES (Continued)

Table Page

17. Estimates of net and discounted annual returns for 100 hectares, in sucres. Management level I 86

18. Net benefits and investments schedule. Management level II 87

19. Estimates of net and discounted annual returns for rice enterprise, in sucres. Management level II 88

20. Net benefits and investments schedule (value of labor excluded). Management level IV 90

21. Area and production of rice, Ecuador 115

22. Production, consumption, trade with exterior and prices of rice, Ecuador, 1961-1968 116

23. Method of land preparation, Guayas Basin, 1969 117

24. Extent of irrigation in the production of summer rice, Guayas Basin, 1968 117

25. Estimated number of operators and total cultivated area of rice for major rice producing provinces, 1969 118

26. Estimated number of properties and total cultivated area of winter and summer rice for major rice producing provinces, 1954. Distribution according to size. 119

27. Estimated number of properties and total cultivated area of winter and summer rice, 1954. National totals. Distribution according to size 120

28. Estimated number of operators and total cultivated area of winter and summer rice, 1969. Distribution according to size of enterprise. National totals. 120

29. Average total yield in metric tons per hectare for 20 varieties of rice with two levels of nitrógen fértilization. "Boliche," 1969 121

30. Average yields in tons per hectare in an experiment comparing three varieties of rice at four levels of nitrogen fertilization and two methods of planting. "Boliche," 1969. 122

LIST OF TABLES (Continued)

Table | Page

31. Results of rice production experiments in Daule, 1968 National Rice Commission 123

32. Reported rates of returns on investment and standardized internal rates of return 124

33. Characteristics of soil associations of Guayas Basin, Ecuador 125

34. Tolerance of three types of crops for salinity as determined by the United States Salinity Laboratory 126

35. Principal areas of rice production 127

36. Machinery and equipment inventory for 500 hectares, management level I 129

37. Machinery and equipment inventory based on 150 hectares production, management level II 130

38. Machinery and equipment inventory for 25 hectares, management level III 130

39. Farm wage rates, Guayas Basin, Ecuador, 1970 131

40. Equipment rental rates, Guayas Basin, Ecuador, 1970 131

41. Cost of selected items at Guayaquil, July 1970 132

42. Unimproved rice land, maximum, minimum and average prices stated in sucres per hectare 133

43. Conversion rates 134

LIST OF FIGURES

Figure Page

1. Maxmimization of the internal rate of return 27

2. Location of the Guayas Basin 35

3. Rice producing areas of the Guayas Basin 37

4. Salinity of the Daule River 38

ABSTRACT

An Economic Appraisal of On-Farm Water Management Practices in Developing Countries: A Study of Summer Rice Production In Guayas River Basin, Ecuador

by

Thomas L. White, Master of Arts

Utah State University, 1971

Thesis Director: Dr. Jay C. Andersen
Department: Economics

The primary objective of this study was to examine rice production methods, with special emphasis on irrigation-water management practices used by producers from all levels of management in the Guayas River Basin, Ecuador. To do this, rice producers were divided into four categories on the basis of the level of mechanization of their operation, use of purchased inputs, and the level of investment in irrigation facilities and general management practices. The levels of investment in irrigation facilities ranged from 7,000 to 500 sucres per hectare, and mechanization of production varied from almost total use of machinery for cultivation operations to no machinery at all. Similar variations were noted in regards to yields which ranged from 100 quintals of hulled rice to just 22 quintals per hectare.

The efficiency of irrigation-water use presented some problems

and could only be calculated for two management levels, I and II; these were found to be low in relation to results found in other areas. This efficiency was defined as being the ratio of the amount of water beneficially used to the amount of water delivered to the farm.

In order to compare the profitability of rice production and investments in machinery and land development, the internal rate of return criterion was used. This rate of return is that rate which equates the flow of net benefits to the flow of net investment for a project over its expected economic life. The streams of benefits were estimated from the costs and returns budgets and the investments stream from the costs of land developments and initial machinery costs, together with expected maintenance and replacement costs of headgates and other water control structures. These rates varied from almost 80 percent for production under management level I, 17.6 percent for management level II, to losses (negative returns--these were not calculated) for management levels III and IV.

(134 pages)

INTRODUCTION

Ecuador is a land of many contrasts, both geographical and economical. It is the second smallest country in South America with an area of approximately 264,466 square kilometers, just slightly more than one-tenth of which is classified as being arable. Of that only about seven-tenths of one percent is irrigated. At the present, this land, approximately 2.7 million hectares, is classified as arable with about 19,000 hectares under irrigation. These land resources must support 5.5 million people, a population which is growing at the rate of 3.42 percent annually (Table 1). This growth rate is second only to that of Costa Rica.

Current projections place total population at 20 million by the year 2005 if the present rate of growth continues (Merrick, 1969).

Table 1. Population growth rate, Ecuador, 1950 to 1968

Year	Gross Birth Rate/1000	Gross Death Rate/1000	Net Population Growth Rate
1950	46.2	17.3	2.94%
1960	47.3	14.0	3.28%
1968	47.7	13.5	3.42%

At an annual rate of growth of 3.4 percent, the population will double in approximately 21 years. (CEDEGE, 1970)

Obviously, with less than one-half hectare of arable land per capita and that becoming less each year, there is a great need to increase the

productivity of all available lands. One obvious way of doing this is to irrigate as much as possible. Since Ecuador straddles the equator, it has a potentially year-long growing season. The only limitation is the lack of sufficient moisture during the summer or dry season (approximately from mid-June through mid-December) to successfully produce most agricultural crops during this period.

Geographically there are four basic regions in Ecuador (Table 2).

Table 2. Population distribution and density by regions, Ecuador.

	1950 Census Total	%	1962 Census Total	%	Area in Km^2 Total	%	Density 1950	Density 1962
Total	3,202,757	100	4,476,007	100	264,466	100	12	17
Sierra	1,856,445	58	2,271,345	50.7	69,342	26.2	27	33
Costa	1,298,495	40.5	2,127,358	47.6	66,049	25.0	20	32
Oriente	46,471	1.5	74,913	1.6	121,263	45.9	0.4	0.6
Archipelago	1,346	0.0	2,391	0.1	7,812	2.9	0.2	0.3

(CEDEGE, 1970)

The four basic regions in Ecuador can be described as follows:

1) The Sierra or highland is the part of the country that straddles the Andes Mountains and is very rough, even in the smoothest places; it makes up about one-fourth of the country's area and has slightly more than one-half of the population.

2) The Costa or coastal plain varies from about 10 kilometers to more than 300 kilometers in width and has roughly one-fourth of the total land area and almost one-half of the population.

3) The Oriente or eastern jungle is part of the great Amazon Basin and has nearly one-half of the land area but less than 2 percent of the population.

4) The Archipelago de Colon or Galapagos Islands are located in the Pacific Ocean about 1000 kilometers from the mainland. They are relatively unimportant in regards to area and population as they are very small and sparsely populated.

Economically, by all of the conventional measures, Ecuador is underdeveloped. Per capita income is less than 200 dollars and showed an average annual increase of only seven-tenths of one percent from 1961 to 1966, which was the second lowest for all Latin America and far below the 2.5 percent minimum set by the Alliance for Progress as necessary to achieve social and economic objectives. The economy of the country is heavily dependent upon agriculture which employs 48 percent of the productively engaged population and accounts for 38 percent of the Gross Domestic Product (GDP). Also, it provides more than 90 percent of the country's foreign exchange, more than 60 percent of which comes from bananas and more than 25 percent from coffee and cacao. The remaining sectors, industry and commerce, and services, employ 16 percent and 27.5 percent, respectively, of the work force and account for 17 percent and 45 percent, respectively, of GDP (CEDEGE, 1970).

These statistics seem to indicate that Ecuador, like many of the other underdeveloped nations of the world, faces the need to increase the efficiency with which it uses its resources to provide goods and services needed by its rapidly expanding population. The most essential area where this improvement must be made is in the production of food with which to feed the masses at a nutritional level that at least matches

the minimum prescribed standards. In order to accomplish this goal, increased productivity and production efficiency in agriculture must be achieved. Research in crop varieties and their adaptation, the introduction of better technology and improved management practices in production techniques are requisites to accomplish these ends.

OBJECTIVES

The major objective of this study is to make an economic appraisal of on-farm water management practices in Ecuador. Obviously, all irrigated agriculture in Ecuador could not be feasibly included. Therefore, this study is limited to rice production--a crop which normally is grown year after year on the same land without rotation with other crops. The study is limited still further, for the calculation of costs and returns budgets, to include only rice production during the summer season. A second crop of rice is grown during the winter but under quite different conditions. However, it should be emphasized that, according to most producers, yields for rice grown during the two seasons are not significantly different. Producers indicated also that total production costs are nearly the same for the two seasons, but individual cost items do vary substantially. Thus, for the purposes of obtaining a reasonable estimate of annual total costs and returns from rice production, the results from one season could simply be doubled. On the other hand, a costs and returns budget for production during one season would not be an adequate representation of a similar budget for production during the other season.

Rice production is an important enterprise to nearly 8,000 farmers in the Guayas Basin. See Appendix A. For most of these farmers, rice is their only product and their major source of income, as well as a major

component of their daily diets. Also, rice is an important staple for the country in general. This is illustrated by the fact that Ecuador's internal consumption of rice is roughly 100,000 metric tons annually. However, it is interesting to note that this level of consumption has existed since at least 1961 (Table 23, Appendix B) which, due to the increase in population, has resulted in a decline in per capita consumption of rice from about 22 kilos in 1961 to 18 kilos in 1968.

Conceptually, since water for irrigation is normally considered to be a relatively scarce resource, any study regarding its use and management ideally should attempt to measure the increases in the efficiency of water use resulting from changes in management practices. Increased efficiency may be obtained at water storage sites, in the distribution system, or on the individual farms. In any case, the aim should be to save water, not otherwise beneficially used, which then can augment crop production. While a high level of efficiency is generally desirable, each increase can be obtained only by incurring costs for such things as canal lining, land leveling, irrigation structures, improved distribution systems, and so forth. Such expenditures, of course, should only be made if they can be justified on a sound economic basis. In order to optimize net income from expenditures such as those mentioned, the residual water value would have to be computed for each crop and weighted to represent the farm rotation program. These estimates of residual water value could then be used to determine the income stream generated by a given water-saving practice. The compu-

tational procedure for estimating the residual water value for each crop is as follows:

$$Vi = \frac{(Yi \times Pi) - (Oi + Fi + Ii)}{Wi}$$

Where: Vi = Annual residual water value per unit of water for crop (i)

Yi = Annual yield per unit of land for crop (i)

Pi = Price per unit of yield for crop (i)

Oi = Annual operating costs per unit of land for crop (i)

Fi = Annual fixed costs per unit of land for crop (i)

Ii = Annual interest cost per unit of land on fixed investments for crop (i)

Wi = Number of units of water required annually per unit of land for crop (i).

An alternative method of analyzing this same problem is to compute the internal rate of return on investment in machinery, land development and irrigation structures. This approach, however, differs from the residual value of water method in that it imputes the returns to the capital or groups of factors, including machinery, land development and irrigation structures as noted above. The former estimates the marginal or residual value of the amount of water saved by improvements or a given improvement in water management practices.

Due to the lack of sufficient data, the residual value of water could not be estimated accurately. Thus, the internal rate of return will be used as the analytical tool for measuring returns to water

used for irrigating rice.

In keeping with the purpose and general objective of the study, the following formal objectives were selected:

1) Identify and describe the various levels of management where irrigation is used in the production of summer (dry season) rice.

2) Estimate the efficiency of irrigation water use for each management situation.

3) Estimate the costs and returns for rice production under each management level.

4) Calculate the internal rate of return to each management category.

REVIEW OF LITERATURE

In considering literature to be reviewed and included in this section, it was felt that two basic areas should be covered. First, the subject of economic development, and in particular the development of the agricultural sector, was felt to be the foundation on which this study is based. For this reason, studies concerning the role of the agricultural sector in development, studies of production in developing countries and studies concerning the role of investment as related to the development of agriculture were all considered and are represented in this review. The second area of interest concerned literature dealing with the concept of the internal rate of return. Also, as a part of this general area of the measurement of the productivity of capital, studies dealing with benefit-cost analysis were reviewed and are included.

Agricultural Development

How applicable are the economic theories of the industrially advanced countries to the underdeveloped countries? A review of literature illustrates that opinions on the topic vary.

Myint (1965) points out that there are two lines of criticism concerning the applicability of economic theory of the industrially advanced countries to the underdeveloped countries: 1) differences in social and institutional settings and stages of development--

realism of economic theory and 2) relevance of economic theory which emphasizes optimum alllocation of resources, maintenance of full employment and prevention of "secular stagnation." The problem with underdeveloped countries, Myint asserts, is to initiate and accelerate the "take-off" into sustained growth. However, he later debates this notion and argues that the realistic approach has been hindered by generalizing from the "special case" of advanced countries and by generalizing from the "special case" of a particular underdeveloped country, such as India. This has been aggravated by the popularity of the "take-off" theory which has minimized attention as an academic discipline and placed it on increasing international aid. "The general good will toward these countries seems to have outstripped an accurate knowledge of how the economic systems of these countries really function," Myint states, urging a renewal of an academic approach to the subject (p. 491).

During the 1950s, most development economists ignored agriculture and looked to industrialization as the dynamic element of development, Witt (1965) believes. However, in more recent times, the agricultural sector has been receiving more and more attention. In part, this shift in emphasis has been brought about by an increased concern with food supplies which have come under increasing pressure from the unexpectedly large increase in population. Witt suggests that there should be increases in productivity in both agricultural and industrial sectors, and that some division or "balance" of effort is required.

Nicholls (1963) defines agricultural surplus as the physical amount by which the total production exceeds the total food consumption of an agricultural population. He believes that "until underdeveloped countries succeed in achieving and sustaining . . . a reliable food surplus, they have not fulfilled the fundamental pre-condition for economic development." (p. 1) Initially, a large and growing agricultural surplus can serve as the principal means of getting industrial development under way.

In presenting an analysis of a number of population and land tenure situations, Nicholls demonstrates the importance of having a substantial and reliable agricultural surplus as the basis for launching and sustaining economic growth. Nicholls believes agriculture is often unduly undervalued. In the short-run context of the next several five-year plans of some of the overpopulated countries, such would be unfortunate: 1) even if investment in agriculture has lower returns than the industrial sector, the high income elasticity of demand can turn modest food surplus into a deficit; 2) due to primitive techniques and very low productivity, overpopulated countries have tremendous opportunities to increase food output by small capital outlays; 3) international comparative advantage is far more likely to rest initially in agriculture than in the industrial sector.

Moore (1956) cites evidence that growth in Brazil has been burdened by economic policies favoring industrialization. However, he

also warns (Moore, 1955) that too much attention may be given to the agricultural sector because of a country's dependence on primary products and too little dependence on the economy in general. He states that historical studies indicate growth with the least disruption occurs if other sectors are growing fast enough to absorb labor released from agriculture as it develops, indicating that a sort of balance should be maintained in the economic development of all sectors of the economy.

Kuznets (1961) writes that agricultural revolution is generally the precondition of industrial revolution. And the relation of industrialization to agricultural change in the settled country is reasonably direct, believes Galbraith (1951).

Pasto (1961) argues that in agricultural economies, just as much emphasis should be placed on development of the agricultural sector as is being placed on the industrial sector. He points out that the agricultural sector contains the biggest single pool of labor, with substantial underemployment, and maintains that lucrative opportunities for raising productivity and employing labor more fruitfully exist right on the farms in underdeveloped countries.

Johnston (1951) maintains that an increase in agricultural productivity has played a crucial role in the industrial development of modern nations and is of particular importance in Asiatic countries, with their relatively dense populations. "Expanded agricultural productivity," Johnston states, "releases people from the land for em-

ployment in industry; it provides food for the growing population which is characteristic of the industrialization process; and, by making food imports less necessary, it relieves pressure on the balance of payments." (p. 498)

One of Africa's greatest needs is a link between the subsistence sector and the rest of the economy, believes Newmark (1959). He agrees that an improved system of agriculture and up-to-date methods of production would result in increased agricultural output, but these, of course, must prove economically advantageous.

No adequate guidebook exists for governments of underdeveloped nations to follow in seeking the most direct path to fostering economic growth, according to Miles (1967). Her contention is supported by Martin and Knapp (1967) who concluded that partial analysis of the problem has led to only partial solutions.

Christensen and Yee (1964) note that in the last few decades, several countries have moved into sustained-growth stages of economic development. In each case, "rising productivity in agriculture was a major source of an economic surplus that supported growth of the non-agricultural sectors." (p. 1060) Evidence shows that the less-developed countries with 3 percent annual population growth rates will not be able to enter the "take-off" stage of economic development unless they are able to increase agricultural output by 4 or 5 percent a year.

Contrary to the case of the developed countries where increase in productivity in the agricultural sector has little effect--due to the

fact that it usually acounts for less than 20 percent of national income--such increases in productivity have significant effects on the national income picture in the underdeveloped nations where agriculture is the primary source of national income, Christensen and Yee propose.

Moore (1956) conducted a study to determine the extent to which the increases in agricultural production in Brazil came from use of additional land, labor and capital. The results strongly support the inference that developments in agricultural production in Brazil are similar to those in the United States. Only about one-half of the additional output since 1925-29 is explained by additional inputs of the conventional type (land, labor and capital); the remainder came from changes in the state of productive arts, Moore reports. But just what is included in the so-called productive arts remains a question.

Johnston (1951) states that an 80 percent increase in agricultural output and the doubling of labor productivity in Japan over a period of 30 years were primarily the result of increased use of fertilizers and advances in farm technology.

He compares Japan to the experience of the USSR and Britain and notes that there were differences in the course of development in the agricultural sector. Johnston reports that there is no apparent single route to success; but in all cases, the development in agriculture seems to have been vital to the industrial expansion experienced in the rest of the economy.

Moore (1956) states that much attention in the post-World War II

period has been placed on factors which induce or accelerate development. On the question of how much increase in production came from conventional inputs from 1945 to 1949 in Mexico, he concludes that these account for 26 percent of a 60 percent total increase, the remaining 34 percent being attributed to better techniques that improved productivity of resources.

In an article dealing with agricultural development in Iraq, Yudelman (1958) writes that the development problem is one of investment. He notes that injections of capital can quickly bring about improvement in land and water resources, but the introduction of improved methods of production is slow and difficult. As a result, the emphasis tends toward the former and neglects things like management, education and communications, which actually could lead to a higher return on investments in physical resources.

Yudelman argues that in Iraq, management, rather than cultivable land, is the factor in short supply; and extending acreage at high investment costs without improved management by producers will lead to very low rates of return on investments.

Schultz (1966) proposes the hypothesis, "There are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture." (p. 37)

Schultz and others assert that in traditional agriculture, a state of economic equilibrium exists which explains its static nature. They maintain that the state of the arts and the state of preferences for holding and acquiring sources of income are both constant and have re-

mained so long enough to establish a condition of equilibrium. This implies that the marginal productivity of resources, given the existing state of the arts, can be viewed as an investment in permanent income streams or net saving which is approximately equal to zero. Investment in the right form is required to upset this balance.

Mellor (1966), Schultz (1966) and other economists have observed that increasing production by increasing traditional inputs is usually very costly and has poor results. On the other hand, they maintain, the introduction of new techniques and other modern factors may have very high returns.

"There is no longer any room for doubt whether agriculture can be a powerful engine of growth," Schultz concludes. "But in acquiring such an engine, it is necessary to invest in agriculture . . . the farmer must have access to and know-how to use what science knows about soils, plants, animals and machines. Incentives to guide and reward farmers are a critical component. Once there are investment opportunities and efficient incentives, farmers will turn sand into gold." (p. 3-5

Internal Rate of Return

In reviewing literature related to the general area of financial management and capital rationing for investment purposes in both private and public situations, two things are outstanding: 1) The subject, it is generally agreed, is very important and there is much interest in it. 2) There tends to be very little agreement as to the criteria for analysis, especially in regards to investment projects of a public nature.

Dean (1954) states that "the basic measure of economic worth is the productivity of capital, which means its power to produce profits." (p. 120) Phillips (1970) supports this idea and suggests that the reason for conducting a feasibility analysis of a project is to attempt to accurately predict the potential productivity of the capital required. However, as was noted by Gardner (1963), Dean (1954) and others, there exists a wide variety of approaches used in calculating this measure. To illustrate the wider range of results that can occur, Gardner (1963) examined several studies of the feasibility of range improvement. In this study, he observed that the rates of return reported varied from 4.8 percent to 297.5 percent. (See Appendix C.) He contends that while these studies all have as a basis for measurement the rate of return on investment, and that the costs and returns are essentially the same, they do not consider the flow of costs and benefits over time. This neglect, Gardner concludes, is a weakness of many such studies which attempt to measure the worth of capital investment.

To overcome this weakness, which is the cause of many errors in analysis of project worth, the concept of the internal rate of return has been proposed. One of its earliest proponents was Keynes (1936), who refers to the internal rate of return as the marginal efficiency of capital and proposes the following formula:

$$\int_0^t [R(t) - E(t)]e^{-rt}dt.$$

This is the net present worth of an investment option. In the equation, the receipt stream is denoted by R(t) and the outlay stream by E(t),

both being functions of time. The discount factor for t is denoted by $^{-rt}$. The rate r then is that rate which sets the present worth equal to zero. This, Keynes said, was the same as Fisher's (1930) rate of return over cost which is calculated by the equation

$$\int_0^t [R_1(t) - E_1(t)] - [R_2(t) - E_2(t)]e^{-rt}dt$$

where the notations are the same as those found in Keynes' equation. The subscripts refer to different investment options. However, according to Alchian (1955), this is not the case. Keynes' marginal efficiency of capital is not the same thing as Fisher's rate of return over cost which was developed in order to rank investment alternatives on the basis of maximum present value. Thus, Alchian contends that at least two alternative investment options must be considered simultaneously. However, he points out that the two measures are equal if only one investment is considered, which may be the reason the two are often confused, Alchian asserts.

There are a number of approaches used in calculating the internal rate of return, in addition to those mentioned and those discussed in the theoretical section of this study. At this point, it should be noted only that the results of each method are the same, since they are all founded on the common concept of the discounted cash flow into and out of a given investment alternative. And, in spite of arguments like that made by Dean (1954), who states that the internal rate of return concept ". . . is demonstratively superior to existing alternatives in accuracy, realism, relevance and sensitivity . . . ." (p. 125),

it is not without its weaknesses and its opponents.

The major weaknesses of the internal rate of return, according to Dean, are its greater complexity as compared to other measures, its higher costs to use and the fact that it is often unfamiliar. Another weakness is suggested by Hirshleifer (1958) who concludes that ". . . the present value rule for investment decisions is correct in a wide variety of cases . . . ." (p. 135), but he goes on to say that this measure (the internal rate of return) may not be precise in the analysis of multiperiod investment projects, since it is the average rate of growth of capital internal to these projects. He suggests that a more accurate measure might be the marginal productivity of capital. However, in spite of these weaknesses, most writers concur that the internal rate of return concept is superior to other measures of the productivity of capital which are based on the rate of return.

Another concept widely used in evaluating public investment projects is the benefit-cost ratio. This concept, according to Phillips (1970), is closely related to the internal rate of return for the same project. He states that the benefit-cost ratio is 1.0 when the investment and net benefit schedules are discounted at a rate exactly equal to the internal rate of return.

The actual calculation of the benefit-cost ratio is a relatively simple process since discounted benefits are simply divided by total discounted costs. However, the problem comes in determining which discount rate to use. Gramm (1963) describes the situation--as it

existed during the 1950s, at least--as being a case of picking a number from one to ten. He observes that during this period, Hirshleifer and others hit the all-time high by recommending that a rate of 10 percent be used, while Krutilla and Eckstein proposed a rate of from 5 1/2 to 6 percent, and Mason went so far as to suggest that, with respect to land resources, the appropriate rate may be close to zero. He concludes that in the case of public projects, there seems to be a consensus, arrived at since the 1950s, that a formal, profit-oriented rate of discount is unacceptable. Steiner (1959) reaches this same conclusion and suggests that in evaluating public projects, factors other than costs and benefits must be considered.

Some other studies which deal with what is referred to as the social discount rate, which is to be used in estimating the benefit-cost ratio, include the following:

Feldstein (1964) suggests that there are two types of rates which can be used. These are the social time preference rates which are normative in nature and reflect society's evaluation of future consumption, and the social opportunity cost rates which are the value to society of the next best alternative project in which public funds could be invested. In discussing these two types of rates, he concludes that the social time preference rate is superior and should be used.

A different view is taken by Castle, Kelso and Gardner (1963) who suggest that the discount rate used should be based on the current average yield of outstanding treasury notes which had at issue a matur-

ity of 15 years or more. But, in the final analysis, they too conclude that the selection of a discount rate is a normative issue which really is the only consensus that writers on the subject of the benefit-cost concept seem to be able to reach. In view of this conclusion, it seems that on the basis of arguments such as those presented by Friedman (1968) indicating that economics is and should be a positive rather than a normative science, the determination of just what rate of discount should be used in project evaluation may very well not even be in the realm of economics. It may be that this problem would be best left in the hands of politicians.

However, in regards to private investment problems, as Dean (1954) states, " . . . management needs an objective means of measuring the economic worth of individual investment proposals . . . . " (p. 120). Lorie and Savage (1955) agree with this idea and insist that in financial management, a major " . . . task is to ration available capital or liquid resources among competing investment opportunities" (p. 229). In still another study, Eckstein (1961) reached this same conclusion and noted that the benefit-cost analysis ranks projects differently than does the internal rate of return. The reason, he asserts, is that in regards to the former, " . . . the implicit assumption is that it is the resource bundle cost which is rationed" (p. 61). On the other hand, he argues that where only " . . . capital is rationed but all other resources are available in sufficient quantity at their market prices . . . " optional allocational of capital " . . . can be

accomplished by capital budgeting and by the use of a rate-of-return criterion."

THEORETICAL BASIS FOR ANALYSIS

When conducting a feasibility analysis of an investment project or when comparing various projects for investment, the primary concern is to accurately predict the economic potential or soundness of each such project. The measurement criteria of analysis of this type is normally the expected rate of return on capital investment. However, leaving the criteria for profitability measurement at this point can be misleading and can result in erroneous conclusions. This results from the fact that the benefits on which the rate of return is based are often not treated as occurring as a continuous stream over time but are merely summed for the entire project life and in this form compared to the investment costs. The error committed in approaching profitability in this fashion lies in the fact that the length of the project life and its effects on the rate of return are ignored. In order to make the measure complete, it must be emphasized that the concept of time as a flow be incorporated in the analysis. By adding this dimension (time as a flow instead of time as a period), the rate of return on investment becomes what is referred to as the internal rate of return.

Definition of Internal Rate of Return (IRR)

A very simple definition of the IRR is that it is the rate of capital growth within the firm, business or project. As such, it is direct-

ly comparable to the interest rate paid by common investments such as bank accounts, bonds or accounts with other financial agencies. Also, it is directly comparable to the interest rate paid by borrowers to lending institutions. These rates are referred to as the external rates of return (interest). A somewhat more sophisticated but clearer way of defining the IRR is to consider it as being that annual compound discount rate which makes the present value of the investment schedule equal to the present value of the net benefit schedule.

Requirements for Calculation of the Internal Rate of Return

There are several variations in solving for the IRR of a project. The variation chosen will depend on the specific situation that exists in regard to the problem being considered. However, all of the approaches require essentially the same basic information and assumptions. First, it is not necessary to assume an interest rate or calculate interest charges. Second, calculation of annual depreciation is not necessary. Third, the rate of inflation need not be considered. And finally, it is not necessary to assume a given percentage of equity or the terms of financing.

In order to calculate the internal rate of return on private investment, only two sets of data are needed: 1) the schedule of total capital investment and 2) the schedule of annual net benefits. Both of these sets of data, however, must be developed with a number of standard rules in mind. These include the following:

1) The limitation of the expected results, in terms of benefits

and costs, to a realistic planning period or horizon.

2) Investment expenditures should be entered in the investment schedule for the year in which they are required.

3) Equipment with a useful life shorter than the planning period should be reentered at cost when replacement is required. Any remaining value in any such equipment may be treated as a credit in the last year of the planning period.

4) Only the direct annual net benefits, which are simply total revenue from the project less the operating costs, should be included when computing the schedule of benefits. Spinoffs and so-called secondary benefits can be ignored since these normally would not accrue to a private operation.

5) Benefits should be entered over the life of the project as they are expected to be received.

6) Both benefit and investment figures should be based on constant price levels. This can be done by using current prices or those of the most recent base period available. For the analysis of this study, current prices were used.

7) Negative net benefits and investment credits should be entered in the appropriate years with a minus sign. By so doing, these figures are reflected automatically in the internal rate of return calculations.

Maximization of the Internal Rate of Return

Under certain investment circumstances, the project life expectancy may be uncertain because of factors external to the project itself,

as it often is in some developing countries. For example, there is the possibility of expropriation of the project by the government, and in cases where the investment project being considered does not necessarily have a fixed economic life expectancy, it may be advantageous to use the maximum internal rate of return possible as the criterion for analysis. If this criterion were to be used for project comparison, the investment and benefit schedules would be calculated in the usual manner, subject to a fixed planning period. However, the internal rate of return would be calculated after each year of the project life, with the maximum rate becoming the criterion for setting the actual project life.

A diagrammatical solution to a problem of the nature described above, where the project does not have a fixed economic life, is presented by Boulding (1966). Boulding considers an investment in new wine which was purchased at the beginning of the period and placed in a cave for aging, which improves the quality of the wine and so, also, its worth, and involves no further costs except the opportunity cost of having the money tied up in the wine.

Boulding's solution to this situation for maximizing the IRR is reproduced in part in Figure 1. For convenience in drawing the graph, Boulding measures costs and returns on a logarithmic scale, so that curves with uniform rates of growth become straight lines. CJAB is the revenue curve showing increase in the worth of the product resulting from the initial investment OC. The internal rate of return at any point, say, J at a time OL, is the average rate of increase in capital during

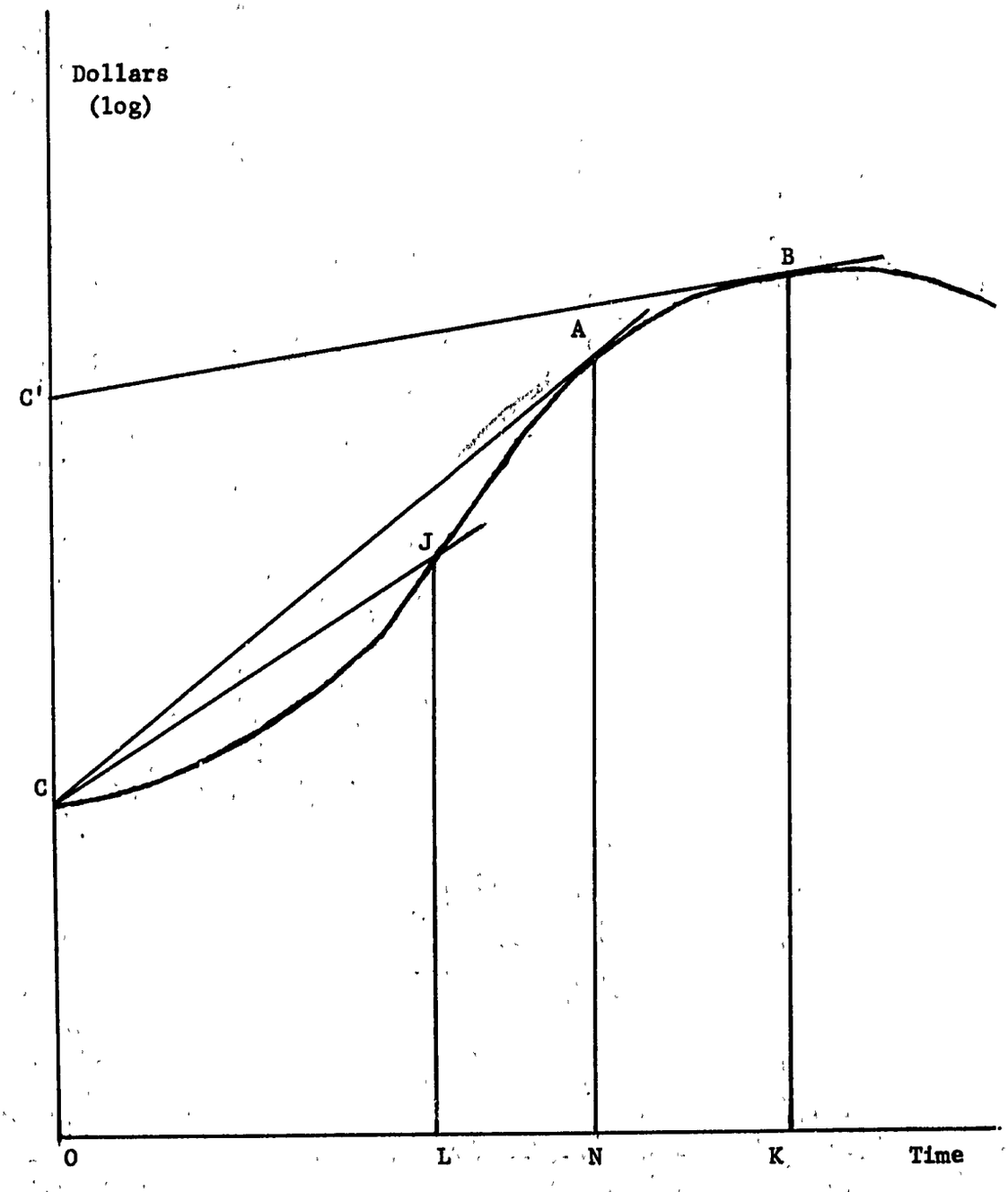

Figure 1. Maximization of the internal rate of return. (Boulding, 1966)

the period, which in the logarithmic diagram is equal to the slope of the line CJ. To find the time ON at which the IRR is at a maximum, Boulding draws the line CA to touch the revenue curve at A; the slope of CA represents the highest average rate of increase in capital possible on the given revenue curve. Boulding concludes the illustration by explaining that if the normal rate of interest is less than this, being represented by a line such as C'B, which is also drawn tangent to the revenue curve and having the appropriate slope, the point of maximum internal rate of return is at a shorter period of investment than the point B, which represents the point of maximum discounted net revenue at that particular rate of interest. A situation quite similar to this may exist in regards to private investment in agricultural projects in Ecuador and other developing countries where investors fear expropriation because of land reform policies. Thus, instead of maximizing the discounted net revenue using the market rate of interest C'B to reach a point such as B, which represents a project life of OK, as in Figure 1, the investor may wish to maximize the internal rate of return from this investment. If this rate is higher than the market rate of interest as was noted earlier, the project time horizon that would be economically profitable, from the point of view of the investor, would be a period such as point A which is shorter than the period that would maximize the discounted net returns.

Calculation of the Internal Rate of Return

The measure of economic soundness or profitability that will be used in this study is the internal rate of return. The internal rate of return measures the potential return on capital investment in a project on the basis of the time flow of funds into and out of the project. By way of review, it is the annual compound discount rate which makes the present value of the investments in the project equal to the present value of the net benefits stemming from the project such that when the two amounts are added, the sum is zero. It can be calculated mathematically by solving for i in the following formula:

$$Id + I_1 \left(\frac{1}{(1+i)}\right) + I_2 \left(\frac{1}{(1+i)^2}\right) + \ldots + I_n \left(\frac{1}{(1+i)^n}\right)$$

$$= Bo + B_1\left(\frac{1}{(1+i)}\right) + B_2 \left(\frac{1}{(1+1)^2}\right) + \ldots + B_n\left(\frac{1}{(1+i)^n}\right)$$

in which I = net investment in each year

B = net benefit in each year

i = internal rate of return

0, 1, 2 . . . n represent the year dating from the present.

Of course there are other mathematical formulas that can be and are used to calculate the internal rate of return, but it should be emphasized that results will be the same in every case because all of these methods are based on the equation of the present value of net benefits to the present value of net investments.

Unfortunately, this formula and all of the others for calculating the internal rate of return are unwieldy; and for practical purposes,

the value for "i" cannot be found very conveniently. However, through the use of present value tables, the rate of return may be estimated satisfactorily by assuming an approximate rate of interest and multiplying the annual net returns by the discount factor corresponding to the interest rate being used. The proper interest rate has been found when the discounted net investments are equal to the discounted net benefits, or in other words, when the sum of these two amounts equals zero. If this sum is greater than zero, the interest rate used is too small and vice versa. This approximating procedure is the method utilized in later sections.

PROCEDURES AND SOURCES OF DATA

Various sources of data related to summer rice production in the Guayas Basin were used in satisfying the objectives of this study. General information concerning Ecuador and the Guayas Basin was obtained from the United Nations Yearbook of Production and Trade and from the Yearbook of National Income Accounts. Also, recent studies of the region made by the Pan American Union and CEDEGE (Comision de Estudios Para el Desarrollo de la Cuenca del Rio Guayas) as well as statistics available from Ecuadorian government agencies were considered and used whenever possible.

The information used in accomplishing the first objectives--identifying and describing the various levels of management where irrigation is used in the production of summer rice--came from several sources. These include 1) a visit to the Guayas Basin during the summer of 1970 where a personal survey of rice production techniques and water management practices was undertaken; 2) personal interviews with officers and agents of the National Rice Commission of Ecuador; 3) personal interviews with representatives of COFIEC, a private finance company which is active in loaning funds for development of irrigated rice production; and 4) personal interviews with representatives of the National Institute of Hydrological Resources of Ecuador.

Objective number two was developed through the use of information obtained in interviews with rice producers in the Guayas Basin. Climatic data concerning evaporation and precipitation rates in the area were obtained from government reports and were used with findings of studies conducted at various locations throughout the world in order to estimate the water requirements for rice in the study area.

The third objective was achieved through the use of data from several different sources. First, a limited number of producers in each of four management categories were interviewed with the aid of a prepared questionnaire. See Appendix A, questionnaire number one. In this survey a total of 12 interviews was made, representing 1 producer in management level I, 28 producers in management level II (one interview in this group represented the average results of 23 producers of the Juján rice cooperative), 3 producers in management level III, and 33 producers in management level IV (one interview in this group represented the average results of 30 producers of the Hacienda Monterey). Second, information obtained from annual surveys made by the National Rice Commission of Ecuador (see Appendix A, questionnaire number two) and including nearly all rice producers in the Guayas Basin was used to supplement the first source of information mentioned. Third, a survey of farm machinery dealers in Guayaquil was made to determine the cost of farm-related equipment and supplies. The information obtained in this survey (see Appendix G, table 41) was also utilized in developing costs and returns budgets for each of the four management groups.

The fourth and last objective was achieved by calculating the schedule of total capital investment, including land development and machinery, and the schedule of net benefits expected on the basis of the results of the third objective. The planning period over which these estimates were made was assumed to be the same for each management level. This assumption was necessary in order to arrive at comparable rates of return which might be useful to an investor considering production of rice at any one of the management levels.[1]

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[1] By adopting the point of view of a potential investor, attention is focused on the net returns to productive factors, given a set life. This may not be an appropriate attitude for a farm operator already in rice production. He may be more interested in the volume of receipts, over and above annual variable costs, since fixed costs are already sunk.

LIMITS OF RICE PRODUCING AREA

Soil Type

Virtually all of the rice produced in Ecuador is grown in the Guayas Basin (Figure 2). This basin covers an area of 33,640 square kilometers. It is a broad north-south trending basin whose extensive southern flood plain merges into a partially dissected and undulating landscape in the upper regions. The basin is enclosed to the east by the very steep and elevated Andean Cordillera, and lower, dissected ranges to the north and west. The elevation of the basin ranges from just a few meters above seal level in the flood plain region to 4000 meters on the Andes Mountains.

It is in the flood plains region that the rice is grown. The heavy clay soils and slight slopes (0-2 percent) are factors which make this area adaptable to rice culture. While there is very limited production of rice in the Naranjito soils, essentially it is limited to the Daule and Vinces soil groups (Appendix E). The Daule soils are heavy clay with poor internal and external drainage and are located along the Guayas and Babahoyo rivers extending back from 10 to 20 kilometers on both sides and continuing up the Babahoyo as far as Samborondon. Also these soils continue from the Guayas River up the Daule River as far as Balzar in a band ranging from as little as one kilometer to 20 kilometers in width along the west bank. The Vinces soils are only slightly lighter in texture than those of the Daule association and occur in depressions.

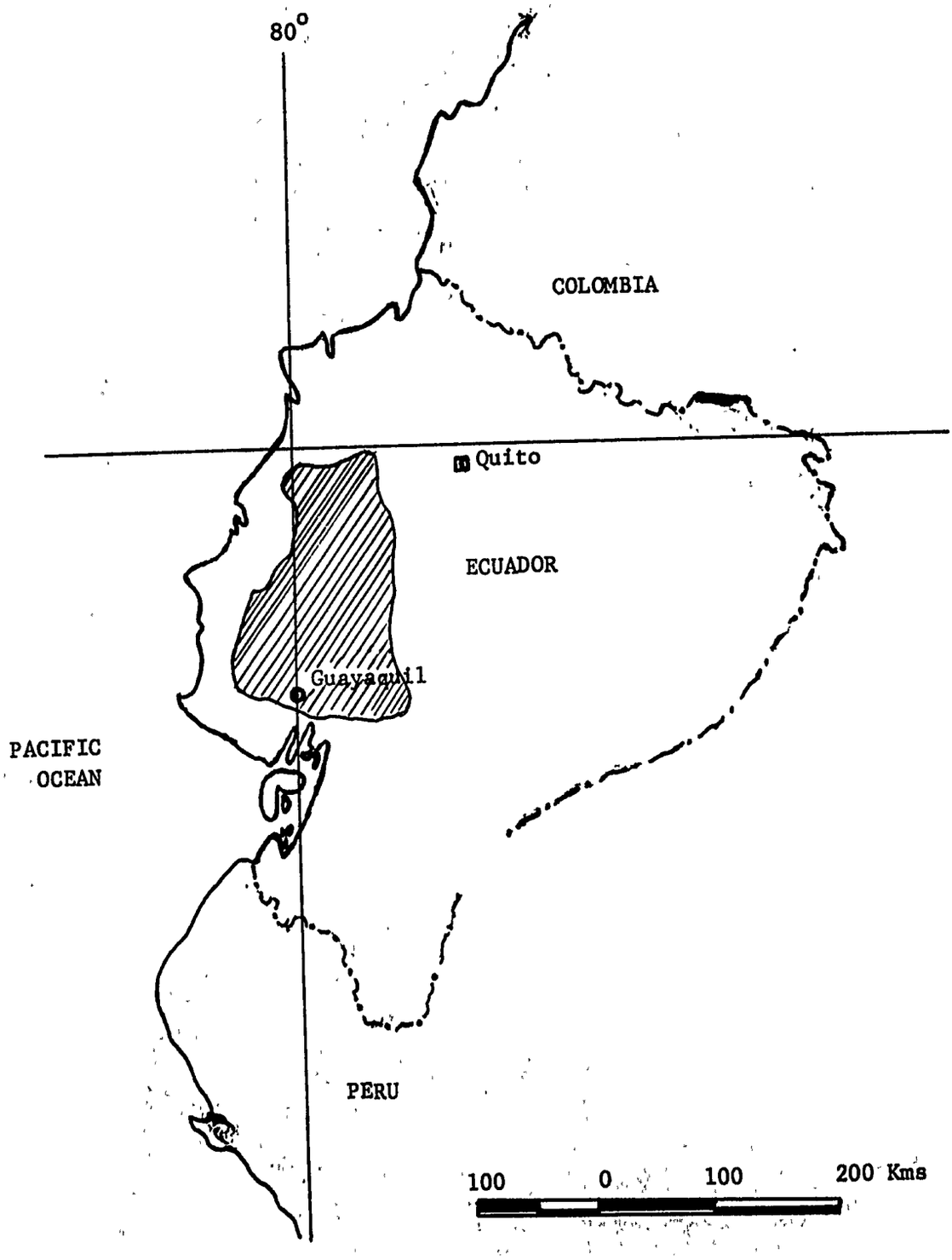

Figure 2. Location of the Guayas Basin.

They have only fair internal and poor external drainage.

Quality of Irrigation Water

The other major factor which limits the extent of the rice-producing region is the quality of the water available for irrigation. The lower portion of the basin has a salinity problem, a result of the low elevation of the flood plain and the tidal effect from the ocean, which extends as far upstream as the Daule area during periods of high tide. However, over much of this distance, upstream from Pascuales (Figure 3), the incoming tide primarily causes the fresh water from the river to back up. There is not enough mixing of the saline water from the ocean with the fresh river water to result in water quality deterioration to the point where it would be unfit for irrigating agricultural crops.

Below Pascuales, beginning at a point 15 kilometers upstream (north) of Guayaquil, there is a substantial increase in the salinity of the water in both the Daule and Babahoyo rivers. Figure 4 shows salinity measurements taken by the Parson Company, Guayaquil, at different locations on the Daule River. These measurements are based on the electrical conductivity of the water, expressed in micromhos. There is a direct relationship between the electrical conductivity of the water and the amount of salinity. It is important to note that the electrical conductivity upstream from La Toma is constant at about 200 micromhos. Downstream from this point, however, the electrical conductivity increases rapidly to over 3000 micromhos at Aurora which is near the confluence

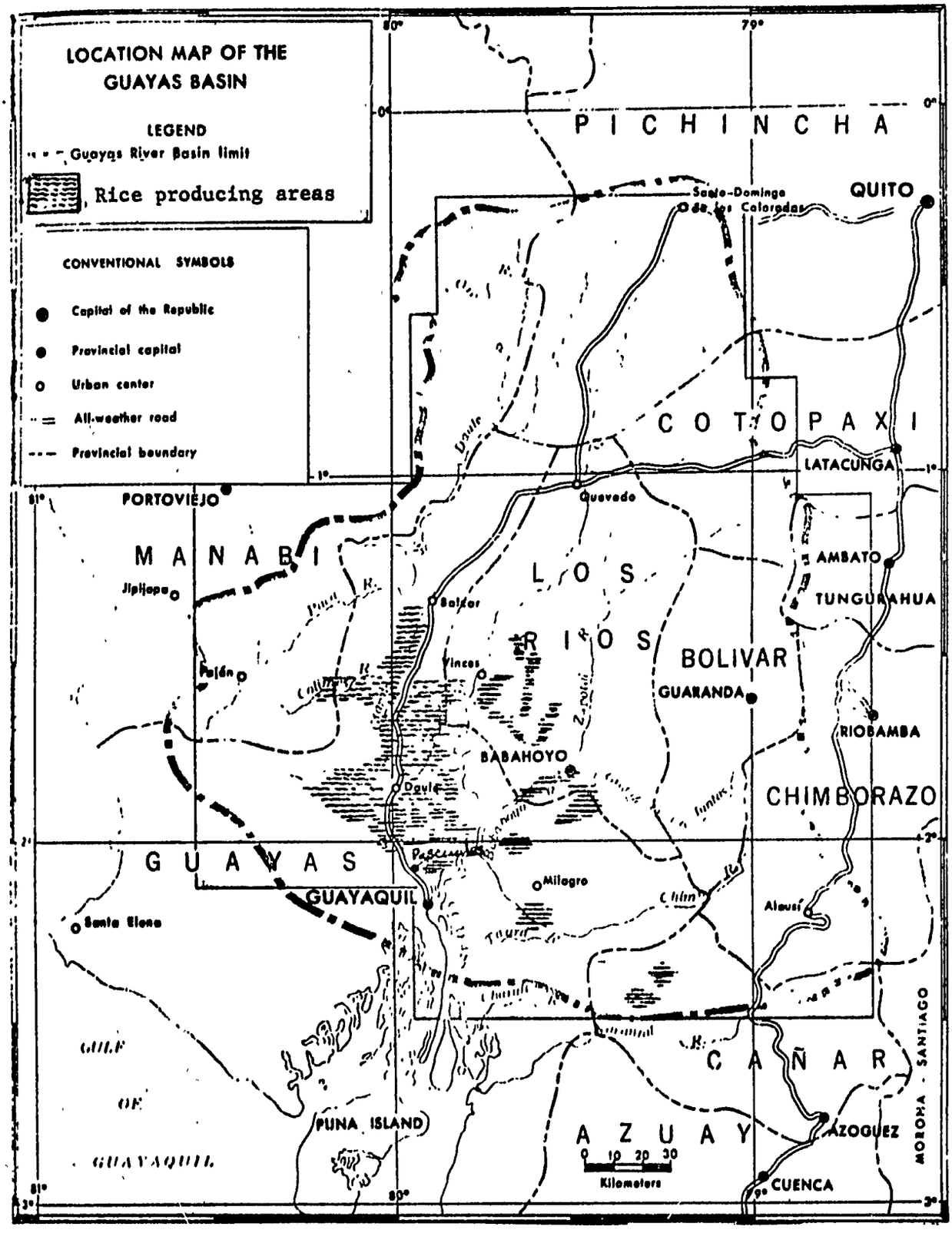

Figure 3. Rice producing areas of the Guayas Basin

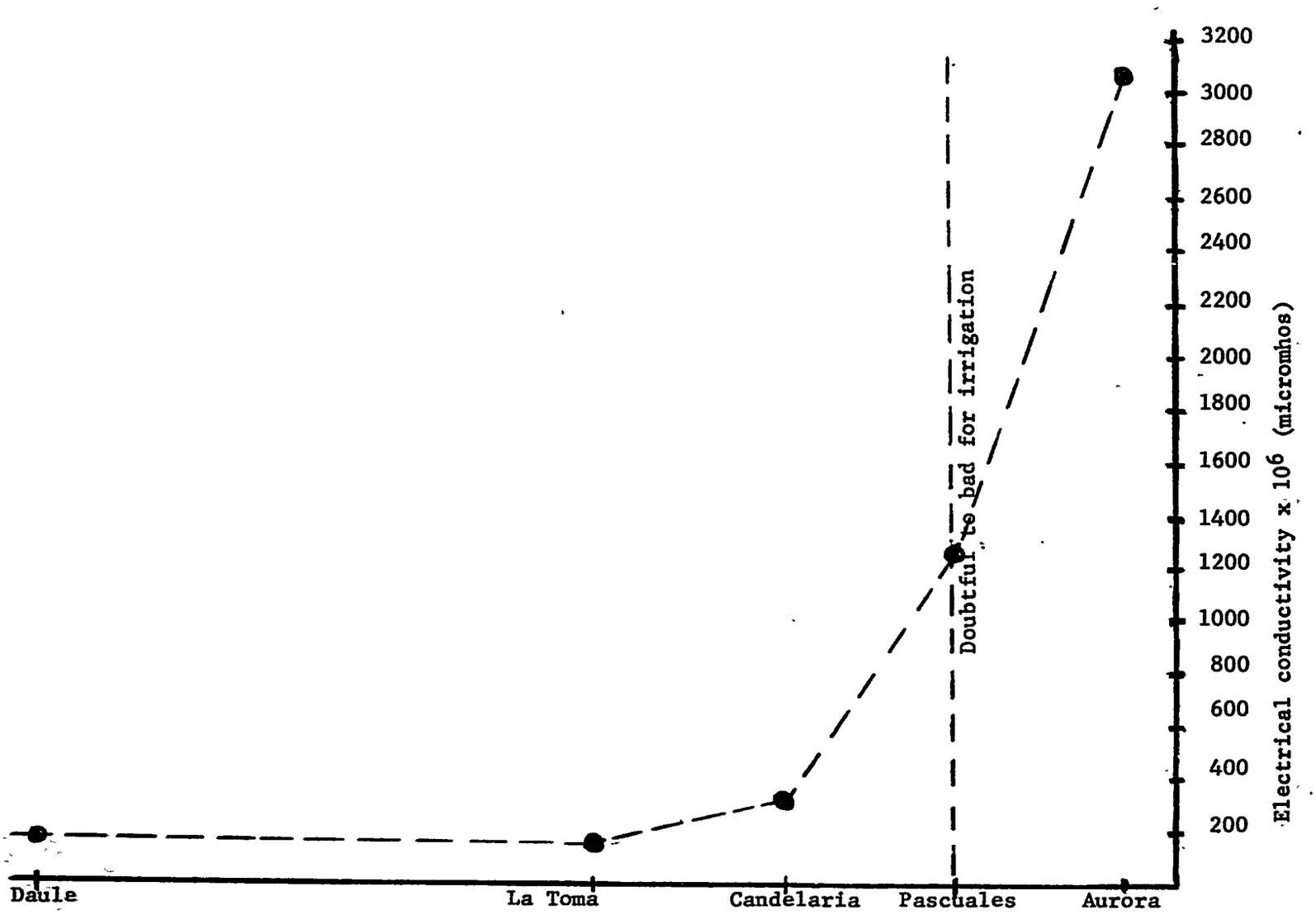

Figure 4. Salinity of the Daule River. (Compania Parson, 1969)

of the Daule and Babahoyo rivers, the head of the Guayas River.

Table 3. Standards for irrigation waters.

Water Class	Electrical Conductivity EC X 10^6	Salt Content Total ppm	Salt Content Tons per Acre-Foot	Sodium %	Boron %
1	0-1000	0-700	1	60	0.0-0.5
2	1000-3000	700-2000	1-3	60-75	0.5-2.0
3	over 3000	over 2000	over 3	75	over 2.0

(Israelsen and Hansen, 1962)

At La Toma, the water is considered to be in Class 1, according to standards set by the United States Salinity Laboratory (see Table 3), and it is excellent to good for irrigation purposes under most conditions. The measurements taken at Pascuales indicate that the water has deteriorated in quality to the point where it is in the Class 2 range, which includes waters that are injurious to the more sensitive crops (Appendix E). The condition of the water at Aurora places it in Class 3. Waters in this class are considered harmful to most crops and unsuitable for use for irrigation under most conditions. Hence, no rice is produced downstream from Aurora; and generally speaking, it ends a few kilometers upstream in the vicinity of Pascuales.

No salinity measurements are available for the Babahoyo River, but rice farmers in the area report that salinity conditions injurious to rice culture extend farther upstream than they do in the Daule River.

These conditions, then, would seem to place the lower limit of the area suitable for rice culture along these rivers at the vicinity of Pascuales, Figure 3.

PRESENTATION AND ANALYSIS OF DATA

This section will serve three distinct purposes. The first part contains a discussion on the efficiency of irrigation water use based on the premise that the amount of water needed for rice culture is the amount required for potential evapotranspiration. The efficiency of water use will be calculated for each management category for which sufficient data are available. Second, each management level category will be described in some detail, and operating costs and returns budgets will be estimated and presented for each group. The final part will present the calculation of the internal rate of return to the required investment associated with each management level.

Evapotranspiration and Efficiency of Irrigation Water Use

On the basis of their water relationships, there are three types of plants: hydrophytes that normally grow in water (paddy rice belongs to this group); mesophytes, which suffer permanent wilt damage after losing 25-50 percent of their water content; and xerophytes, which are plants that wilt permanently only after losing from 50 to 70 percent of their total water content.

Water, according to Kramer (1963) is needed by plants because it is 1) the major constituent of physiologically active plant tissues; 2) a reagent in photosynthesis and in the hydrolytic processes; 3) the solvent

in which salts, sugar, and other solutes move through the plant, and 4) an essential element for maintaining plant turgidity, which is necessary for cell development. In addition, water is needed for transpiration, which, while serving no direct function, is essential for plant growth. The lack of sufficient water reveals itself in reduced yield and changes in growth pattern.

Israelsen and Hansen (1962) define consumptive use or evapotranspiration as being the sum of 1) the amount of water entering plant roots and used to build plant tissue or being passed through the leaves of the plant into the atmosphere, which is transpiration and 2) the amount of water that evaporates from the adjacent soil or water surfaces, which is evaporation. It is influenced by temperature, irrigation practices, length of growing season, precipitation and other factors. The amount of water transpired by plants depends in part on the amount of water at this disposal, the temperature and humidity, wind movement, intensity and duration of sunlight, stage of development of the plant, type of foliage, and the nature of the leaves.

Many methods have been devised to measure the amount of water consumed by crops and natural vegetation. These can be divided into three general categories. First, there are the direct measurements of evapotranspiration. The principal methods employed are tank and lysimeter experiments, field experimental plots, soil moisture studies, integration, and inflow-outflow for large areas. Second is the use of climatic observations as an index to evapotranspiration. This approach

emphasizes the influence on consumptive use of such climatic factors as temperature, humidity, wind velocity, vapor pressure, and solar radiation. Several formalized theoretical models with these factors as their bases have been developed by such notable scholars as Penman, Thornthwaite, Lowry and Johnson, and Blaney and Criddle. Each model emphasizes the importance of a different factor and approaches the problem in a slightly different manner. The third technique used to measure evapotranspiration uses evapotranspiration as measured with a United States Weather Bureau pan as an index to consumptive use. Regardless of the method used, the problems encountered are numerous, and the accuracy of any given measure under all circumstances is questionable. Thus, coefficients of evapotranspiration developed for use in one geographical area or climatic zone may not be accurate in a different one. Hence, the method selected for use in any given situation depends primarily upon the type and quality of the data available and the applicability of the measure as indicated by experiments conducted in the particular area to be studied.

In this study, for the reasons mentioned above, the evaporation index was selected as the basis for measuring consumptive use of rice in the Guayas Basin. This selection is also supported by findings reported by Christiansen and Hargreaves (1966) in which they conclude that the evaporation index which uses Hargreaves crop coefficients (these coefficients relate consumptive use as a percent of evaporation as measured by the United States Weather Bureau pan) gives much more accurate results in the tropics than the other methods to which it was compared--

namely the methods developed by Thornthwaite and Blaney and Criddle.

The Piche evaporometer is used to measure evaporation in many countries. It is essentially a test tube filled with water, inverted with a blotter over the end, and installed in a conventional shelter. The comparison of evaporation measured by the Piche unit and that measured by the Weather Bureau pan is debatable. Israelsen and Hansen (1962) argue that because of the small size of the Piche unit, rates of evaporation exceed water use by crops. They also claim that Piche values are larger than those obtained from a Weather Bureau pan. They indicate that " . . . multiplying Piche readings by 0.7 gives average comparable values, although the coefficient does change with climate, season and exposure." Christiansen (1971) and others, however, disagree with this conclusion. These writers take the opposite position and argue that due to the fact that Piche units are sheltered, there is less than the natural amount of air circulation present, and the humidity around the unit is higher than it is outside the shelter, resulting in decreased evaporation. They argue that the evaporation from the Piche units is less than that measured by the Weather Bureau pan. This contention is supported by weather data obtained at the Milagro Weather Station, Ecuador, as shown in Table 4. The information shown here indicates that Piche readings are substantially smaller than those taken from the Weather Bureau pan, and that multiplying them by 1.5 (not 0.7) will give comparable readings to those from the Weather Bureau pan.

For the purpose of this study, in estimating the required amount

Table 4. Comparison of Piche and Weather Bureau pan evaporation data by month from Milagro Weather Station, Ecuador. 1969.

	Evaporation (MM) Pan	Piche	Difference	Pan/Piche
January	138.8	93.8	45.0	1.5
February	129.7	81.6	48.1	1.6
March	122.3	64.8	57.5	1.9
April	111.0	61.3	49.7	1.8
May	104.5	64.8	39.7	1.6
June	89.0	61.4	27.6	1.4
July	99.7	68.8	30.9	1.4
August	102.9	78.3	24.6	1.3
September	133.4	91.6	41.8	1.5
October	118.3	83.9	34.4	1.4
November	112.8	89.4	23.4	1.3
December	132.7	103.3	29.4	1.3
Total	1395.1	943.0	452.1	1.5

of water for rice culture, the conclusions of Christiansen and the data in Table 4 are accepted, and evaporation measurements used are those from the Weather Bureau pan.

The amount of water required to meet the consumptive use needs or potential evapotranspiration of plants varies from crop to crop. Studies conducted at different locations around the world indicate that the ratio

between the potential evapotranspiration and evaporation from a Weather Bureau pan--both measurements being taken at the same locality--for mature crops varies from .35 for pineapple as measured in Hawaii to 1.40 for sugar cane as measured in South Africa. For rice, studies conducted in Australia by Butler and Prescott (1955) indicate that the average is 1.10. These findings are in close agreement with Hargreaves who has developed coefficients for rice for each stage of development. These ratios range from .95 during the early stages of growth to 1.10 at maturity and drop to .90 as the plants ripen.

Efficiency of water use can be examined from various viewpoints which include the efficiency with which water is conveyed to the farm, the efficiency of water application, water-use efficiency, water-storage efficiency, water-distribution efficiency and consumptive-use efficiency. In calculating the efficiency with which a given farm or irrigation project uses its water, several of these measures may be used. For this study, the concept of water-use efficiency used is the ratio of the water delivered to the farm and the amount of that which was beneficially used. It is calculated by using the formula

$$Eu = 100 \frac{Wu}{Wd}$$

where Eu = water use efficiency

Wu = water beneficially used

Wd = water delivered.

The amount of water beneficially used is defined as being equal to the potential evapotranspiration for rice during the summer of 1969 less

the amount of precipitation that occurred during the same period plus 15 centimeters of water required initially for presaturation of the soil prior to planting. The amount of water delivered to the farm is defined as the total amount of water pumped from the river; no consideration is made for conveyance losses because of the close proximity of the fields to the river. To arrive at an estimate of the amount of water pumped from the river, the capacity of the pumps used was multiplied by the amount of time they were operated.

Table 5 shows the calculation of the net amount of water required by the plants. The precipitation and evaporation data were taken as reported at Milagro, the location of which is shown in Figure 3. Average yearly and monthly precipitation data are important in regards to irrigation water needs and give indications as to what conditions can generally be expected. However, in estimating the water-use efficiency, a more accurate estimate can be made if actual amounts of precipitation are used, as they occurred during the irrigation season.

In Table 6 the water-use efficiency for each level of management for which the required information was available was calculated using the above formula. The net amount of water needed is the same as that shown in Table 5. Management level I was the highest in water-use efficiency, with 37 percent of the water delivered to the farm beneficially used. The water-use efficiency for management level II was estimated to be 34 percent. Due to the lack of sufficient data, it was not possible to make comparable estimates for the other two management

Table 5. Potential evapotranspiration and net water needs for summer rice, stated in millimeters. 1969.

Month	Evaporation Milagro	Hargreaves Coefficients	Potential Evapo-transpiration	Liters/ Sec./ Hectare	Total Water Needed	Precipitation	Net Water Needed	Liters/ Sec./ Hectare
June	89	.95	43[1]	.33	193[2]	36	157	1.21
July	100	1.05	105	.39	105	0	105	.39
Aug.	103	1.10	113	.42	113	1	112	.42
Sept.	133	1.10	146	.56	146	1	145	.56
Oct.	118	.90	106	.40	146	0	146	.40
Total	543	1.02	513	.42	703	38	665	.60

Notes:

1. Irrigation for only last 15 days of the month.

2. Includes 15 centimeters for presaturation.

Table 6. Estimates of water-use efficiency.

Management level	Net water needed per hectare (mm)	(liters)	Total water supplied per hectare (mm)	(liters)	Water-use efficiency %
I	665	6,650,000	1,820	18,200,000	37
II	665	6,650,000	1,955	19,550,000	34
III	665	6,650,000	--	--	--
IV	665	6,650,000	--	--	--

levels. Both of these groups cultivate rice in natural depressions which contain water received during the rainy season. This, of course, eliminates the need for irrigation during the early part of the growing season. Later, when irrigation is needed, farmers in management level IV rely solely on the high tides to bring the water to a level which will permit it to flow naturally into the paddies. This same practice is followed by the farmers in group III, but flooding is supplemented by pumping during the latter half of the growing season. The total amount of water used in either case could not be measured with sufficient accuracy to enable the calculation of the efficiency of water use.

Generally, water is considered to be a scarce resource and, as such, efficient use of irrigation water is an obligation of each water user. The level of irrigation efficiency achieved by an indiv-

idual farmer, however, depends on a number of factors, some of which are beyond his control. In areas where water is scarce and costly, it is usually used carefully. However, if it is abundant, the value is less, and the tendency is to waste water. Also, efficiency is influenced by the cost and quality of labor, ease of handling water, crops being irrigated, and soil characteristics. The most common losses of water in most farm situations, though, are represented by runoff and deep percolation. In regards to paddy-rice culture losses, runoff can be controlled relatively easily, but deep percolation is a function of soil type and cannot be controlled. It is for this reason that rice is usually grown on heavy clay soils where internal drainage is poor. Thus, losses from deep percolation are usually negligible.

In regards to the paddy rice irrigation water use efficiencies estimated in this study, it must be concluded that the efficiency levels are relatively low, since in other areas studies indicate efficiencies are in the range of 60 to 75 percent and even higher (Israelsen and Hansen, 1962; U.S. Department of Agriculture, 1961). It will be remembered that the rice production studied was limited to the Daule and Vinces soil groups which have poor internal drainage. This would indicate that the low water use efficiencies found (Table 6) are probably due mainly to losses from runoff. It is likely that some water wastage is desirable in the Guayas Basin because of the salt content of the water used for irrigation. However, this would not account for the low irrigation efficiency levels. Thus, on the basis of the present data,

it should be concluded that excessive amounts of water are being used, at least by management levels I and II. Further study would be required, however, in order to draw any conclusions as to the exact amount of water being wasted and the amount by which irrigation costs could be decreased.

Description of Management Levels and Presentation of Costs and Returns Budgets

The purpose of this section is to discuss and describe the different management levels through consideration of cultivation operations. Also, costs and returns for summer rice production are presented in budget form, by management level. In all, four management levels have been identified and are discussed. Table 7 shows, in summary, some basic differences that exist among the four management levels. Before proceeding, a few observations concerning additional factors affecting the overall production performance in each management level should be made. First, it was discovered that several seed varieties are used. In general, the upper two management levels used improved seed varieties--the IR-8 variety was the most frequently used--while the lower two used unimproved strains. Several experimental studies conducted in the Guayas Basin indicate that the improved varieties are better producers and respond more readily to fertilization. See Appendix C for results of these experiments. Second, both direct planting and planting by transplant were observed. Studies regarding any

Table 7. Differences among management levels.

Management Level	Investment per Hectare (Sucres)	Mechanization (Percent)	Commercial Fertilizer Used (Lbs. per Hectare)			Amount of Irrigation	Yield (Quintals per Hectare)
			N.	P_2O_5	K_2O		
I	18,406	82	600	200	100	Total	100
II	15,970	88	225	0	0	Total	43
III	2,490	0	8	0	0	Supplementary	42
IV	500	0	0	0	0	Minimal	22

differences in yields due to the different planting techniques are inconclusive at this point. But, one study conducted in the Guayas Basin by Andrade (1969), in which both planting methods with three varieties of rice and four levels of nitrogen were included, found no significant difference in yields (Table 30, Appendix C). No adjustments to data have been made to reflect or compensate for impact on yields due to such factors.

The costs and returns budgets are broken down into each operation performed on a given rice enterprise. As mentioned previously, only farms located on the Daule soil group are included. Hence, differences in production due to soil differences are ignored. Sources of income and expenditure from and on other enterprises on the farm are not included. Also, all labor used is included at actual cost where such information was available, or it is entered at the average cost determined for the type of work done. However, in the case of management level IV, since no cash expenditure is actually made for labor, production costs will be calculated in two ways. First, labor costs are imputed at existing market rates. Second, a budget for this group is calculated excluding labor costs. Management and administrative costs are only included where such services are hired.

The primary basis for categorizing producers of summer rice into different management levels is their water management practices. Also, in connection with these, the level of rice-land development is considered to be an important distinction. The degree of mechanization

of cultivation as indicated by the percent of the total number of cultivation operations that are carried out by machine is also considered in establishing management categories. In the four management levels delineated in making the field survey in the Guayas Basin, however, some common practices and conditions were observed. The most notable of these was that all rice producers use the land on which rice was planted solely for rice culture. No crop rotation practices were observed.

Management level I

Management level I represents the highest level of management. These managers are highly trained and take advantage of the most recent innovations in rice culture. When the data for this study were being collected, this group of managers was relatively new in the Guayas Basin and was not widely established.

The irrigation system and practices used by managers in level I are highly dependent on the organization of rice fields. Land for rice culture is divided into production units of approximately 100 hectares in size (Table 8). An average farm in this category cultivates about 500 hectares and so has five such units. The production units are further divided into permanent paddies which average about two hectares in size (Table 8) and are leveled to zero slope. The exact size of each paddy is determined by topographical conditions. Generally the size of a paddy is inversely related to the amount of earth per hectare that must be moved in leveling. The maximum amount of leveling per hectare that is generally acceptable is 500 cubic meters or the equivalent of

Table 8. Average size production unit and rice paddy in hectares.

Management Level	Number Production Units/Farm	Production Unit	Rice Paddy
		Hectares	
I	5	100	2
II	1	150	7
III	1	25	1.4
IV	1	5	.7

an average cut of five centimeters over the entire area. It is felt that the cuts in excess of this five centimeter average significantly reduce natural soil fertility. The exact arrangement of the paddies is also influenced by topographical conditions, but they are ordered so that water flows from a main canal through several paddies before it reaches drainage ditches. Thus, successive paddies must be lower than the previous one. This type of arrangement has some disadvantages in water control for individual paddies, but the advantages of minimizing the amount of water distribution network and of minimizing water losses from drainage far outweigh any disadvantages in terms of investment and operating costs. The cost of this type of system at 9,000 sucres (see Appendix H for conversion tables) per hectare (Table 9) is relatively high. Excluding investment in land per se, development costs account for about 48 percent of total investment (Table 10).

Table 9. Investment per hectare in land development and machinery stated in sucres.

Management Level	Land Development			Machinery	Total Investment
	Leveling	Infrastructure*	Total		
I	2,000	7,000	9,000	9,406	18,406
II	1,500	2,500	4,000	11,970	15,970
III	-----	1,200	1,200	1,290	2,490
IV	-----	500	500	-----	500

*Includes dikes, canals, headgates and farm roads.

Table 10. Land development investment as a percent of total investment per hectare.

Management Level	Total Investment*	Land Development	
		Investment	% of Total
I	18,406	9,000	48
II	15,970	4,000	25
III	2,490	1,200	48
IV	500	500	100

*Excludes cost of land.

The costs and returns in the production of summer rice on farms with management level I are shown in Table 11. Rice production by farmers in this group, based on the percent of the total number of operations performed, is 82 percent mechanized (Table 12). The only hand operations are the first application of fertilizer and transplanting. An inventory of the machinery required is shown in Table 36, Appendix F. This budget was computed following the general assumptions and conditions outlined above.

Table 11. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level I.

Costs		
Land preparation		
Plow--1X		
Machine power (.85 hr. @ 80.00)	68.00	
Operator (.85 hr. @ 8.00)	6.80	
Labor (1.3 hr. @ 4.00)	5.20	
Mudding--2X		
Machine power (1.2 hr. @ 46.00)	55.20	
Labor (1.4 hr. @ 5.00)	7.00	142.20
Planting		
Seed (1 cwt. @ 156.00)	156.00	
Seedbed--urea (7.8 lbs. @ 1.27)	10.00	
Seedbed--labor (4 hr. @ 4.00)	16.00	
Transplating--labor (contract)	800.00	
Replanting--labor (100 hr. @ 4.00)	400.00	
Bird control--labor (17.5 hr. @ 4.00)	70.00	1452.00
Fertilization (fertilizers in oxide form)		
Nitrogen--(6 cwt. @ 127)	762.00	
Phosphate--(2 cwt. @ 90)	180.00	
Potassium--(1 cwt. @ 130)	130.00	
Application		
Labor (contract)	135.00	
(To apply 5 cwt. nitrogen, 2 cwt. phosphate, 1 cwt. potassium)		
Airplane (1 cwt. @ 105/cwt./ha.)	105.00	
(To apply 1 cwt. nitrogen)		
Machine power (1 hr. @ 46.00)	46.00	1358.00
(For transporting fertilizer)		
Weed and Pest Control		
Insecticides	367.00	
Aerial application (3X @ 35.00)	105.00	
Herbicides	36.00	
Labor (1 hr. @ 4.00)	4.00	512.00
Water		
Pumping (10 hrs. @ 28.00)	280.00	
Operator (10 hrs. @ 5.00)	50.00	
Irrigators (56.25 hrs. @ 4.00)	225.00	
Dike repair--labor (40 hrs. @ 4.00)	160.00	

Table 11. Continued

Dike repair--supplies	10.25	
Canal maintenance and		
Weed control--canals and dikes		
Labor--(65 hrs. @ 4.00)	260.00	
Supplies	15.00	1000.25
Harvesting		
Combine	620.00	
Operator (3 hrs. @ 5.00)	15.00	
Hauling grain from field		
Machine power (2 hrs. @ 46.00)	92.00	
Labor (15 hrs. @ 4.00)	60.00	
Supplies	18.00	
Other harvesting	50.00	855.00
Other		
Administration	1050.00	
Miscellaneous transportation	172.00	
Marketing costs	135.00	1357.00
		S/.6676.45
Interest on operating capital (6 months @ 1% per month)		400.56
Amortization of land--initial value (S/.1666 @ 10%)		110.00
Total costs		S/.7187.01
Returns		
Sale of rice (100 qq. @ 125)		S/.12500.00
Net returns to capital investment in land development and machinery		S/. 5312.99

Table 12. Number of operations completed by machine and by hand.

Management level	Machine operations	Hand operations	Total	% by Machine
I	9	2	11	82
II	8	1	9	88
III	-	10	10	0
IV	-	7	7	0

Land preparation. Land preparation is accomplished by first plowing, usually with a disc-type plow. Following the plowing operation, the land is flooded with about 10 centimeters of water, and it is gone over twice by tractors with metal cage-like rear wheels called "mudders." This is done to break up clods and incorporate the fertilizer and organic matter into the soil.

Planting. The transplant method of planting is used. Seedlings are grown for approximately two weeks in seedbeds that receive the same preparation treatment as does the land on which the rice is actually grown. Approximately 100 pounds of seed are used per hectare. The IR-8 seed variety is most frequently used. Before planting, the water is drained from the seed beds, and seed that has been pregerminated by being kept wet for a period of 48 hours is planted by broadcasting. Within 24 hours, the new plants have taken root, and irrigation begins. At this time, water management is important, since too much water will cause the new plants to drown, while too little will result in excess drying and sunburn which will also kill the plants.

After a period of approximately 15 days, seedlings can be transplanted. Previous to this time, the paddies to be planted have been prepared, following the same procedures as with the seed beds. However, water is not drained off. Following the operation with the "mudders," water is left in the paddies at a depth of 6 to 10 centimeters. This prevents weed growth and virtually eliminates the need for using herbicides except for one application to the seedbeds prior to transplanting. Transplanting is done by hand, with plants being placed from 20 to 30 centimeters apart. The water level at the time of transplanting is lowered to a level of 4 centimeters. After approximately a week, the water level is again increased and maintained at a gradually increasing depth, depending on the height of the plant, to a maximum depth of approximately 15 centimeters. During this time, a small amount of water is allowed to flow through the paddies. However, this water is not wasted, as it is collected and pumped into another production unit. It is believed that by allowing some water to flow through the paddies, water stagnation is prevented, thus providing better growing conditions.

During the entire growing period, water is drained from the rice paddies only twice. The first draining comes after the grain has formed to a soft dough stage. The purpose of drainage at this time is to prevent excessive plant growth. Excessive plant height causes plants to become top heavy and fall down as the grain is maturing, resulting in loss of grain during harvesting. The second draining comes approximately two weeks preceding harvest. Its purpose is to facilitate harvesting.

Fertilization. Very heavy amounts of fertilizer, including nitrogen, phosphate and potassium, are used. They are applied in two applications to the paddies in general, and one application of nitrogen is applied to the seed beds. The first application to the paddies precedes plowing. At this time, the phosphate and potassium are all applied, but only part of the nitrogen used is put on. This first application is by hand-broadcasting; the second nitrogen application is done aerially toward the middle of the growing season.

Weed and pest control. Water management is the main source of weed control; paddies are kept flooded to prevent weeds from getting started. This flood is maintained until the rice is big enough to create enough shade to keep weeds from growing. The only commercial herbicide used is applied once to control weeds in the seed beds prior to transplanting. Insects are controlled by aerial spraying of commercial herbicides three times during the production process. It was observed that no effort is made to control birds except at the seed beds. Apparently they do not cause a significant amount of damage except in small isolated fields. Also, the improved varieties of rice are characterized by heads that droop beneath the upper leaves of the plants. This discourages birds from feeding in the rice paddies because these upper leaves are rigid and stickery, thus making it difficult for the birds to land in the paddies.

Water. The primary cost of water is that of pumping it out of the river. Pump expenses account for about one-third of the total

irrigation costs. To handle the water, five full-time irrigators are employed on each production unit (100 hectares). Other day labor is employed to repair and build up dikes and clean canals prior to planting. This operation, however, is minimal since all water used in irrigation is pumped. The control of weeds is the major expense in maintaining the canals and dikes. Work on this begins before planting, and weeds are cut and burned from all dikes and canal banks. Later, during the summer crop, follow-up control is done by hand-spraying with herbicides. Rain during the winter crop prevents this practice, and all weeding must be done by hand.

Harvesting. Harvesting is done by large, self-propelled combines. One combine is needed for every 90 hectares. This relatively large number of combines is necessary because the time during which the crop may be harvested is limited due to the double-cropping system of production and the wet weather conditions that prevail particularly during the winter harvest. The grain is hauled from the paddies in wagons; wheeled tractors pull the wagons. Normally rice is not stored but is sold to millers at harvest time because of the lack of storage and drying facilities. Rice must be dried either mechanically or by sun drying in patios before it can be stored for any length of time.

Other costs. Other costs include administrative and professional management expenses. Typically, managers are experienced and have had university training. Also included as other costs are miscellaneous

transportation and any costs incurred in marketing the crop.

Interest on operating capital. Interest costs are calculated on all of the cash required for production operations. The annual cost of land is not included since it is deducted later and at a different rate of interest than the rate used in computing the interest on operating capital. The rate used is 12 percent per annum or 1 percent per month. This rate represents an approximate average interest charge paid by operators in the Guayas Basin. Also, it is the rate used by the Comision Nacional Del Arroz (National Rice Commission) for estimating these same costs.

Amortization of land. Land is treated as an annual cost for two reasons. First, producers indicate that, due to economic and political conditions, there exists a good deal of insecurity in land tenure beyond a 15-year time horizon. Second, the final objective of this study is to calculate the internal rate of return to investment in land development and machinery used for rice production. In order to do this, land costs must be deducted from returns prior to any such computations.

The cost of land used for rice production is calculated on the basis of an initial land value of 1666 sucres per hectare. This figure was estimated from the average of the prices of marshy and dry land in the Guayas Basin. See Appendix G, Table 42. The initial land value was then amortized over 15 years (the estimated economic life of the project) at an interest rate of 10 percent. This resulted in a total annual cost of 220 sucres per hectare. However, since double cropping

is practiced, only one-half of this amount is included in the budget (Table 11).

Returns. Returns are based on an average yield of 100 quintals of rice per hectare. These are quintals that are estimated equivalents of paddy rice for 100 pounds of hulled rice. In 1969, an average of 196 pounds of paddy rice was needed to yield 100 pounds of hulled rice. The price used in estimating returns is the average price received by farmers in this group for the summer crop. This resulted in costs totaling 7,187.01 sucres and gross receipts of 12,500.00 sucres or a net return to capital invested in land development and machinery of 5,312.99 sucres per hectare.

Management level II

A typical rice farm in the management level II category consists of a single production unit and averages 150 hectares in size. As noted in Table 8, rice paddies average 7 hectares in size. These are organized differently than those observed in category I, in that each paddy is served by a canal. Also, they are laid out in grid-like fashion without regard to topography. This has the advantage of uniform size and shape of paddies but the disadvantage of being more costly in leveling if they are leveled to zero slope and require a greater amount of canals. However, less diking is required which reduces initial investment costs of development, as well as maintenance costs. The cost of this system averages 1,500 sucres per hectare for leveling and 2,500 sucres for infrastructure (Table 9). This

amounts to 25 percent of total investment as shown in Table 10.

The budget showing costs and returns for rice production under management level II was calculated in the same manner as those for the previous budget and is presented in Table 13. Machinery requirements for farms in this group are shown in Table 37, Appendix F.

Land preparation. Two operations are required in preparing the land for planting under management level II. It is first plowed to a depth of approximately 20 centimeters with a disc-type plow. The land is then gone over once with a land plane or a heavy drag, the purpose being to break up the large clods and smooth the land surface.

Planting. Generally improved varieties of rice are used by this group of producers. Seed is planted directly in the paddies at rates ranging from 150 to 350 pounds per hectare. The average amount used was 250 pounds per hectare. Two different seeding techniques were used. The method most frequently observed was that of mechanically broadcasting dry seed at the heavier rates on dry soil, followed by frequent light irrigations to germinate the seeds. The other planting method used involves irrigating the paddies first and then seeding by air pregerminated seed at the lower rates. Yields did not appear to differ significantly between the two methods.

Fertilization. The only fertilizer used is nitrogen at an average rate of 225 pounds per hectare. Normally this is applied by means of a mechanical spreader in one application prior to land preparation.

Weed and pest control. Weeds are controlled usually with one

Table 13. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level II.

Costs		
Land preparation		
Plowing		
Machine power (.80 hr. @ 80.00)	64.00	
Operator (.80 hr. @ 8.00)	6.40	
Labor--weed clearing (21 1/3 hr. @ 3.00)	64.00	
Leveling		
Machine power (.47 hr. @ 105.00)	49.35	
Operator (.5 hr. @ 5.00)	2.50	186.25
Planting		
Seed (2.5 cwt. @ 156.00)	390.00	
Planting		
Machine power (1 hr. @ 46.00)	46.00	
Labor (2 hr. @ 3.00)	6.00	442.00
Fertilization (fertilizers in oxide form)		
Nitrogen (2.25 cwt. @ 127.00)	286.00	
Application		
Machine power (1.5 hr. @ 46.00)	69.00	
Labor (3 hrs. @ 3.00)	9.00	364.00
Weed and pest control		
Herbicides	293.00	
Application (1X)		
Airplane (1X @ 100.00)	100.00	
Labor (1 hr. @ 3.00)	3.00	
Hand weeding (50 hrs. @ 3.00)	150.00	
Insecticides	210.00	
Application		
Airplane (2X @ 32.50)	65.00	
Labor (.5 @ 4.00)	2.00	823.00
Water		
Pumping (11 hrs. @ 32.00)	352.00	
Irrigators (50 hrs. @ 4.00)	200.00	
Dike and canal maintenance		
Machine power (.25 hr. @ 105.00)	26.25	
Labor (16 hr. @ 3.00)	48.00	
Supplies	2.50	628.75
Harvesting		
Combine	615.50	

Table 13. Continued

Operator (.25 hrs. @ 5.00)	12.50	
Hauling from field		
Machine power (1.5 hr. @ 46.00)	69.00	
Labor (11 hrs. @ 3.00)	33.00	730.00
Other		
Administration	282.00	
Miscellaneous	80.00	362.00
		S/.3536.00
Interest on operating capital (6 months @ 1% per month)		212.16
Amortization of land--initial value (S/.1666 @ 10%)		110.00
Total costs		S/.3858.16
Returns		
Sale of rice (43 qq. @ 125)		5375.00
Net returns to capital investment in land development and machinery		S/.1516.84

application of commercial herbicides by aerial spraying two to three weeks after planting. A second weeding is done by hand about one month before harvesting during the time when the paddies are drained. Insects are controlled by two aerial applications of commercial insecticides. The first application is made during the first month after planting and the second two to five weeks later. No effort is made to keep birds away from the fields.

Water. The major water cost is the cost of pumping the water from the river. To handle the water, three to four full-time irrigators are employed. The maintenance of dikes and canals is done by machine prior to planting when the canals are cleaned and the dikes are repaired as needed. The control of weeds along the dikes and canals is done in conjunction with weed control in the paddies. Following the eight irrigations necessary to start and establish the new plants during the first three weeks or so after seeding, the water level is maintained at a depth of approximately 10 centimeters. Water is not circulated through the paddies. So, it is added only when required to maintain the desired level of water. However, due to inadequate leveling, water coverage is not complete; there are always areas that receive too little water and others that have too much. Water is completely drained twice, once during the growing season in order to allow the ground surface to dry and again just prior to harvesting.

Harvesting. The crop is cut and threshed by combines. Both the self-propelled and tractor-drawn types are used. The other major ex-

pense in harvesting is removal of the grain from the field, which is also done with machines.

Other costs. Other costs incurred in producing rice are administrative costs and miscellaneous expenses. Administrative costs are lower than that for the previous category because only overseer-type administrative help is hired. The management decisions are made by the owner, usually on a part-time basis, and are not included as part of the costs, since no actual expense is incurred.

Interest on operating capital. Interest on operating capital is handled in this budget in the same manner as it was in the previous budget. Again, interest on the value of land is not included since it is treated separately. The rate of interest used is 12 percent per annum.

Amortization of land. As was the case with management level I, land is treated in this budget as an annual cost. This is done because investors, in considering investment in rice, look at the project as having a finite time horizon at the end of which the value of all investments will be zero. Another reason is to avoid confounding the returns to land with the returns to investment in land development and machinery.

The cost of land is calculated in the same manner used for the previous management level. The initial value was assumed to be 1666 sucres per hectare and was amortized as a cost of production over the life of the project at an interest rate of 10 percent. The annual cost was estimated at 220 sucres per hectare, but because two crops are grown each year, only one-half of this amount is included in Table 10, the crop budget.

Returns. The returns to the enterprise are received entirely from the sale of the rice produced. Yields for this group averaged 43 quintals per hectare. A quintal, as was explained for the previous budget, was the amount of paddy rice required to yield 100 pounds of hulled rice. Amount required depends on the moisture content and the amount of trash in the paddy rice. The amount required averaged 196 pounds per quintal. Yields achieved by producers in this group are substantially lower than those experienced by management level I producers. There seem to be several factors which may help to explain this. First, management level II producers use only about one-fourth as much fertilizer. Second, the only fertilizer used is nitrogen, while producers in group I use phosphate and potassium in addition to nitrogen. Third, in the case of most group II producers, paddies are not completely level, and so complete control over irrigation is not possible. The low spots are oversaturated, and the high spots do not receive sufficient water. Fourth, weed and pest control are not as intense and complete as they are with management level I producers.

The price used was the same as that for the previous group. This resulted in costs totaling 3878.90 sucres and gross receipts of 5375 sucres or a return to capital invested in land development and machinery of 1496.10 sucres per hectare.

Management level III

Producers in management level III use irrigation only on a supplementary basis. The organization of their rice producing land, which averages 25 hectares in size (Table 8), is determined entirely by local topography. No leveling is done, but dikes costing about 1200 sucres per hectare (Table 10) and forming paddies averaging 1.4 hectares in size are built following contour levels in order to aid in water control and to expand cultivable land. Areas that can be cultivated under this system are only those that are natural depressions which fill with water during the rainy season or with the high tide. Other lands are used only as unimproved pastures.

Mechanization of cultivation is nonexistent (Table 12). All operations are completed by hand and so are kept to a minimum. The costs and returns for production of irrigated rice by farmers in management level III are shown in Table 14. These costs and returns were estimated in the same manner as those for the previous budgets. An inventory of machinery used by farmers in this group is shown in Table 38, Appendix F.

Land preparation. Land preparation in the form of plowing, leveling, etc., is not practiced by these growers. The only operation involved in preparing the land for planting is that of cutting and burning the weeds from the paddies and dikes. This is done entirely by hand.

Planting. Planting of rice in the paddies is done by the transplant method. On these farms, this is a necessity since the paddies cannot be drained, particularly during the early part of the summer when rivers

Table 14. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level III.

Costs		
Land preparation		
Cut weeds--labor (10 man days @ 30.00)	300.00	
Burn weeds--labor (.5 man days @ 30.00)	15.00	
Supplies	19.00	334.00
Planting		
Seed (.75 cwt. @ 135.00)	101.25	
Seedbed preparation--labor (3 hrs. @ 3.00)	9.00	
Transplanting	400.00	510.25
Fertilization (fertilizers in oxide form)		
Nitrogen (9 lbs. @ 1.27)	11.43	
Application--labor (.75 hrs. @ 3.00)	2.25	13.68
Weed and pest control		
Hand weeding 2X		
Labor (14 man days @ 30.00)	420.00	
Insecticides	157.00	
Application 2X		
Labor (15 hrs. @ 3.00)	45.00	
Bird control--3 months		
Labor (90 days @ 10.00)	900.00	
Firecrackers	15.07	1537.07
Water		
Pumping (14 hrs. @ 21.00)	294.00	
Operator--labor (14 hrs. @ 4.00)	56.00	
Irrigators (25 hrs. @ 4.00)	100.00	
Dike repair (7 man days @ 30.00)	210.00	660.00
Harvesting		
Cut and thresh--hand (contract)		
(42 qq @ 12.00)	504.00	
Haul from field--hand (contract)		
(42 qq @ 6.00)	252.00	756.00
Other		
Administration	120.00	
Miscellaneous	25.00	145.00
		S/.3956.00

Table 14. Continued

Interest on operating capital (6 months @ 1% per month)	237.36
Amortization of land--initial value (S/.1666 @ 10%)	220.00
Total costs	S/.4413.36
Returns	
Sale of rice (42 qq @ 100.00)	4200.00
Net returns (loss) to capital investment in land development and machinery	S/.(213.36)

are still high. Generally, improved varieties of rice are used for seed. However, the quality of seed is generally quite low because it is not certified, and storage and handling practices are poor. The first operation is the preparation of a small seed bed to produce the seedlings to be transplanted. This involves only the selection of an adequate spot located in wet but not flooded soils, the removal of weeds and the planting of the seed. The seed is planted by making a small, shallow hole in the ground with a stick and dropping in the seed. Water to maintain the proper level of soil moisture for germination and growth of the new plants is hand carried to the seed bed in buckets. Transplanting begins any time after the seedlings are of adequate size and continues for about two months as the water in the paddies recedes. Several small seed beds may have to be prepared and tended during planting season. Seedlings are transplanted 20-30 centimeters apart.

Fertilization. The use of fertilizer is limited to application of nitrogen to the seed beds in which seedlings are grown for transplanting in the rice paddies. The nitrogen is applied by hand shortly after the plants sprout.

Weed and pest control. Weeds are controlled by two hand weedings, one a few weeks after transplanting and the other about a month later. Commercial insecticides are used to control insects that are damaging to the crop, and applied by hand sprayers once to the seed beds prior to transplanting and once to the paddies two to three weeks after transplanting. The largest expense in this category is incurred in keeping birds away from the crop. This is an interesting practice since the previous two management levels did not feel that this was important. However, birds may be more of a problem in this case because of the small field size and somewhat isolated locations.

Water. Water costs for this group are relatively low since irrigation is used only to supplement the water already present in the paddies. Initially the high tides (locally referred to as aguajes) are taken advantage of to fill the paddies when needed. The depressions in which rice is planted are connected to the main river by a small channel in which a small earth dam and headgate are constructed so that water flow can be controlled. This method of irrigation works fairly well during the first part of the summer; but as the dry season continues, the level of water in the river lowers to the point where

the water during the aguaje no longer reaches the paddies on the higher ground. At this time, beginning in early October and continuing through the month, a small motorized pump--usually about four inches in size with a capacity of approximately 450 gallons per minute--is used to supply water where needed. This practice reduces losses from droughts and enlarges the area on which it is possible to grow rice. Only one irrigator is needed. The only other major cost in this category is that of repairing dikes which are usually damaged quite badly during the rainy season by the water and by animals pastured in the fields.

Harvesting. Harvesting is done by hand. The rice is first cut and stacked so that it will dry. After it has dried sufficiently, it is threshed by beating the heads on a large stick. This results in a good deal of trash getting into the grain which must be removed. The grain is then carried from the field by hand or on beasts of burden and sold to the nearest miller.

Interest on operating capital. Interest on operating capital is treated for management level III in the same manner as it was for management levels I and II. The rate of interest used is 12 percent per annum or 1 percent per month. The annual cost of land is not included as part of the operating capital.

Amortization of land. Land used for rice production is treated here, as it was for the previous management groups, as an annual cost of production. This is done in order to avoid confounding the returns to land with the returns to investment in land improvement and machinery. The

cost is based on the amortized initial value of unimproved land. The amortization was computed at an interest rate of 10 percent over the estimated project life of 15 years. This amounted to an annual cost of land of 220 sucres per hectare, and since only one crop is grown during the year, the total amount is included in the budget as shown in Table 10.

Returns. The returns from the summer rice enterprise come entirely from the sale of the rice which yields an average of 42 qq. per hectare. As with the previous two budgets, the quintal is the amount of the paddy rice required to yield 100 pounds of hulled rice. Due to excessive amounts of trash, the amount required often exceeds 200 pounds. The quality of rice delivered by these producers is generally quite low because of trash, dirt and rotting which results from the handling practices. As a result, a lower price is received than that received by the two management groups previously discussed. During 1969, the price received averaged 100 sucres per quintal as compared to 125 sucres for the other types. Another factor which influenced price was the timing of sales. This resulted in gross receipts of 4200 sucres and costs of 4413.36 sucres or a net loss to capital of 213.36 sucres per hectare.

Management level IV

This management group is composed of the producers who use the traditional methods of production. Most rice growers in the Guayas Basin fall into this category. Plantings are small, with the average cultivated area only five hectares (Table 8). They are located in

natural depressions, and the high tides are used as the only source of irrigation. The design of the irrigation system, if it can be called a system, is made according to the topography, as in management level III. However, paddies are somewhat smaller (Table 8), and infrastructure represents a much lower investment--approximately 500 sucres per hectare (Table 9).

With three exceptions, management practices are the same as those observed in the previous group. First, no fertilizer is used; second, insecticides are not used; and third, irrigation is not supplemented by pumping. This last increases substantially the risk of crop loss from drought and lessens the amount of land that could otherwise be cultivated. The costs and returns budget for rice production under management level IV is shown in Table 15. For this management group, two budgets were calculated. The first includes the cost of all labor at the existing labor rates for the type of work done, whether or not an actual cash expense was incurred by the operator. The second budget is calculated excluding the value of labor supplied by the operator and his family for which no money wages were paid. This approach is based on the argument supported by many scholars of development economics which suggests that there are no real alternative employment opportunities outside the farm, thus indicating that the opportunity cost of labor on peasant farms similar to those in management level IV are close to zero and should not be included as part of the production costs.

Table 15. Production costs and returns for irrigated rice, stated in sucres per hectare. Management level IV.

Costs	Including labor value	Excluding labor value
Land preparation		
Cut weeds--labor (9.5 man days @ 30.00)	285.00	
Burn weeds--labor (1.2 man days @ 30.00)	36.00	
Supplies	7.00	7.00
Planting		
Seed (1 cwt. @ 110.00)	110.00	110.00
Seed bed preparation--labor (3 hrs. @ 3.00)	9.00	
Transplanting--labor (10 man days @ 30.00)	300.00	
Weed and pest control		
Hand weeding 2.5X		
Labor (20 man days @ 30.00)	600.00	
Bird control--2 months		
Labor (58 days @ 10.00)	580.00	
Water		
Labor (15 days @ 30.00)	45.00	
Supplies	20.00	20.00
Harvesting		
Cut and thresh--hand (22 qq @ 12.00)	264.00	
Haul from field--hand (22 qq @ 6.00)	132.00	
Other harvesting	50.00	50.00
Other	50.00	50.00
	S/.2488.00	S/.237.00
Interest on operating capital (6 months @ 1% per month)	149.28	14.22
Amortization of land--initial value (S/.1666 @ 10%)	220.00	220.00
Total costs	S/.2857.28	S/.471.22
Returns		
Sale of rice (22 qq @ 100.00)	S/.2200.00	S/.2200.00

Table 15. Continued

Net returns (loss) to capital investment in land development and machinery	(S/.657.28)	
Net returns to capital investment in land development, machinery, labor and management		S/.1728.78

Land preparation. No machinery is used by this group in rice cultivation. Generally the varieties of rice planted are the criollo or unimproved strains. All planting is done by the transplant method. Seedlings for transplanting are grown in seed beds following the same general practices as were observed in the previous case.

Weed and pest control. After the rice has been transplanted to the paddies, weeds are controlled by two hand weedings. No effort is made to control insects that may damage the crop. However, birds are carefully kept away throughout the early and later parts of the growing season and during the harvest. This task is the most costly of all operations performed in rice culture by this group since it requires so much time.

Water. Water cost for this group of producers is very low since no pumping is done. The rice paddies are located in natural depressions, along water ways which permit water from the main river to enter at times of high tide. Thus, the only expense involved in irrigation is the cost of the labor required to regulate the amount of water that enters or leaves the paddies.

Harvesting. Rice is harvested by hand in the same manner as was discussed in the section on management level III.

Interest on operating capital. Interest is calculated on the same basis here as it was for the previous budgets. It is computed on all production costs except the annual cost of land which is treated separately. The rate of interest used is 12 percent on an annual basis.

Amortization of land. Land is treated here as a cost of production, as it was with the other management groups. Initial land value is estimated at 1666 sucres per hectare. This is amortized at 10 percent interest over a period of 15 years to arrive at the annual land cost of 220 sucres. Only one crop is produced each year by producers in this group, so all of the cost is included in the production budget.

Returns. Returns come solely from the sale of paddy rice which yields, on the average, 22 quintals of hulled rice per hectare. The price received was the same as that received by producers in group III and for the same reason. For both budgets in group IV, gross returns totaled 2200.00 sucres. For the budget that includes labor as a cost, total costs were 2857.28 sucres per hectare, indicating a negative return to capital of 657.28 sucres per hectare. However, by excluding the value of labor, mostly if not all of which is supplied by the family, as a cost, production expenses total only 471.22 sucres per hectare, thus showing a net return to capital and labor of 1728.78 sucres per hectare.

Calculation of the Internal Rates of Return

In estimating the flow of net benefits and investments as the basis for calculating the internal rate of return to irrigated paddy rice for each of the management levels previously described, several assumptions have been made. These assumptions are briefly outlined below and include the following:

1. All producers operate under conditions of pure competition in regards to both what they supply to the market for sale and what they demand from the factor market. In other words, they can each sell as much as they can produce without affecting the price, and they each may buy as much or as little as they want without affecting prices in the input market.

2. The length of the planning period for each management level was determined by the expected project life, by producers in each group and by the expected economic life of the equipment required. The major factors which influenced what producers expect were economic and political risks--fear of excessive inflation and expropriation because of land reform policies.

3. Land values at the beginning of the planning period are assumed to be the same for all management groups. This initial value was calculated on the basis of the average of recent sales of marsh and dry land in the Guayas Basin and was estimated to be 1666 sucres per hectare. It should be noted that it is not implied here that land in this area can be purchased at this price, as it is simply an average of

most recent past sales. In fact, according to Aviles (1968), an analysis of the property registers and the corresponding deed transfers in the Guayas Basin indicates that there is very little transfer of land although, apparently, there is a relatively large number of people who are willing to purchase land.

4. Because rice farmers indicated that their planning period was limited in length, the initial cost of the land was treated as an annual production cost. As was explained previously, this is done by amortizing the initial land value over the planning period, using an interest rate of 10 percent. Thus, land values at the end of the project life are assumed to be zero. Also, the value of investments in land development at the end of the planning period is considered to be negligible and so is ignored.

5. Total investment in land development and machinery during the planning period includes the initial cost of the required equipment. Additional investments in machinery are also entered in the stream of investments, as dictated by the expected life of the machinery. See Appendix F.

6. Estimated replacement costs of headgates and other water-control devices, not including dikes and canals, are included in the flow of net investments. The maintenance of dikes and canals is included as part of the costs of production.

7. As was mentioned earlier, climatic conditions that exist in the Guayas Basin permit continuous production of agricultural crops. In the case of rice, this means that two crops can be grown. If double-

cropping is practiced, in effect the equivalent number of hectares on which rice is grown is doubled.

8. Under double-cropping, costs, yields and returns are assumed to be the same for both crop periods in spite of the fact that one is grown during the rainy season. By way of review, however, this does not imply that all costs are the same for production during the two seasons but only that total costs are roughly the same. Also, there is no evidence to suggest that yields differ; producers who currently practice double-cropping assert that yields are the same.

9. The calculations are all limited to the Daule soil group because development costs and yields for other soil conditions vary substantially from those typical to this group. Yields drop significantly on the lighter soils, and other soils similar to the Daule soils are not included because the slope is greater, implying higher development costs.

10. Returns for all management groups are calculated using current prices for inputs and for rice.

11. Also, no changes in management practices which would affect costs or production are taken into consideration. Management levels are assumed to remain constant throughout the entire planning period.

Management level I

The schedule of net benefits and investments for rice production under management level I is shown as a stream by years in Table 16. Development of the rice enterprise is carried out over a five-year

Table 16. Net benefits and investments schedule for one production unit. Management level I.

Year	Number of hectares developed	Net annual investment in land development and machinery	Equivalent no. hectares cultivated	Net annual benefits
0	100	1,840,600	100	531,299
1	---	1,000	200	1,062,598
2	---	1,000	200	1,062,598
3	---	1,000	200	1,062,598
4	---	1,000	200	1,062,598
5	---	65,000	200	1,062,598
6	---	1,000	200	1,062,598
7	---	397,000	200	1,062,598
8	---	1,000	200	1,062,598
9	---		200	1,062,598
10	---	65,000	200	1,062,598
11	---	1,000	200	1,062,598
12	---	1,000	200	1,062,598
13	---	1,000	200	1,062,598
14	---	1,000	200	1,062,598

period with 100 hectares (one production unit) being brought into production during each of these periods. The planning period used was 15 years for each production unit. During the year in which a unit is developed, it is assumed that only one crop will be grown. During the following years and until the end of the planning period, at which time it is assumed that production will end (for planning purposes at least), two crops will be grown annually. This in effect doubles the number of hectares cultivated. This effect is shown as the equivalent number of hectares cultivated in Table 16. The total benefits column in the table is derived from the costs and returns budget as shown in Table 11

and from the equivalent number of hectares. The total investment column is taken from the development costs as shown in Table 10 but also includes annual maintenance and replacement costs of the headgates and other water control structures.

As was noted earlier, the formulas for solving for the internal rate of return directly are complicated and unwieldy. So, an indirect method of approximating the internal rate of return through the use of present value tables will be used. This is the procedure employed in making the calculation in Table 17 which indicates that the internal rate of return to investment in machinery and land development for rice production under management level I conditions is slightly more than 80 percent. It will be noted that this table, however, is only for 100 hectares, whereas a total of 500 hectares is developed. But, this does not present a problem since each 100 hectares constitutes a production unit; each is treated as having the same planning period--15 years--and it can be assumed that the internal rate of return will be the same for each production unit. It also follows that the internal rate of return will be the same for the entire farming enterprise.

Management level II

The same procedure used to calculate the internal rate of return for management level I is used in making the calculations for returns to management level II conditions. The same length of planning period is used, also. Table 18 shows the stream of land development and machinery investment costs, the equivalent number of hectares culti-

Table 17. Estimates of net and discounted annual returns for 100 hectares, in sucres. Management level I.

Year	Investment Costs	Annual Costs	Annual Returns	Annual Returns Less Investments, Costs	Discount Factor -- 80%	Discounted Net Benefits
0	1,840,600	--	531,299	-1,309,301	1.0000	-1,309,301
1	-	1,000	1,062,598	1,061,598	0.5555	589,717
2	-	1,000	1,062,598	1,061,598	0.3086	327,609
3	-	1,000	1,062,598	1,061,598	0.1714	181,957
4	-	1,000	1,062,598	1,061,598	0.0952	101,064
5	-	65,000	1,062,598	997,598	0.0529	52,772
6	-	1,000	1,062,598	1,061,598	0.0294	31,210
7	-	397,000	1,062,598	665,598	0.0163	10,849
8	-	1,000	1,062,598	1,061,598	0.0090	9,554
9	-	1,000	1,062,598	1,061,598	0.0050	5,307
10	-	65,000	1,062,598	997,598	0.0028	2,793
11	-	1,000	1,062,598	1,061,598	0.0015	1,592
12	-	1,000	1,062,598	1,061,598	0.0008	849
13	-	1,000	1,062,598	1,061,598	0.0004	424
14	-	1,000	1,062,598	1,061,598	0.0002	212
Total	1,840,600	538,000	15,407,671	13,029,071		6,608 *

* Error indicating that the internal rate of return of 80% is slightly too low

Table 18. Net benefits and investments schedule. Management level II.

Year	Number of hectares developed	Net annual investment in land development and machinery*	Equivalent number hectares cultivated	Net annual benefits*
0	150	2,395,500	150	227,526
1	---	2,000	300	455,052
2	---	2,000	300	455,052
3	---	2,000	300	455,052
4	---	2,000	300	455,052
5	---	30,000	300	455,052
6	---	2,000	300	455,052
7	---	2,000	300	455,052
8	---	423,500	300	455,052
9	---	2,000	300	455,052
10	---	30,000	300	455,052
11	---	2,000	300	455,052
12	---	2,000	300	455,052
13	---	2,000	300	455,052
14	---	2,000	300	455,052

*Sucres

vated and total benefits. In this case, it is assumed that the entire rice enterprise is developed in the first year. During the first year, one crop can be harvested; but following this, it is assumed that two crops will be grown annually.

The calculations required for estimating the internal rate of return are shown in Table 19. The procedure used is the same as that followed in making these same calculations for the previously discussed case. The results show that the land development and machinery investments incurred have an internal rate of return of roughly 17.6 percent.

Table 19. Estimates of net and discounted annual returns for rice enterprise, in sucres. Management level II.

Year	Investment costs	Annual costs	Annual returns	Annual returns less investments, costs	Discount factor--17.6%	Discounted net benefits
0	2,395,500	--	227,526	-2,167,974	1.0000	-2,167,974
1	---	2,000	455,052	453,052	0.8503	385,230
2	---	2,000	455,052	453,052	0.7231	327,601
3	---	2,000	455,052	453,052	0.6149	278,581
4	---	2,000	455,052	453,052	0.5229	236,900
5	---	30,000	455,052	425,052	0.4447	189,020
6	---	2,000	455,052	453,052	0.3781	171,298
7	---	2,000	455,052	453,052	0.3215	145,656
8	---	423,500	455,052	31,552	0.2734	8,626
9	---	2,000	455,052	453,052	0.2324	105,289
10	---	30,000	455,052	425,052	0.1977	84,032
11	---	2,000	455,052	453,052	0.1681	76,158
12	---	2,000	455,052	453,052	0.1421	64,378
13	---	2,000	455,052	453,052	0.1215	55,045
14	---	2,000	455,052	453,052	0.1033	46,800
Totals	2,395,500	505,500	6,598,254	3,697,254		6,640 *

*Error in excess indicating that the internal rate of return of 17.6% is slightly too low

Management level III

Rice production under conditions existing in this management group does not have positive returns. As shown in the budget of production costs and returns (Table 14), there is a net loss of 213.36 sucres per hectare of rice grown; thus an internal rate of return cannot be estimated, and it must simply be concluded that production of rice under these conditions is not profitable.

Management level IV

In regards to management level IV, an examination of the costs and returns budget including the value of labor in Table 15 reveals that there is a negative return to investments in the amount of 657.28 sucres; no calculations regarding an internal rate of return need be made. Suffice it to note that costs of production are not covered following the cultivation practices used by producers in this group if the labor supplied by the operator and his family is included as a cost. If, however, labor is not included as a cost, there are positive net returns to rice production; and an internal rate of return could be calculated. The flow of net annual benefits and investments costs is in Table 20. But, since these returns include the value of labor, an internal rate of return that would be comparable to those estimated for management levels I and II cannot be computed. For this reason, an internal rate of return is not estimated for rice production under management level IV conditions. Instead, it can only be concluded that the return to capital investment, management and labor for this group is approximately 1728.78 sucres per

Table 20. Net benefits and investments schedule. (Value of labor excluded.) Management level IV.

Year	Number of hectares developed	Net annual investment in land development and machinery *	Equivalent number hectares cultivated	Net annual benefits *
0	5	2,500	0	---
1	-	---	5	8,644
2	-	---	5	8,644
3	-	100	5	8,644
4	-	100	5	8,644
5	-	200	5	8,644
6	-	100	5	8,644
7	-	100	5	8,644
8	-	200	5	8,644
9	-	100	5	8,644
10	-	100	5	8,644
11	-	200	5	8,644
12	-	100	5	8,644
13	-	100	5	8,644
14	-	200	5	8,644

* Sucres

hectare and 8644 sucres for the entire farm.

HYPOTHETICAL AGGREGATE IMPLICATIONS

In accomplishing the goals of development, agriculture can play an important role not only as a source of labor, but also as a source of capital. In this study, it was noted that in Ecuador, rice yields an average of about 25 quintals per hectare. In all, approximately 107,000 hectares are dedicated to rice production, resulting in total production for the country of just over 280,000 metric tons. Of this, less than 15 percent is produced by mechanized techniques of production. Nearly 90 percent of the producers use no fertilizer, and only about 40 percent of the farmers use irrigation. (Comision Nacional del Arroz, 1969). However, as it was noted in this study, rice yields need not be so low. Management level I producers achieved yields of 100 quintals per hectare and through development of irrigation were able to produce two crops each year at essentially the same costs per hectare for each drop. Also, it was discovered that the capital investment required for land development and machinery in the above management category had very high returns--approximately 70 percent.

It is obvious that if management techniques and investment in machinery and land development for all of the rice producers were brought to the level at which the management level I group now operates, there would be a substantial increase in the total production of the country's agricultural sector. According to the Pan American Union, 1964, there

are approximately 70 thousand hectares of land of the Vinces soil group and 225 thousand hectares of the Daule soil group (Figure 3)--the two soil groups to which this study was limited. Thus, theoretically, there is a total of about 295 thousand hectares on which rice could be produced and which could be developed. On the basis of this assumption and the assumption that two crops could be grown annually, making a total of 590 thousand hectares actually being harvested, which would yield 100 quintals of milled rice per hectare per crop, the total annual production for the country could reach 59 million quintals or roughly 2.5 million metric tons instead of the 280 thousand metric tons being produced.

To reach the level of production indicated above, the total number of hectares planted to rice would have to be increased by more than five times over the amount planted in 1969. Whether or not such an increase would be possible cannot be determined at this time. But, even if such an increase were not possible, the amount of land planted to rice could at least be doubled by simply producing two crops instead of one as is the present practice. If this were done at yields corresponding to those being obtained now by producers in management level I, total production still could be increased from the present 280 thousand metric tons to approximately 950 thousand metric tons.

At the present levels of internal consumption, increases in the amount of rice available for exportation would be substantial in either case. For example, if internal consumption were to remain at a level of less than 200 thousand metric tons, in the first instance discussed above

where total production was estimated at 2.5 million metric tons, there would be roughly 2.3 million metric tons available for export. Further, if the world market price were to remain at 128 dollars (U.S.) per metric ton--the average price from 1961 through 1967--the potential income to the nation in foreign exchange would be approximately 290 million dollars (U.S.). On the other hand, if no further land could be developed, as was the case in the second situation discussed above, where total production was estimated at 950 thousand metric tons, the amount of rice available for export would still be about 750 thousand metric tons. At the same export price as used above, this would result in a national income of about 96 million dollars (U.S.) from the sale of rice on the world market.

These figures are, of course, estimates of gross sales and so do not represent the potential returns to investment in land development and farm machinery. At the current local price of 125 sucres per quintal or 118 dollars (U.S.) per metric ton, and assuming that 1) per hectare costs of production could be kept at the same level as that found in this study for management level I producers and 2) costs of marketing, storing and handling for export would not exceed 10 dollars (U.S.) per metric ton (the difference between the world market price and the current local price), net returns to capital investment in land development and farm machinery would be approximately 104 million dollars (U.S.) for the sale of 2.3 million metric tons or 34 million dollars (U.S.) for the sale of 750 thousand metric tons of rice.

Naturally, increasing the amount of land used for rice production and/or bringing rice production practices to the level at which management level I producers now operate would involve several problems. To begin with, large amounts of capital would have to be obtained. For example, if the development of all of the land in the Daule and Vinces soil groups, constituting 295 thousand hectares, were undertaken as in the first situation described above, roughly 114 million dollars (U.S.) for land development and 120 million dollars (U.S.) for farm machinery would be needed. And even if development of just currently used land (approximately 110 thousand hectares) were undertaken, the capital requirements would be nearly 43 million and 45 million dollars (U.S.) for land development and farm machinery, respectively.

Capital is not the only problem that would be encountered. Others would probably include the following: efficient use and allocation of water resources, particularly during the summer (dry) season; sources of necessary production inputs would have to be developed; farms would have to be reorganized in units large enough to permit taking advantage of any economies of scale that exist; the present marketing, handling and storage systems and facilities would have to be restructured to handle the large amounts of rice that would be produced; and, of course, managers would have to be trained and sources of production and operating capital developed.

All of these calculations are purely hypothetical, but they seem to represent a maximum and minimum level of production as well as invest-

ment costs and potential returns that could be achieved through improvement in management and production techniques and through investment in irrigation for rice.

SUMMARY

In recent years, there has been an ever-increasing interest on the part of the richer and more powerful nations of the world in the welfare and development of the world's poor and underdeveloped countries. Concern is felt over the ever-widening economic gap between these two classes of countries. Many of the latter are rich in natural resources, but economic progress in terms of higher per capita incomes and levels of living has passed them by, while countries such as Japan, the United States and the European countries have experienced relatively high rates of growth. The questions haunting today's scholars are why has economic progress been experienced by some countries while not by others, and what can be done to initiate and sustain growth of the underdeveloped nations? Another question related to the problem of initiating growth concerns the role of agriculture in development. A firm conclusion on this subject has not been reached; some view agriculture as the primary impetus for growth, while others stress the need for industrialization as the growth vehicle, and still others argue the need for parallel development of both sectors.

Ecuador, it was discovered, is a country that numbers among the underdeveloped countries and shares most of their problems, having a per capita income of approximately 200 dollars (U.S.) and the second highest population growth rate in the world. The need for increasing output,

particularly in the form of agricultural products, was apparent. And, it was observed that the required natural resources are in abundance.

Rice is one of the crops in which production and yields have remained relatively static for a number of years. This crop is produced almost entirely in the Guayas Basin on the heavy clay soil along the Daule and Babahoyo rivers in flood plains region of this basin. Water quality was also found to be an important factor in limiting the extent of the rice-producing region. It was found that, due to the low elevation of this valley, saline water from the ocean adversely affects the quality of the water for irrigation use as far upstream as Pascuales, about 60 kilometers inland.

The primary objective of this study was to examine rice production methods, with special emphasis on irrigation-water management practices used by producers from all levels of management. To do this, rice producers were divided into four categories on the basis of the level of mechanization of their operation, use of purchased inputs, and the level of investment in irrigation facilities and general management practices. The levels of investment in these facilities ranged from 7,000 to 500 sucres per hectare, and mechanization of production varied from almost total use of machinery for cultivation operations to no machinery at all. Similar variations were noted in regards to yields which ranged from 100 quintals of hulled rice to just 22 quintals per hectare.

The efficiency of irrigation-water use presented some problems and could not be calculated for all four management categories. This was de-

fined as being the ratio of the amount of water beneficially used to the amount of water delivered to the farm. Since no studies have been done in Ecuador in regards to water requirements for rice, findings from a different climatic zone were used; the water requirements were assumed to be the same as the potential evapotranspiration of water for this crop. The amount of water delivered was determined to be the amount of water diverted from the river. In all cases, this is done by pumping; thus the total amount of water used was estimated on the basis of the total amount of pumping time. However, for the lower two management categories, it was discovered that tidal fluctuations are used for supplying irrigation water; the amount used could not be determined. The efficiency of water use for the other two groups was 37 and 34 percent for management level I and II respectively.

In regards to the production techniques employed in rice cultivation, there is a wide range of variability, as was noted above. In order to evaluate profitability associated with the different production practices, costs and returns budgets were calculated for each management group. It was found that costs which include value of all labor used ranged from 7187.01 to 2857.28 sucres per hectare, while net returns varied from 5312.99 to a loss of 657.28 sucres per hectare of rice grown for management level I and management level IV, respectively.

In order to compare the profitability of rice production and investments in machinery and land development, the internal rate of return criterion was used. This rate of return is that rate which equates the flow

of net benefits to the flow of net investment for a project over its expected economic life. The streams of benefits were estimated from the cost and returns budgets and the investments stream from the costs of land developments and initial machinery costs, together with expected maintenance and replacement costs of headgates and other water control structures. These rates varied from about 80 percent for production under management level I, 17.6 percent for management level II, to losses (negative returns--these were not calculated) for management levels III and IV.

Upon examining the potential aggregate implications of a shift of management and rice production techniques to the management level I classification, it was shown that the country could benefit substantially. As an upper limit it was estimated that the amount of land used for rice production could be increased from the present level of 107 thousand hectares to approximately 295 thousand hectares of land in the Daule and Vinces soil group. This could then be cropped twice during the year, making the total production possible, at yields of 100 quintales per hectare per crop, roughly 2.5 million metric tons. At the present levels of internal consumption, 2.3 million tons would be available for export. At the average of recent world market prices, it was found that the incomes from rice sales would be approximately 290 million dollars (U.S.).

As a lower limit to the potential aggregate, benefits of investment in rice irrigation and modernization of the 107 thousand hectares currently being cultivated could be utilized more efficiently by growing two crops instead of one and by increasing yields from the present level

of 25 to 100 quintals per hectare. By doing this, total production would be roughly 950 thousand metric tons, 750 metric tons of which would be available for export. The sale of this much rice would contribute about 96 million dollars (U.S.) to the national income.

CONCLUSIONS AND NEED FOR FURTHER RESEARCH

This project was undertaken to study the effects of irrigation and production techniques on production in developing countries. A case study was made on summer rice production in Ecuador.

In regards to objective number one, it was found that producers who use some type of irrigation system in producing rice could be divided into four distinct groups. Producers in the top two management levels used irrigation extensively while the bottom two categories used irrigation only to supplement the water supply already present in the natural depressions in which the rice was grown.

In attempting to evaluate the efficiency of irrigation water use, as outlined in the second objective, it was found that the information required was sketchy and in some cases nonexistent. The estimates of efficiency could only be made for the first and second management categories. Similar calculations could not be made for the third and fourth levels because of the lack of data and because the irrigation practices used by operators in these two groups do not lend themselves to measurement and evaluation.

From the calculations made in connection with objective number three, it was found that generally higher production costs were associated with the higher management levels. Also, it was discovered that the amount of manual labor employed is substantially lower in the management levels

I and II than that used by the bottom two categories. The primary reason for this probably lies in the fact that some high-labor intensive practices followed by the rice growers in the lower categories are not practiced by those operators in the two highest groups. As an example, bird control, which is entirely manual and uses a large part of the labor required in rice production under management groups III and IV, is not practiced at all by operators in the remaining two groups. Another observation made in connection with the production costs was that the degree of mechanization of production practices was very high for the top categories and nonexistent in the bottom category.

From the estimates made in calculating the internal rates of return for each management group, it can be concluded that investment in mechanization and irrigation for rice production, given the proper level of management capabilities, has a very high rate of return. At least, this was found to be the case in the Guayas Basin. Not only is this true for the individual operator but also for the country as a whole. It was discovered that the Daule and Vinces soils, which are ideal for rice culture, are quite extensive in this area. If it were all to be exploited, the potential return to the country from the sale of rice on the world market would be nearly 290 million dollars (U.S.). Of course, this assumes that there is enough water to irrigate such a project and that the price of rice in the world market remains within the range established from 1961 through 1967.

In view of all the evidence, one important point seems to be clear:

developing countries with ample agricultural resources can benefit substantially from the development of these resources, in most cases.

Naturally, this study does not answer all of the questions regarding the potential or role of agriculture in a developing nation. Such is not the case even for Ecuador or for the Guayas Basin for that matter. There is a need for further research on many of the subjects touched upon in this thesis. First and foremost is probably the need for further information regarding water requirements of rice and other crops in the tropics. To date, most of the studies regarding water use requirements have been carried out in the temperate regions of the world. Second, in regards to rice culture, research is needed to determine the real effects of birds on a crop. Third, more information is needed regarding the extent of the water resources of the Guayas region. Fourth, studies similar to this one need to be made for other crops with export potential in order to establish the proper allocation of water and other resources among the various crops. Fifth, in regards to production by the peasant farmers--those particularly in management level IV--information is needed that will permit the establishment of some logical criterion on which basis labor may be accurately valued. And sixth, studies with an aggregate viewpoint need to be carried out to determine what effects shifting production towards management level I methods and the resulting increases in total output might have on the local labor force and on the world market for rice.

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APPENDIXES

Appendix A

Questionnaire Used in Making Farm Survey

PRODUCCION DEL ARROZ BAJO RIEGO EN LA CUENCA DEL GUAYAS

CUESTIONARIO

1. Información a base de cuadra _____.

   hectárea _____.

2. Hacienda: _____.

3. Propietario: _____.

4. ¿Quién tiene las siembras de arroz?

   _____el propietario. _____arrendatarios.

5. ¿Cuántas cuadras/hectáreas tiene sembradas? _____.

6. ¿ Qué método de riego usa?

   _____ A. Bombeo

   _____ B. Abra con bombeo auxiliar

   _____ C. Abra (marea cada 15 dias)

   _____ D. Gravedad desde el río.

7. ¿ Qué facilidades de riego se usan?

   _____ A. Compuertas u otra facilidad para controlar el movimiento del agua.

   _____ ¿entrada?

   _____¿ salida?

   Descripción del sistema: _____

   _____

   _____

   Costo Total _____, por hectárea _____

_____B. ¿Usa usted bombas para regar?

¿Cuántas tiene? _____. ¿De qué tamano son _____

_____C. ¿Tiene usted el terreno mureado?

¿De que tamado son las parcelas? _____

Costo total_____, por hectárea _____

_____D. ¿Ha nivelado usted el terreno?

Costo total_____, por hectárea_____.

_____E. ¿Tiene usted compuertas y repreuas auxiliares?

¿ En los canales? _____. ¿En los muros? _____

Costo total_____, por hectárea _____.

8. Descríbanse las prácticas de riego. _____

_____

_____

_____

9. ¿ Qué método de simebra usa? _____

10. ¿ Qué variedad de semilla usa? _____

11. ¿ Qué cantidad se siembra por hectárea? _____

12. ¿ Usa usted fertilizantes? _____.

Nitrógeno _____, cantidad_____.

Fosfato _____, cantidad_____.

Potasio _____, cantidad_____.

13. ¿Usa usted herbicidas? _____.

¿Cuántas aplicaciones?

Al semillero _____.

A las siembras_____.

14. ¿Usa usted insecticidas? _____.

¿Cuántas aplicaciones? _____.

Al semillero_____.

A las siembras_____.

15. ¿Cuáles son sus costos de producción? (Sucres por hectárea)

Desbroce (socola)	_____
Quemada	_____
Arada	_____
Fangueo/Arrastrada	_____
Nivelada	_____
Semilla	_____
Preparación del semillero	_____
Siembra	_____
Fertilizantes	_____
Aplicación de fertilizantes	_____
Deshierbas cuántas? _____	_____
Insecticidas cuántas? ____	_____
Aplicación de insecticidas Método? __	_____
Pajareo	_____
Cosecha Método? ____	_____
Transporte	_____
Riego	_____

Mantenimiento de muros y canales _____

Administración--profesional _____

Interés _____

Alquiler de la tierra--si es arrendetario _____

Costo total _____

16. ¿Cuántos quintals de arroz fueron producidos? _____

Questionaire #2

COMISION NACIONAL DEL ARROZ

EVALUACION DE AREAS SEMBRADAS DE ARROZ DE _____DE 19_____.

Provincia_____ Nombre del Técnico_____

Cantón_____ _____

Parroquia_____

Sitio_____

1. Fecha_____.

2. Nombre de la hacienda_____.

3. Nombre del agricultor_____.

4. Tenencia: Propietario_____. Arrendetario_____.

5. Superficie sembrada en cuadras_____.

6. Nombre de la variedad_____.

7. Cantidad de semilla sembrada por cuadra_____.

8. Plagas_____.

9. Emfermedades_____.

10. Preparación del terreno

    a. Mecanizada_____.

    b. Muros_____.

    c. Canales_____.

    d. Nivelación_____.

11. Sistema de siembra:

    a. Espeque_____.

    b. Máquina_____.

    c. Transplante_____.

12. Uso de fertilizantes.

    a. Si_____.

    b. No_____.

13. Recursos hidráulicos

    a. Naturales (lluvias)_____.

    b. Artificiales: Bomba_____. Tape_____.

14. Observaciones: _____

_____

Appendix B

Production, Yield, Consumption and Price Data for Rice, Ecuador

Table 21. Area and production of rice, Ecuador.

Year	Area		Production			Yield (hulled)	
			Paddy rice	Hulled rice		per hectare	per acre
	Hectares	Acres	Metric tons	Metric tons	Quintals	Quintals	Quintals
1954	51,300	126,760	146,157	83,518	1,829,200	35.85	111.51
1955	78,500	193,971	198,443	113,396	2,497,700	31.82	12.88
1956	92,920	229,602	206,292	117,881	2,596,500	27.94	11.31
1957	104,200	257,475	248,488	141,993	3,127,600	30.02	12.15
1958	108,800	268,841	258,947	147,600	3,253,104	29.90	12.10
1959	115,800	286,138	262,266	159,492	3,515,204	30.36	12.29
1960	91,100	225,105	307,128	175,063	3,858,388	42.35	17.14
1961	94,600	233,753	296,759	169,150	3,728,066	39.41	15.95
1962	111,700	276,006	300,780	171,445	3,771,790	33.77	13.67
1963	113,059	279,364	304,490	173,559	3,818,298	33.77	13.67
1964	105,282	260,148	236,416	135,094	2,972,068	28.23	11.42
1965	99,729	246,427	260,397	148,793	3,272,556	32.81	13.28
1966	101,166	249,977	275,684	157,533	3,465,726	34.26	18.86
1967	110,561	273,192	249,639	142,650	3,738,300	28.89	11.49
1968	112,376	277,677	144,552	82,601	1,817,222	16.17	6.54
1969	107,419	265,428	288,016	164,550	3,620,460	33.71	13.64

(Comision Nacional del Arroz, 1969)

Table 22. Production, consumption, trade with exterior and prices of rice, Ecuador, 1961-1968.

	Metric tons				Dollars per metric ton					
Year	Production	Used for seed and food	Variation in supply	Exporta-tion	Importa-tion	Internal consumption	Market price	Wholesale price	Price of export	Ave. price of world exportation
1961	169,150	16,915	13,800	24,269	-	114,166	125.40		120.30	112.00
1962	171,480	17,148	16,200	5,161	-	132,971	126.40	(1)	127.50	123.90
1963	104,737	10,473	-11,800	33,845	-	72,219	150.70	126.50	109.00	122.60
1964	90,877	9,088	-26,300	10,571	-	97,518	155.10	126.50	126.00	124.60
1965	85,470	8,547	17,200	-	5,500	65,223	200.20	144.98	-	128.00
1966	110,050	11,005	1,700	22,474	-	74,871	184.80	141.46	132.10	141.20
1967	111,121	11,112	2,300	2,300	-	97,709	239.80	152.46	-	149.00
1968	71,500	-33,200	7,150	-	4,000	101,550	232.10	197.67	-	-

(1) The data concerning prices at the wholesale level for 1961 and 1962 are not consistent with the retail prices. For this reason, they are not included. (CEDEGE,1970)

Table 23. Method of land preparation, Guayas Basin, 1969.

Area planted	Mechanization					
	Complete *		Partial		None	
Acres	Acres	%	Acres	%	Acres	%
Winter Crop						
208,773	31,107	14.9	107,518	51.5	70,148	33.6
Summer Crop						
44,381	4,695	10.6	27,148	61.2	12,538	28.2
Total						
253,154	35,802	14.1	134,666	53.2	82,686	32.7

* Plowing, harrowing two times, diking and leveling. (Comision Nacional del Arroz, 1969)

Table 24. Extent of irrigation in the production of summer rice, Guayas Basin, 1968.

Province	Irrigation by pumping		Cultivation in natural ponds		Total area planted	
	Acres	%	Acres	%	Acres	%
Guayas	29,597	54.2	11,690	21.4	41,287	75.6
Los lios	2,095	3.8	4,201	7.7	6,296	11.5
Canar	1,296	2.4	0	0.0	1,296	2.4
Others	3,868	7.1	1,863	3.4	5,731	10.5
National Total	36,856	67.5	17,754	32.5	54,610	100.0

(Comision Nacional del Arroz, 1969)

Table 25. Estimated number of operators and total cultivated area of rice for major rice producing provinces, 1969.

Size of enterprise	Winter rice				Summer rice			
	No. of operators	%	Total area	%	No. of operators	%	Total area	%
Guayas Province								
to 4.9 cds	1,728	42.8	4,167	5.9	698	55.4	2,227	10.7
5 to 19.9 cds	1,461	36.2	14,071	19.8	368	29.2	3,212	15.5
20 to 49.9 cds	509	12.6	14,873	20.9	111	8.8	3,483	16.8
50 to 99.9 cds	193	4.8	12,258	17.3	39	3.1	2,619	12.6
100 or more	149	3.6	25,642	36.1	45	3.5	9,210	44.4
Total	4,035	100.0	71,001	100.0	1,261	100.0	20,751	100.0
Los Rios Province								
to 4.9 cds	2,205	58.2	4,710	13.2	496	74.5	1,021	21.7
5 to 19.9 cds	1,185	31.3	10,405	29.2	121	18.2	994	21.2
20 to 49.9 cds	265	7.0	7,553	21.2	29	4.4	758	16.1
50 to 99.9 cds	92	2.4	5,129	14.4	11	1.7	820	17.4
100 or more	41	1.1	7,897	22.0	9	1.2	1,110	23.6
Total	3,788	100.0	35,694	100.0	666	100.0	4,703	100.0
Grand total	7,823		106,705		1,926		25,454	

(Comision Nacional del Arroz, 1969)

Table 26. Estimated number of properties and total cultivated area of winter and summer rice for major rice producing provinces, 1954. Distribution according to size.

Size of properties	Winter rice				Summer rice			
	No. of properties	%	Total area	%	No. of properties	%	Total area	%
Guayas Province								
to 4.9 has.	8,374	66.2	10,240	34.0	1,991	65.6	2,340	31.3
5 to 19.9 has.	2,611	20.7	8,000	26.7	671	22.1	2,220	31.7
20 to 49.9 has.	913	7.2	3,360	11.2	197	6.5	1,040	13.9
50 to 99.9 has.	408	3.2	2,150	7.1	76	2.5	550	7.4
100 or more has.	336	2.7	6,310	21.0	98	3.3	1,320	19.7
Total	12,642	100.0	30,080	100.0	3,033	100.0	7,470	100.0
Los Rios Province								
to 4.9 has.	1,722	51.9	1,870	13.6	100	61.3	120	27.3
5 to 19.9 has.	537	16.2	1,410	10.5	5	3.1	20	4.5
20 to 49.9 has.	546	16.5	1,280	9.5	41	25.2	170	38.6
50 to 99.9 has.	251	7.6	700	5.2	2	1.2	10	2.3
100 or more has.	259	7.8	8,210	61.2	15	9.2	120	27.3
Total	3,315	100.0	13,420	100.0	163	100.0	440	100.0
Grand total	15,957		43,500		3,196		7,910	

(Comision Nacional del Arroz, 1969)

Table 27. Estimated number of properties and total cultivated area of winter and summer rice, 1954. National totals. Distribution according to size.

Size of property	Winter rice				Summer rice			
	No. of properties	%	Total area	%	No. of properties	%	Total area	%
to 4.9 has.	10,096	63.3	12,060	27.7	2,091	65.4	2,460	31.1
5 to 19.9 has.	3,148	19.7	9,430	21.7	676	21.2	2,240	28.3
20 to 49.9 has.	1,459	9.1	4,640	10.7	238	7.4	1,210	15.3
50 to 99.9 has.	659	4.1	2,850	6.6	78	2.4	560	7.1
100 or more has.	595	3.8	14,520	33.3	113	3.6	1,440	18.2
Total	15,957	100.0	43,500	100.0	3,196	100.0	7,910	100.0

(Comision Nacional del Arroz, 1969)

Table 28. Estimated number of operators and total cultivated area of winter and summer rice, 1969. Distribution according to size of enterprise. National totals.

Size of enterprise	Winter rice				Summer rice			
	No. of operators	%	Total area	%	No. of operators	%	Total area	%
to 4.9 cds.	3,971	50.1	8,963	8.3	1,194	62.0	3,248	12.8
5 to 19.9 cds.	2,696	34.0	24,905	23.1	489	25.4	4,206	16.5
20 to 49.9 cds.	791	10.0	22,902	21.2	140	7.2	4,241	16.7
50 to 99.9 cds.	286	3.6	17,467	16.2	50	2.6	3,440	13.5
100 and more	187	2.3	33,764	31.2	54	2.8	10,320	40.5
Total	7,931	100.0	108,001	100.0	1,927	100.0	25,455	100.0

(Comision Nacional del Arroz, 1969)

Appendix C

Response of Rice to Fertilizer

Table 29. Average total yield in metric tons per hectare for 20 varieties of rice, with two levels of nitrogen fertilization. "Boliche," 1969.

Varieties	Levels of nitrogen 0 kg.	100 kg.	Average
IR 95-23-5-1-3	6.82	7.31	7.065 a
IR 305-3-17-2	6.73	7.28	7.005 ab
IR 8-288-3-41	6.51	7.01	6.760 abc
IR 3-56-3-2-2	6.01	6.91	6.460 abcd
IR 503-1-104	6.45	6.21	6.330 bcde
IR 12-178-2-3	5.88	6.55	6.215 cde
IR 181-2-2-1	6.15	6.26	6.205 cde
IR 154-18-2-1	5.42	6.52	5.970 def
IR 532-1-14	5.18	6.61	5.895 def
IR 5-47-2	6.31	5.39	5.850 defg
IR 532-1-91	5.71	5.96	5.835 defg
ICA 10	5.58	5.91	5.745 defg
Tapuripa	5.94	5.45	5.695 efg
IR 272-2-6-3	5.49	5.48	5.485 efgh
IR 532-E-207	4.87	5.92	5.395 fgh
IR 140-165	5.33	5.44	5.385 fgh
IR 239-149-1	4.89	5.36	5.125 gh
IR 60-9-6-1-3	4.66	4.91	4.785 hi
Bluebonnet 50	3.93	4.58	4.255 i
Canilla	5.00	2.07	3.535 j

Averages followed by the same letter are not statistically different at a 1% probability level. (Arevalo, 1968)

Table 30. Average yields in tons per hectare in an experiment comparing three varieties of rice at four levels of nitrogen fertilization and two methods of planting. "Boliche," 1969.

	Direct planting					Planting by transplant				
	Levels of nitrogen				Average	Levels of nitrogen				Average
Variety	0	40	80	120	yields	0	40	80	120	yields
IR 8	5.12	5.82	5.84	6.45	6.80a**	4.47a--	4.96	5.31	5.57	5.07a **
IR 5	3.70	3.61	3.32	2.91	3.38c	4.23	4.43	4.84	4.44	4.48a
Bbt. 50	3.91	4.35	4.20	3.91	4.09b	2.83	2.81	3.36	3.01	3.00b
Average of levels	4.24	4.59	4.45	4.42	4.42	3.84c	4.06bc	4.50a	4.34ab	4.18

**Averages having the same letter designation do not differ statistically with a confidence level of 99%. (Andrade, 1969)

Table 31. Results of rice production experiments in Daule, 1968. National Rice Commission.

Variety	Production per hectare in quintals of 165 pounds	Fertilization N	P_2O_5	K_2O	Cycle in days	Height in meters
IR-8	165.40	180 kilos	120 kilos	150 kilos	141	1.06
Blue Bonnet 50	71.81	84 "	48 "	166 "	126	1.36
Dawn	93.33	84 "	48 "	66 "	110	1.35
Blue Belle	70.33	84 "	48 "	66 "	110	0.86
Tapuripa	153.33	84 "	48 "	66 "	165	1.42
Balilla x Sollana	120.00	50 "	35 "	40 "	90	0.91

(Comision Nacional del Arroz, 1969)

Appendix D

Comparison of Internal Rates of Return to Other Rates of Return

Table 32. Reported rates of return on investment and standardized internal rates of return.

	Rate of return on investment originally reported	Internal rate of return
	(percent)	(percent)
A. Caton, McCorkle, and Upchurch (Seeding)		
Plan I		
Beef 15¢ per pound	14.50	6.27
Beef 20¢ per pound	52.70	9.14
Plan II		
Beef 15¢ per pound	9.30	5.83
Beef 20¢ per pound	45.70	8.81
B. Lloyd and Cook (Seeding)		
Use Situation No. 1	44.84	27.26
Use Situation No. 2	29.93	22.17
Use Situation No. 3	11.88	14.14
C. Caton and Beringer (Seeding)		
Alternative I		
Beef 15¢ per pound	198.10	18.12
Beef 20¢ per pound	297.50	23.22
Alternative II		
Beef 15¢ per pound	159.80	15.13
Beef 20¢ per pound	246.60	18.90
D. Gardner		
Seeding	15.34	15.34
Spraying	9.54	22.60
Beating	4.80	6.53

(Gardner, 1963)

Appendix E

Factors Limiting Rice Producing Region

Table 33. Characteristics of soil associations of the Guayas Basin, Ecuador.

Association	Symbol	Altitude meters	Rainfall mm.	Slope percent	Parent material
Pichilingue	P	20-650	2000-3000	0-5	Alluvium from basic intrusives and volcanic ash
Naranjito	N	0-10	1500-2000	0-10	Unconsolidated tertiary alluvium with additions from basic intrusives and volcanic ash; coarse to fine sand with high % of feldspar grains
Daule	D-	0-60	500-1500	0-2	Idem, finer textured
Vinces	V	0-60	1500-2000	0-2	Idem, finer textured
Chimbo	C	2000-3000		10-60	Leaned volcanics; some cretaceous (undifferentiated)
Balzar	B	60-1000	1200-1300	10-60	Tertiary sandstone, shale and limestone. Some volcanics
Ayora	A	0-100	500-800	0-5	Silstone, shale; some limestone
Zumbagua	Z	3000-4000	400-1500	0-80	Volcanics and sedimentary (cretaceous) rocks
Oro	O	1000-2000	0-700	60 plus	Sandstone, shale, silstone. Locally iron cemented
Mana	M	200-1000	2000-3000	20-80	Basic volcanics and diabase intrusives
Tambo	T	1000-3000	2200-3000	80 plus	Basic volcanic ash and diabase intrusives
Riobamba	R	3000 plus	1500-2500	10 plus	Basic volcanics, intrusives

Vegetation and use of land	Drainage Internal	Drainage External	pH
Evergreen broadleaf in north, 25%; 75% cultivated, mainly bananas	Excellent	Excellent	5.8-7.2
Almost entirely cultivated--annual and perennial crops. Some patches of deciduous broadleaf	Excellent	Fair	5.8-7.0
Annual crops, pasture. Some broadleaf scrub and mangrove	Poor	Poor	5.3-7.5
Annual crops, some pasture	Fair	Poor	5.4-7.5
High mountain forest, annual crops--grain and tubers, pasture	Excellent	Excellent	5.5-7.0
40% annual crops and pasture. 30% deciduous broadleaf; 30% Evergreen broadleaf	Poor	Poor	5.1-8.0
Mixed tree and annual crops. Broadleaf scrub, deciduous broadleaf	Poor	Poor	5.1-8.0
Pasture, annual crops. Some High Mountain forest in north	Good	Excellent	5.6-6.5
1/2 deciduous broadleaf. 1/2 Evergreen broadleaf; slight annual ag.	Fair	Excellent	5.0-7.5
Shifting cultivation--perennial crops (coffee), other subsistence. Low Mountain forest. Evergreen, deciduous broadleaf at lower elevations	Good	Excellent	5.5-7.0
Annual agriculture. High Mountain forest and Paramo. Pasture	Fair	Excellent	5.5-7.0
Pasture. Snow	None	Excellent	

(Pan American Union)

Table 34. Tolerance of three types of crops for salinity as determined by the United States Salinity Laboratory. (Under each of the three types of crops, the most tolerant crops are listed first and the least tolerant last.)

Type of crop	Salt Tolerance			
	Good (Group I)	Moderate (Group II)		Poor (Group III)
Fruit	Date palm	Pomegranate		Grapefruit
		Fig		Pear
		Grape		Almond
		Olive		Apricot
				Peach
				Plum
				Apple
				Orange
				Lemon
Field and truck	Sugar beet	Alfalfa	Cantaloupe	Vetch
	Garden beet	Flax	Lettuce	Peas
	Milo	Tomato	Sunflower	Celery
	Rape	Asparagus	Carrot	Cabbage
	Kale	Foxtail millet	Spinach	Artichoke
	Cotton	Sorghum-grain	Squash	Egg plant
		Barley-grain	Onion	Sweet potato
		Rye-grain	Pepper	Potato
		Oats-grain	Wheat-grain	Green beans
		Rice		
Forage	Alkali sacaton	White sweet clover	Wheat-hay	White Dutch clover
	Salt grasses	Yellow sweet clover	Oats-hay	Meadow foxtail
	Nuttall alkali	Perennial rye grass	Orchard grass	Alsike clover
	Bermuda	Mountain brome	Blue grama	Red clover
	Rhodes	Barley-hay	Meadow fescue	Ladino clover
	Rescue	Birdsfoot trefoil	Reed canary	Burnet
	Canada wild rye	Strawberry clover	Big trefoil	
	Beardless wild rye	Dallis grass	Smooth brome	
	Western wheat grass	Sudan grass	Tall meadow oat grass	
		Hubam clover	Cicer milk vetch	
		Alfalfa-Calif. common	Sour clover	
		Tall fescue	Sickle milk vetch	
		Rye-hay		

(Israelsen and Hansen, 1962)

Table 35. Principal areas of rice production.

Canton	Parrish	Sites
GUAYAS PROVINCE		
Balzar	Balzar	Left and right margins of Daule River
	Colimes	Congo River - Macul River - Cerr El Naranjal
	Velasco Ibarra	
	Guayas	
Daule	Daule	Los Tintos - Península de Quimas
	Juan B. Aguirre	Naupe - Sante Lucía - Cascol
	Nobol	La Maravilla - América - Barbazc
	Sta. Lucía	Imperio - La Aurora
	Palestina	Las Lojas - Lomas de Sargentillo Guarumal
Milagro	Milagro	Zona limítrofe con Yaguachi
	Chobo	
Samborondón	Samborondón	The whole area
	Tarifa	
Yaguachi	Yaguachi Nuevo	El Triunfo - Vuelta Larga
	Yaguachi Viejo	La Violeta - Pallo - Buena Fé
	Pedro J. Montero	Nauza - Guayala - Eugenia Amelia - Clementina
	Marcelino Mariduena	
	Baquerizo Moreno	
	Simón Bolívar	
LOS RIOS PROVINCE		
Babahoyo	Montalvo	El Carment - Clementina
	Pimocha	La Elvira - La Carmela
	F. Cordero	La Iegua - Porvenir
	Babahoyo	Legua de ios Indios - Santa
	Caracol	Rita - Via Babahoyo - Jujan
	Barreiro	Via Rio Chico - F. Cordero Via San Juan - Pueblo Viejo
Vinces	Vinces	Abras de Mantequilla - La Balza
	Antonio Sotomayor	La Carmela - Guayabo - Juaneche Junquillo - Soberana y premavera

Table 35. Continued

Baba	Guare
	Isla de Bejucal
Pueblo Viejo	Pueblo Viejo
	Pechicha
Urdaneta	Catarama
	Rioaurte

(Aviles, 1968)

Appendix F

Machinery and Equipment Requirements

Table 36. Machinery and equipment inventory for 500 hectares. Management level I.

Item	Expected life (years)	Number	Unit cost (sucres)	Total (sucres)
Pump 16"	15	4	S/.210,000	S/.840,000
Pump 4"	15	1	30,000	30,000
Crawler Tractor	15	1	560,000	560,000
Wheel Tractor (60 hp)	15	7	130,000	910,000
Combine	7.5	6	330,000	1,980,000
Jeep	5	2	100,000	200,000
Rome Plow	15	1	35,000	35,000
Ditcher	15	1	12,000	12,000
Tool Bar	15	1	50,000	50,000
Mudding Wheels	15	6 sets	6,000	36,000
Terrace Blades	15	3	6,000	18,000
Transport Trailer	15	4	8,000	32,000
				S/.4,703,000

Table 37. Machinery and equipment inventory based on 150 hectares production. Management level II.

Item	Expected life (years)	Number	Unit cost (sucres)	Total
Crawler tractor	15	1	S/. 560,000	S/. 560,000
Wheel tractor (80 hp)	15	1	200,000	200,000
Wheel tractor (40 hp)	15	1	95,000	95,000
Rome plow	15	1	35,000	35,000
Disc harrow	15	1	20,000	20,000
Land plane	15	1	58,000	58,000
Drill	15	1	60,000	60,000
Pump (5400 gal/min)	15	2	170,000	340,000
Terrace blade	15	1	6,000	6,000
Combine	8	1	421,500	421,500
				S/. 1,795,500

Table 38. Machinery and equipment inventory for 25 hectares. Management level III.

Item	Expected life (years)	Number	Unit cost (sucres)	Total
Pump--4"	15	1	S/. 30,000	S/. 30,000
Hand sprayer	5	2	1,120	2,240
				S/. 32,240

Appendix G

Miscellaneous Tables

Table 39. Farm wage rates--Guayas Basin, Ecuador, 1970.

General farm labor	per hour	S/. 4.00	$ .17
Irrigators	per hour	4.00	.17
Pump operators	per hour	5.00	.215
Wheel tractor operator	per hour	5.00	.215
Crawler tractor operator	per hour	8.00	.345
Technical assistant--agronomist university training	per month	6000.00	258.00
Irrigators	per day	30.00	1.30
Pump operator	per hour	4.00	.17
General farm labor	per day	40.00	1.73
Bird control	per day	10.00	.43
Transplanting	per hectare	800.00	24.50
Harvesting--hand	per sack (165#)	15-20.00	.65-.85
Weeding--machete	per hectare	300.00	13.00

Table 40. Equipment rental rates (with fuel, operator and maintenance)--Guayas Basin, Ecuador, 1970.

Tractor--Ford 5000, 70 hp	per hour	S/. 70.00	$ 3.00
Bulldozer--D4 Cat	per hour	140.00	6.00
Aerial fumigation	per hectare	30-35.00	1.30
Aerial application of herbicides	per hectare	100.00	4.30
Aerial seeding--pregerminated	per hectare	105.00	4.50
Tractor--John Deere 4020 (plowing--molboard--3/4 acre/hr)	per hour	150.00	6.50
Bulldozer--D6 Cat	per hour	200.00	8.60
Bulldozer--TD9 INT	per hour	100.00	4.30
Combine--rice	per sack (165#)	15.00	.65

Table 41. Cost of selected items at Guayaquil, July 1970.

Item		Sucres	Dollars
Pickup 1/2-ton Chevrolet		S/. 115,000	$ 4,950
Pickup 3/4-ton Dodge		132,000	5,690
Truck 2-ton Chevrolet		195,000	8,400
Truck 5-ton Fiat		360,000	15,500
Jeep CJ5		100,000	4,300
Disc plow (Ford) 5 disc		26,000	1,120
Tandem disc (Ford) 2 meters		20,000	860
Tandem disc (Ford) 3 meters on wheels		32,000	1,380
Rotary cutter (Ford) 60"		19,000	820
Cat D6 with dozer		1,200,000	51,725
Cat D4 with dozer		560,000	24,200
Home plow		35,000	1,510
Tractor Ford 4000 60 hp		130,000	5,600
Tractor John Deere 3120 80hp		200,000	8,620
Tractor John Deere 4020 105hp		270,000	10,640
Tandem disc harrows 14 disc--on wheels John Deere		44,000	1,895
Drill 17 disc John Deere		60,000	2,390
Pump--low pressure 16" 70 hp cat. (capacity of 800 gals/min)		215,000	9,050
Pump--low pressure 14" 75hp (capacity of 5400 gals/min)		170,000	7,325
Combine--rice M140 Clayson (17' cut, wheels, tracks)		421,500	18,168
Combine--rice M133 Clayson (12' cut, wheels, tracks)		330,000	14,225
Gasoline--premium	per gallon	4.65	.20
Gasoline--regular	per gallon	4.45	.192
Diesel	per gallon	3.25	.14
Urea 46%	per 100 wt.	127.00	5.47
Potash	per 100 wt.	130.00	5.60
Phosphate	per 100 wt.	90.00	3.88
Portland cement	per bag 42 1/2 kgl.	20.40	.88
Brick	per 1000_3	100.00	4.30
Sand	per 3 M_3	140.00	6.03
Gravel	per 3 M	240.00	10.35
Concrete block	per 1000	1,750.00	75.45

Table 42. Unimproved rice land, maximum, minimum and average prices stated in sucres per hectare.

	Marsh--Swampy Land			Fallow and Dry Land			Savanna		
Canton	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Daule	6000	3000	4500	1500	350	925	1500	500	1000
Balzar	1500	800	1150	900	350	625	125	100	112.5
Vinces	1500	450	975	500	275	387.5	300	250	275
Babahoyo	3200	1500	2350	3500	1000	2250	---	---	---
Yaguachi	3000	1000	2000	2000	1000	1500	---	---	---
Average	3040	1350	2195	1680	595	1137	642	283	462.5

(Aviles, 1968)

Table 43. Conversion rates.

S/. 1 (Sucre Ecuatoriano)	=	$ .0431 or 4.31 cents
1 kgl. (kilo or kilogram)	=	2.2046 pounds
1 qq. (quintal)	=	100 pounds (cwt.)
1 M.T. (metric ton)	=	2204.6 pounds
1 mm. (millimeter)	=	.03937 inches
1 cm. (centimeter)	=	.3937 inches
1 m. (meter)	=	39.37 inches or 1.0936 yards
1 km. (kilometer)	=	1093.6 yards or .6214 miles
1 cd. (cuadra)	=	.7 hectares or 1.73 acres
1 ha. (hectare)	=	2.471 acres
1 km^2 (square kilometer)	=	.3861 square miles
1 l. (liter)	=	.264 gallons
1 M^3 (cubic meter)	=	1.3078 cubic yards