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INVESTMENT STRATEGIES IN PERUVIAN AGRICULTURE: SOME RECENT EXPERIENCES IN DEVELOPMENT PLANNING

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RAND RESEARCH BRIEF

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RM-4791-AID, Investment Strategies in Peruvian Agriculture: Some Recent Experiences in Development Planning, D. A. Fitchett, June 1966.

PURPOSE: To illustrate the use of techniques of economic analysis in evaluating development projects and sectoral development programs. The analytic approach suggested here is intended to help decisionmakers choose among alternative proposals for development planning.

APPROACH: Four geographically and culturally different agricultural projects, each an example of contrasting agricultural development strategies, are evaluated in terms of net increase in farm output.

FINDINGS: The widely varying payoffs observed in the four projects reveal that too little attention was given to the problems of uncertainty, sensitivity analysis, and time discounting in planning the development strategy for each project. In particular, the analysis reveals that uncertainty is inherent in estimating cost and output in planning development projects. To alleviate this problem of uncertainty, alternative levels of costs and benefits should be considered in evaluating development proposals. Not only should the predicted costs and outputs be examined, but multiples of predicted cost and fractions of predicted output should be included in the preparation of feasibility studies for development planning. Using this analytic approach, a comparative evaluation of the four projects suggests that intensive agricultural development activities involving large-scale capital investment should be avoided and that resources should be directed toward increasing the operating efficiency of currently established farming enterprises.

BACKGROUND: This study is a contribution to RAND's investigation of the problems involved in allocating scarce resources in those Latin American countries receiving foreign aid. Other aspects of planning the economic development of Latin American countries are discussed in RM-4522-AID, Bargaining in AID Program Assistance: The Case of Chile, by L. L. Johnson, and RM-4594-AID, An Appraisal of U.S. Capital Assistance to Less Developed Countries (U), by F. T. Moore, A. P. Carlin, R. L. Slighton, W. A. Johnson, L. L. Johnson, A. H. Pascal, Confidential.

PREFACE

Peru, like many Latin American countries, is experimenting with agricultural development programs to better the living standards of its people. Four of Peru's agricultural development projects are described in this Memorandum, which was prepared for the Agency for International Development as a part of The RAND Corporation's continuing study of resource allocation problems in the economic development of aid recipient nations. This material is addressed to the economic analyst who must evaluate a project proposal, or, hopefully, several alternative and competing proposals, of relatively careful engineering design.

While the content is aimed primarily at individuals making evaluations in AID's country missions and regional offices, it is hoped that our suggestions will be well received by host-country groups submitting proposals to AID for financing. We try to demonstrate in what follows some of the costs of disregarding an analytic approach.

SUMMARY

The agricultural sector in most Latin American economies is characterized by primitive farming methods that engage a large part of the population, and generally result in low levels of performance. To obtain a better standard of living for their people, many Latin American governments are experimenting with agricultural development programs. However, the human and material resources for such projects are limited, so decision-makers must choose wisely among alternative and competing development activities. It is hoped the historical as well as the analytical content of this study of one country's experiences will be of considerable interest to AID personnel who must evaluate and compare proposals for project assistance.

This Memorandum describes examples of four diverse agricultural development strategies in Peru. These are:

1. The San Lorenzo project -- a large-scale irrigation project to colonize an arid region, requiring considerable investment in water supply facilities and infrastructure. This project appears to be an overly expensive one relative to the anticipated returns. It is the least desirable development strategy.

2. The Lower Piura Valley project -- an improvement of irrigation supplies to already established farms in an arid region, largely via regularizing the seasonal discharge of water. Part of the probably exaggerated cost of this project may be due to its association with the San Lorenzo program. However, it suggests what may be attained by constructing a reservoir at the head of a coastal valley to regularize the seasonal volume of river flow.

3. The Coast project -- a plan to increase the productivity of small and medium-sized farms by stimulating peasant agriculture through increased supply and use of credit, technical assistance, improved seeds, and fertilizers. Of the alternatives examined here, this project is probably the most desirable for expanding the country's agricultural output.

4. The Tingo María-Tocache project -- a plan to colonize the Central Huallaga Valley of Eastern Peru, a high rainfall tropical area. While this project appears to offer comparatively high payoffs relative to its costs, it represents the riskiest strategy. It is located in a frontier area of difficult access and the stock of agricultural techniques suitable to tropical rainforest zones is relatively underdeveloped.

To the extent possible, we present for each activity a chronological history, a physical description, and a brief economic evaluation. At this time, chronology will have some meaning only for the first two projects, which are separable parts of a scheme initiated in 1949. A brief history is presented of the settlement of the Tingo María-Tocache area, although the project itself still only exists as a feasibility study undertaken in 1962. The Coast Plan was only recently initiated with AID financing.

After these individual presentations, a comparative evaluation of the four projects is made. We chose a relatively narrow objective function for evaluating and comparing these activities -- the net increase in farm output. In reality, of course, there are many possible objectives. Given the large variety of considerations, it is neither feasible nor desirable that we claim to have reduced the decision-making problem to one single rule such as "maximize present worth."

Briefly, the analytic method applied is as follows. The net payoff function for each project is composed of the time stream of anticipated farm output (less estimated farm operating costs) less the time stream of investment and operating costs. In our study we observe that initial cost and benefit estimates for projects are usually not realized, that is, there is some uncertainty surrounding these estimates. This uncertainty with respect to cost overruns and output shortfalls requires that project evaluation include consideration of alternative levels of costs and benefits. As an approach to this problem of uncertainty, not only are the respective predicted costs and outputs examined, but the multiples of predicted cost and fractions of predicted output are considered as well, a practice we strongly recommend for future feasibility studies. Moreover, as the question of time bulks large in some of these projects (i.e., there are a number of years during which resources are poured in before returns are forthcoming), we discount these time streams of resource flows to obtain their present value. Three different discount rates are applied, representing different assumptions with respect to the opportunity cost of capital.

This Memorandum is not intended as a detailed guide for preparing project feasibility studies. It is an attempt to demonstrate that attention to the problems of uncertainty, sensitivity analysis, time discounting and choice criteria, as discussed and applied in Sec. V, would contribute to prefeasibility and feasibility studies of a more informative and useful nature for decision-makers. The widely varying payoffs (realized or potential) observed in the four programs leave little doubt that, at present, decision-makers are not receiving the information that is essential for them to perform their tasks. The costs of improving this information flow are probably not excessive, especially in view of how costly future decision errors might be.

Finally, our study suggests that large-scale capital intensive agricultural development activities should be avoided and resources devoted instead to increasing the operating efficiency of currently established farming enterprises.

ACKNOWLEDGMENTS

We wish to acknowledge the support, assistance, and cooperation of US/AID personnel in Washington and Peru, and the help of the many Peruvian nationals with whom we were in contact while making this study. We also wish to express our gratitude to our RAND colleagues, M. A. Geisle L. L. Johnson, F. T. Moore, A. H. Pascal, and W. S. Sharpe, for their suggestions and comments.

CONTENTS

PREFACE iii

SUMMARY v

ACKNOWLEDGMENTS ix

Section

I. INTRODUCTION 1
Nature of the Study 1
Organization of the Study 2

II. THE SAN LORENZO AND LOWER PIURA PROJECTS 5
History 5
The Project and Its Costs 15
The Payoffs 24
Concluding Comments on San Lorenzo 25

III. THE COAST PROGRAM 27
The Project and Its Costs 27
The Payoffs 29

IV. THE TINGO MARÍA-TOCACHE SETTLEMENT PROJECT 33
History 34
The Project and Its Costs 35

V. A COMPARATIVE EVALUATION OF THE PROJECTS 40
The Techniques Utilized 40
Uncertainty 40
Sensitivity Analysis 41
Time Considerations 42
A Comparison of Project Payoffs 43

VI. BROADENING THE SCOPE OF THE EVALUATION 55

VII. CONCLUSIONS 56

I. INTRODUCTION

NATURE OF THE STUDY

As the less developed countries in Latin America attempt to raise their living standards and to make the structural changes associated with economic development, they have focused their attention on problems of agricultural development. With large segments of their populations engaged in agricultural pursuits, often of a commercially marginal or subsistence nature, the room for improvement seems great. Improvement programs, however, face constrained development budgets, as well as the limited human and material resources available in any single time period or over a series of time periods. Thus, in allocating resources, decision-makers must choose wisely among competing development activities, accepting some, eliminating some, and deferring others.

It is to this problem of choice that we turn. We will not discuss how to design a desirable or feasible project, for that task lies in the realm, for example, of the agricultural or hydraulic engineer. We are addressing the economic analyst who must evaluate a project proposal (or, more hopefully, several alternative and competing project proposals) of relatively careful, though not necessarily perfect, engineering design, for we are going to make allowances for some degree of uncertainty in costs and benefits. We will not develop any new analytical tools. Rather, we hope to demonstrate that by applying a few simple methods of economic analysis, it is possible to considerably improve current efforts in evaluating development projects and sectoral development programs.

Efficient resource allocation is not an end in itself, but a means to an end. In the context of this study, our payoff function (our objective) is to increase the value of farm output. Although this is a very general concept, for our purposes we will not attempt a finer classification, e.g., export products, import substitutes, etc. Actually, development projects probably have multiple objectives. With respect to sectoral program composition, the decision-maker may need to establish (at least in his own mind) the rates at which he can trade off some of

the objectives (and their correlative projects) against others. In the final instance, choice may largely depend on the economic and political implications of various alternative projects or groups of projects. At this stage, however, we are examining a problem perhaps less sophisticated, but by no means lending itself to facile solution.

As the vehicle for this demonstration, we chose four agricultural development projects in Peru, whose great environmental and cultural diversity offers a background for quite contrasting agricultural development strategies. Drawing all the examples from a single country allows a greater degree of homogeneity than would likely exist if the projects were drawn from various countries. While the examples are specific to Peru, the methods may offer solutions to the agricultural bottleneck in a number of LDC's. The four undertakings (shown in Fig. 1) are:

1. The San Lorenzo irrigation settlement project -- a large-scale irrigation settlement in an arid region, requiring considerable investment in water supply facilities and infrastructure.

2. The Lower Piura Valley project -- improving irrigation supplies to already established farms in an arid region, largely via regularizing the seasonal discharge of water.

3. The Coast Plan to increase the productivity of small and medium-sized farms -- stimulating peasant agriculture through increasing the supply and utilization of credit, technical assistance, improved seeds, and fertilizers.

4. The Tingo María-Tocache settlement project in the Central Huallaga Valley of eastern Peru -- a new settlement (colonization) in a tropical area of high rainfall, organized and planned on a large scale.

By no means, of course, do these projects exhaust the spectrum of development strategies available. Others not specifically analyzed here that could have a significant impact on agricultural development are: land reform programs, changes in water laws, spontaneous settlement, etc.

ORGANIZATION OF THE STUDY

For each project we present a chronological history, a physical description, and a brief economic evaluation. Chronology will have some import only for the first two studies, which are separable parts of a

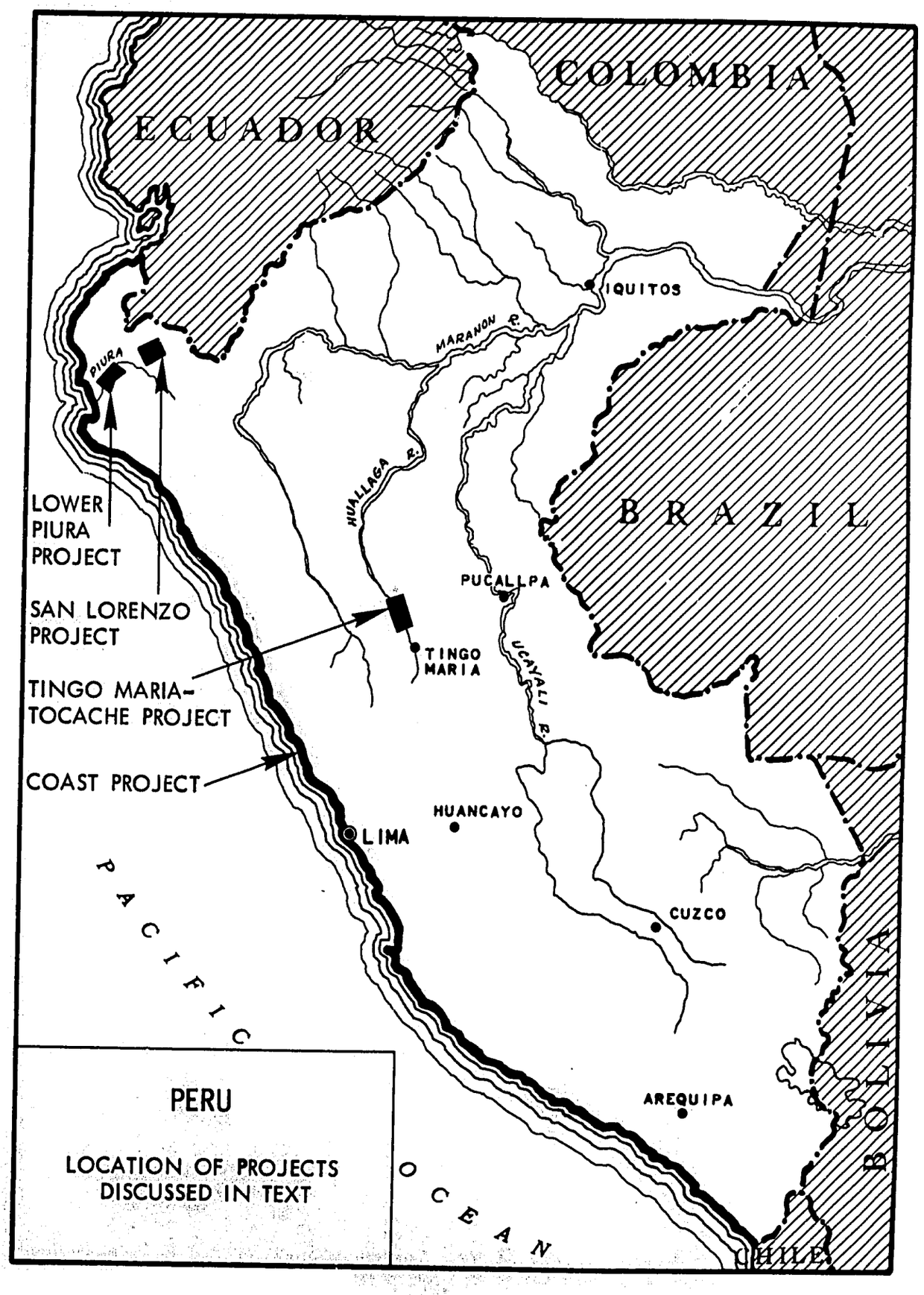
COLOMBIA
ECUADOR
IQUITOS
MARANON R.
PIURA
HUALLAGA R.
BRAZIL
LOWER PIURA PROJECT
SAN LORENZO PROJECT
PUCALLPA
TINGO MARIA
UCAYALI R.
TINGO MARIA-TOCACHE PROJECT
COAST PROJECT
HUANCAYO
LIMA
PACIFIC
CUZCO
BOLIVIA
AREQUIPA
PERU
LOCATION OF PROJECTS DISCUSSED IN TEXT
OCEAN
CHILE

Fig. 1

scheme initiated in 1949. A brief history is presented of the settlement of the Tingo María-Tocache area, although the project itself still only exists as a feasibility study undertaken in 1962. The Coast Plan was only recently initiated.*

A brief economic evaluation accompanies the discussion of each project. In Sec. V, a comparative evaluation is made. Presented at that time is a description and short discussion of the analytical method utilized for this comparative evaluation. For now, let us state that the net payoff function for each project is composed of the time stream of anticipated farm output (less estimated farm operating costs) less the time stream of investment and operating costs. We examine not only the respective costs and outputs, but also multiples of predicted cost and fractions of predicted output, a practice we strongly recommend for future feasibility studies. Moreover, as the question of time bulks large in some of these projects (i.e., there are a number of years during which resources are poured in before returns are forthcoming), we discount these time streams of resource flows to obtain their present value. In part because of the various opinions about a proper discount rate for LDC's and in part to demonstrate the sensitivity of alternative strategy payoffs to variations in discount rates, three different rates are applied.

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*One advantage is that the output predictions for projects 1, 3, and 4 have been formulated recently and in a relatively compact period of time (1962-1964).

II. THE SAN LORENZO AND LOWER PIURA PROJECTS

The San Lorenzo and Lower Piura irrigation projects were originally intended to take three years to complete and to cost about $4 million. Development was begun in 1949, and completion is now scheduled for 1967, at which time, total costs will have amounted to almost $87 million. Because of this project, the water supply to a rich cotton-producing area, the lower Piura Valley, has been regularized and increased; on the 45,000 hectare* settlement in San Lorenzo, small and medium-sized farming units are being developed and offer considerable potential profit for a limited number of private farmers. But should this activity have ever been undertaken? In the material to follow, the history and characteristics of this undertaking are discussed. In Sec. V, where its returns are compared to those of other activities, we suggest that the project was a poor choice.

HISTORY**

The northern coast of Peru is extremely arid, normally receiving little or no rainfall. Agricultural activities undertaken in this region are irrigated by rivers flowing westward from the Andes. There is great seasonal fluctuation in the volume of water these rivers carry; early in the year there are occasional flood threats, while later on the river beds nearly dry up. There is also considerable inter-year variation in the river flow.

Although most of the Peruvian coast is a relatively narrow strip, it widens considerably as one moves north in the Department of Lambayeque. And the next department to the north, Piura, contains a large area sloping gently upward, with slightly rolling terrain for

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*A hectare is roughly equivalent to 2.5 acres.

**Certainly, a planner who must evaluate a project proposal will not have at his disposal or be able to foresee with much certainty all that will befall an undertaking before it is completed. With careful forethought, however, perhaps some pitfalls can be avoided. To illustrate the possible costs of total neglect of this factor, we present a rather lengthy, though not complete, history of the projects. To our knowledge, these facts have not been compiled elsewhere.

some distance inland. Here, between 100 and 200 meters above sea level, are located the San Lorenzo irrigation settlement and the lower Piura Valley projects

Toward the end of the nineteenth century, it was judged possible in the Piura area to divert water from the Quiroz River through the beds of the Totoral and San Francisco streams into the Piura River. In 1937-1942, the Dirección de Aguas e Irrigación undertook further studies regarding the possibilities of such a project.* Then, in April 1943, a Supreme Resolution authorized the Ministry of Agriculture to draw up plans for financing and carrying out extensive irrigation works in the Department of Piura.

The 1943 plans called for diverting water from the Quiroz and Chipillico Rivers to a reservoir at Palomino on the confluence of the San Francisco stream and the Piura River. The project would (1) regularize the supply of water to 31,000 hectares that were intermittently cultivated in the lower Piura Valley, and (2) allow the cultivation of 20,000 unused hectares in San Lorenzo. Increasing the area under cotton cultivation in this region appeared to be the main goal.

The project's estimated cost was 25,270,471 Peruvian soles** (about 3.9 million U.S. dollars at the controlled, 6.5 to 1, exchange rate extant).*** In 1946, the parliament passed a law to finance the

*Irrigaciones en el Peru, 1948-1956, Lima, Peru, 1956, p. 11.

**Andean Airmail and Peruvian Times (hereafter Peruvian Times) Apri, 16, 1943, p.2.

***We convert costs expressed in terms of soles to dollars by applying the official rate of exchange (6.5 to 1) for those few occasions where pre-1949 figures are considered. All sol values for 1949 (when spending actually commenced) to 1959 are converted to dollars using the free market rate of exchange reported by the Banco Central de Reserva del Peru, Renta Nacional del Peru: 1942-1960 Lima, Peru, 1962, p. 21.

1949.....18.19	1955.....19.18
1950.....15.43	1956.....19.23
1951.....15.18	1957.....19.07
1952.....15.55	1958.....23.40
1953.....16.94	1959.....27.64
1954.....19.69	1960.....27.30

For the remaining years, the rate of 27 to 1 is used.

project with a S/. 30-million, 6-percent bond issue. The executive was authorized to expropriate the currently unused 20,000 hectares that would eventually be cultivated. This area was to be sold off in plots of 5 to 20 hectares to: (1) local peasants, (2) other small farmers (having less than 5 hectares), (3) the bond holders, and (4) others, in that order.* There was as yet no activity at the site.

In 1948, the government (a military junta) decreed that persons owning more than 6 hectares to be benefitted along the Piura River would be required to subscribe to the above-mentioned irrigation bonds, for one-third of the total issue.** In this 31,000-hectare area, 27,000 were owned by 118 persons (for an average of 230 hectares per person), the plots ranging from 70 hectares on up. The other 4000 hectares were owned by 1500 persons.***

In the spring of 1949, activity on the site commenced. There appears to have been some problem in ordering and paying for the imported machinery to be used (imported goods accounted for about 21 percent of the estimated budget), probably because of the shortage of dollars at the official 6.5 to 1 exchange rate. (The sol was quoted at about 18 to 1 on the unofficial market.)**** In the meantime, canal-digging progressed. While a peon on a local hacienda was earning about S/. 1 daily (and perhaps had a small plot of land to cultivate rent-free or nearly so), on the project common laborers were earning S/. 5 daily plus piece rates in some cases. Foremen were brought from

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*Peruvian Times, March 25, 1949, pp. 5-6.

**Ibid., pp. 6-8. The total estimated cost had risen to about S/. 40 million. One-fourth of this would be paid within 20 years by the owners of the hectares to be benefitted (by government default on their bonds?), while the remaining cost (S/. 30 million) would be recuperated by selling the 20,000 newly irrigated hectares. Thus the price per hectare of the new land would be about S/. 1500 -- hardly more than annual gross returns per hectare of cotton at that time.

***Ibid., pp. 12, 14.

****Banco Central de Reserva, op. cit., p. 27.

southern Peru and earned around S/. 10 daily.*

In March 1951, the Peruvian government signed a cost-plus-10-percent contract with the Morrison-Knudsen Construction Company to complete the project in three years.**

In mid-1953, the activity was said to be "on schedule," but it had undergone some changes. It was stated that only Stage I (the river diversion) would be completed by year's end. For Stage II (building the dam), the dam originally designed to store 50 million cubic meters of water at Palomino, was now replaced by a dam at Los Cocos on the Chipillico River designed to store 250 million cubic meters of water. According to the study by Cotton and McGee (apparently the first feasibility study of the project that gave any significant attention to economic factors), the new dam site was chosen as it:***

(1) Provided a better foundation for dam construction;

(2) Had five times the water capacity; and

(3) Could irrigate more and better land.

We might point out that (1) suggests inadequate engineering studies at the beginning of the activity, while (2) and (3) indicate that for quintupling the dam size, the newly irrigable area was slightly more than doubled (from 20,000 to 45,000 hectares). The cost of the original small dam had been estimated at about $700,000 (in 1948),**** while the new large dam had a cost estimate of $14.42 million. This appears to be a rather expensive tradeoff (even allowing for some overrun in the small dam's construction cost). Moreover, 63 percent of the large dam's cost represented a foreign exchange bill.***** (In the mid-1950's Peru consistently experienced a deficit in her trade balance on current account.)

*Peruvian Times, March 25, 1949, p. 10.

**Irrigaciónes, op. cit., p. 14.

***J. S. Cotton and H. T. McGee, Report on the Río Quiroz-Piura Irrigation Project, Ministerio de Fomento y Obras Públicas, Lima, Peru, 1953 (Reproduced in Denver, Colorado, June 1955), pp. 55-56.

****Peruvian Times, October 22, 1948, p. 4.

*****World Bank Report on Quiroz-Piura Project, reproduced in Cotton and McGee, op. cit., p. 107.

In 1955, the World Bank made its first loan ($18 million) for the San Lorenzo Project, although it had been making interested sounds since 1949. Also in 1955, the United States and Peru signed an agreement under which P.L. 480 commodities would be shipped to Peru, with the proceeds to finance the local currency costs of Stage II.

While the lower Piura Valley began to benefit from the diversion works in 1954, in mid-1955 the Morrison-Knudsen Company was again awarded a cost-plus contract to construct the dam, planning to complete it in three years (by June 1958). In mid-1957, it was anticipated that the first 5,000 hectares could be sold by year end, with the remaining 40,000 hectares ready by the end of 1958.* Somewhere the timetable slipped. Stage II was completed in May 1959, eleven months behind schedule. And then the project just sat. In mid-1961, the Peruvian Times attributed the two-year delay in colonizing "to a controversy over the manner in which the land would be distributed."**

The various changes in plot distribution policy went something like this. In early 1956, the administration hoped to distribute the land in plots ranging from 35 to 250 hectares, "creating a new family of small [sic] landowners."*** In 1957, it appeared that "most of the land will be parcelled out in lots of around 70 hectares, but some will be as small as 15".**** In 1959, the plots were to range from 20 to 80 hectares. In 1961, the plots were to range from 6 to 60 hectares, with perhaps a few as large as 80 hectares.***** In all, 1494 plots were planned, accounting for 45,949 hectares of irrigated land.****** At the time of the 1961 announcement, officials stated that the preceding (Odría) government had planned to auction

*Peruvian Times, September 20, 1957, p. 10.

**Ibid., May 12, 1961, p. 1.

***Ibid., March 16, 1956, p. 15.

****Ibid., September 21, 1957, p. 8.

*****Ibid., May 12, 1961, p. 1.

******Informe: Irrigación y Colonización San Lorenzo, Lima, Peru, 1962, p. 123.

the land off to the highest bidder with no area limit, thus favoring the "already rich landowner."* Despite this kind of holier-than-thou statement, it appears that the Prado administration suffered no moral pains over the skewed distribution of ownership of the 31,000 hectares benefitted by Stage I, which we mentioned on page 7.

By 1961, when the differences of opinion over plot size were ironed out, the administration was within twelve months of terminating its 6-year term in office. Since Peru's constitution prohibits two successive terms, the Prado regime probably had a very short time horizon -- too short for the time remaining until colonization could be completed. Thus only token settlement activities proceeded; for example, while AID organized a $3 million loan for settler credit in 1961, very little was disbursed until 1963. Also, the Prado government tended to identify its interests with those of groups like the Liga Agrícola y Ganadera de Piura, made up of the valley's larger landowners. While the lower valley was legally entitled to one-third of the water made available by Stage I (the Quiroz diversion, operating since 1954) and the reservoir, completed in 1959, following 1954 they probably enjoyed more than this share as there had been no cultivation in the projected settlement area. Apparently,** this induced an over-extension of cultivation to lands that could not be irrigated once the settlement project was in full swing. The desire to protect or extend the irrigated area in the lower valley, at the expense of the project, may be a factor in the continued animosity of the Liga toward the settlement activity.

The first 64 colonists were handed their titles in July 1961. They moved onto their plots and, living in lean-to shanties, ordinarily without their families, they proceeded to prepare their land and plant the first crops. By July 1963, 373 colonists had entered the

* Peruvian Times, May 12, 1961, p. 6

** The only way of verifying this would be to compare registrations of irrigable lands for several years in the Valley's Padrón de Regantes. Cotton acreages might be available through the Cámara Algodonera.

project.* By December 1964, there were 915 colonists.** Thus during the first two years, colonists entered at the rate of almost 16 per month, and in the following year and one-half, about 30 per month entered.

Table 1 shows the number of plots (by size distribution) and the area granted by the end of 1964.***

Table 1

PLOTS GRANTED BY DECEMBER 1964

Size Hectares	No. of Plots	Gross Hectares	Irrigated Hectares
0.0- 8	458	3,623	3,076
8.1-13	136	1,812	1,521
13.1-20	149	2,967	2,427
20.1-40	67	2,568	1,934
40.1-60	75	5,192	3,741
60.1-80	30	2,680	2,082
Totals	915	18,852	14,781

As 1825 plots were available, and half have now been distributed, it might be hoped that the path to project completion will be smoother than in the past.**** Moreover, as the remaining plots account for about two-thirds of the project area, it appears that these will tend to be larger. Hopes are that the settlement activity will be completed in the 1965-1967 period. How much land may finally be settled

*Oficina Nacional de Reforma y Promoción Agraria, Irrigación y Colonización San Lorenzo, Memoria, Irrigación y Colonización San Lorenzo, Agosto 1963-Mayo 1964, p. 6.

**Instituto de Reforma y Promoción Agraria, Progress Report, Irrigación y Colonización San Lorenzo, San Lorenzo, Peru, December 31, 1964, p. 4.

***Ibid, p. 4.

****As this differs from the 1961 anticipated total (1494) there may have been some ensuing change with respect to the size distribution planned under the Prado government.

is uncertain, however. In 1961, an agrologic study classified only 32,000 out of the 45,000 hectares as suitable for cultivation.* The remaining area has a high saline content or is suitable only for (extensive) livestock operations. More recently (1964) revised estimates show that some 7500 hectares of the 45,000 total have a saline problem and will not be sold for the time being. Corrective drainage will be attempted in these areas. According to the present project director, while soil studies had been made some time ago, no one had paid much attention to the actual or potential water table in the area.

The project director is optimistic about the future. He recalls that in 1961 it was almost necessary to "lasso the peasants and drag them onto the project." At the fourth public sale (early 1965) there were almost five thousand applicants for some 400 plots.

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*Informe: Irrigación y Colonización San Lorenzo, op. cit., pp. 39-40.

Group A has soil suitable for irrigation farming.
Group B has soils suitable for irrigation farming but with low productive capacity under average management.
Group C has soils moderately suitable for irrigation farming, but of lower productive capacity than Groups A and B.
Group D has soils of restricted capability that are primarily suitable for special crops.
Group E has soils of restricted capability for special crops.
Group F has soils not suitable or recommended for irrigation.

Only the first five groups appear in the Informe with this distribution and these sale prices.

Group	A	B	C	D	E	Total
Area in Hectares	4,530	601	15,160	9,996	1402	31,689
Percent	14.3	1.9	47.8	31.6	4.4	100.0
Price per Hectare (Given in soles)	22,500	17,500	15,500	12,000	6000	

In allocating plots to bidders, applicants are graded on a point system according to:

(1) Age of the head of the household,

(2) Working capacity of the household,

(3) Family responsibilities of the head of the household,

(4) Agricultural experience,

(5) Educational level,

reportedly in the above order.

The size distribution of the plots allocated in the fourth public sale was:*

Size (hectares)	Number of Plots
0.0--13	281
13.1--20	42
20.1--40	94
40.1--60	5
	412

The total area was 7,000 hectares. When these newest titles are granted and the plots settled, about 500 plots of the anticipated 1825 total will remain. A fifth public sale was scheduled for August, 1965.

This strong response to the public sales is hardly surprising, however, in view of returns on these plots. One example is a 9-hectare plot settled in 1962. In 1964 it produced 5 hectares of cotton, 1.3 hectares of bananas, 0.9 hectares of yucca and 0.9 hectares of orange trees. The gross returns from sales of these products reached S/. 148,000 (about $5,481). Production costs were some S/. 65,000, and plot and improvement amortization another S/. 16,000. The income of the family (including the return on any of its capital invested in the operation) was some S/. 66,000

*Progress Report, Irrigación y Colonización San Lorenzo, op. cit. pp. 3-4.

or about $2,445* -- an appreciable amount in a country where per capita income in the agricultural sector is about S/. 2,600 ($96), or some S/. 13,000 for a family of five.

As mentioned, the project has moved more rapidly since mid-1963, when some elements of political uncertainty were resolved by the election of Fernando Belaunde Terry, and by the appointment of Renato Rossi, an impressive, hard-working and dynamic agricultural engineer (ingeniero agrónomo), as a project director. Political problems have continued to plague the program, however. The director suggests that the large landowners' organization in the lower Piura Valley (Liga Agrícola y Ganadera de Piura) has fought the Project since its inception, apparently fearing a loss of cheap labor from their haciendas and a possible "demonstration effect" caused by the presence of successful small landowners. This animosity has been manifested in complaints from the lower valley on the amount and timing of water released from the reservoir; delays in paying water charges (S/ 0.01 per cubic meter or about 37 U. S. cents per 1,000 cubic meters);** and charges of "bossism" (gamonalismo), empire-building, arbitrariness, communism, etc., culminating in February 1965, in the required appearance of the director and a member of his staff before the (opposition-controlled) parliament to answer these charges. The director requested and received the support of President Belaunde, otherwise he would have resigned. The storm was weathered.

A tour of the project now is almost a "must" for visiting foreign personalities in the agricultural or development aid fields. According to the World Bank press release announcing its latest (1965) loan supporting the project, "Besides raising farm income and improving

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*This example appears in the 1964 Informe to the IBRD requesting further financing. While it may not be typical, even half this amount would be a very good spur to an aspiring colonist.

**By way of comparison, according to Hirshleifer, DeHaven and Milliman Water Supply: Economics, Technology and Policy , University of Chicago Press, Chicago, 1960, 1,000 cubic meters of irrigation water in the Imperial Valley cost about $1.62 (p. 49). And these authors feel that water is cheap to the Imperial Valley farmer!

standards of living in its own area, the San Lorenzo Project is serving as a model for the development of irrigation land settlement, agricultural education and social services in other parts of Peru."

THE PROJECT AND ITS COSTS

As presently composed, the project has three stages.

Stage I (1949-1953): (1) a diversion dam on the Quiroz River 600 meters above sea level with a maximum capacity of 70 cubic meters per second, (2) a 13.1-kilometer lined derivation canal and an 8-kilometer lined tunnel to the Quebrada Totoral (which flows into the Chipillico River), (3) a diversion dam on the Chipillico River with a maximum capacity of 50 cubic meters per second and 7.3 kilometers of lined canals and tunnels leading to the Quebrada San Francisco, which flows into the Piura River.

Stage II (1955-1959): (1) an earth dam 780 meters long that forms a reservoir with the Chipillico River, having a capacity of 258 million cubic meters of water and covering an area of 16 square kilometers, (2) earth dikes to protect the Chipillico derivation canal, and (3) 643 kilometers of distribution canals and their respective service roads over an area of 50,238 hectares.*

During the 1960-1963 interregnum, most of the activity was directed toward land preparation and constructions to receive and maintain early colonists. The remaining settlement and its accompanying investment should take place during 1965-1967. To help finance this activity the government applied to the World Bank in the fall of 1964 for a $17.5 million loan. In April 1965, the Bank announced a loan of $11 million for San Lorenzo. For lack of more recent information, we assume that this shortfall will not materially affect the government's plans. The largest portion of spending for this period is to go toward farm infrastructure (homes, etc.), machinery and equipment, construction and roads, according to the budget the government presented in its loan application to the Bank.

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*Informe: Irrigación y Colonización San Lorenzo, op. cit., pp. 27, 28, 31.

Thus, while the Peruvian budget bore the cost of Stage I ($12,543,000), Stage II was financed by the Peruvian government ($11,000,000), by the World Bank ($18,000,000), and through P. L. 480 ($9,000,000). Of the anticipated cost of Stage III ($36,045,000) it appears that the Bank will finance about 30 percent. AID also granted a $3 million loan in 1961 for settler credits. It appears that in early 1965 this amount (later increased to $5 million) was almost entirely committed or disbursed.

Spending was not reported annually for Stages I and II. For 1949 and 1950, the amount disbursed appears in Irrigaciones en el Peru, 1948-1956 (p. 13) as a single sum; we split this evenly between the two years. The remaining expenditures for 1951-1953 (Stage I) also appear as one amount, which we assume was spent at a constant annual rate. As the costs of Stage II also were available only as a single sum, we assumed here again a constant annual rate.

The figure for expenditures in 1960 was drawn from a project progress report.* The amount spent during 1961-1963 was obtained by subtracting the amount spent through 1960 from the "total investment through 1963" figure appearing in the report prepared for the World Bank in 1964. This remainder was then divided equally over the three years. The projected spending for 1964 through 1967 appears on an annual basis in the 1964 report to the World Bank which backed up the government's loan application. The total cost of the settlement and regularization activities appears in Table 2.

Table 2

SAN LORENZO SETTLEMENT-LOWER PIURA IRRIGATION PROJECT
(Investment Costs)

Stage	Years	Investments
Stage I	1949-1953	$ 12,543,000
Stage II	1955-1959	34,007,000
Interregnum	1960-1963	4,181,000
Stage III	1964-1967	36,045,000
Total		$ 86,776,000

*Ibid., p. 136.

Investment expenditures for works common to both the irrigation settlement and the regularization of water to the lower Piura Valley are allocated two-thirds to the former and one-third to the latter, in line with the government's practice and the proportional distribution of irrigation water to the two benefitted areas. All of the works in Stage I are considered common, while only the dam is considered common in Stage II. None of the costs of the interregnum or of Stage III (colonization) are allocated to the lower valley.

The operating costs of the regularization activity for the lower valley are based upon reimbursement the project received from this area during 1954-1959. This may be largely made up of payments for water. Administration costs of the settlement project are drawn from cash flow estimates appearing in the 1964 report to the World Bank. These cost data are summarized in Tables 3 and 4 for San Lorenzo and the Valley, respectively. The total investment cost of these two activities approaches $87 million. The irrigation settlement accounts for the lion's share of this amount.

Table 3

SAN LORENZO IRRIGATION SETTLEMENT PROJECT

Stage	Years	Investment
A. Investment Costs		
Stage I	1949-1953	$ 8,429,000
Stage II	1955-1959	26,321,000
Interregnum	1960-1963	4,181,000
Stage III	1964-1967	36,045,000
Total		$ 74,976,000
B. Annual Operating Costs		
	1959-1964	$ 480,000
	1965-1967	1,373,000
	1968-1998	141,000

Table 4

REGULARIZATION OF IRRIGATION WATER SUPPLIED TO THE LOWER PIURA VALLEY

Stage	Years	Investment
A. Construction Costs		
Stage I	1949-1953	$ 4,114,000
Stage II	1955-1959	7,686,000
Total		$ 11,800,000
B. Annual Operating Costs		
	1954-1998	$ 120,000

Table 5 presents a succinct cost history of the project from its conception through the latest (1964) estimates. The final figure is a long way from the initially anticipated $4-million project. Graphical illustrations of the time streams of costs and benefits for these two projects appear at the end of this section.

It is difficult to account for the dramatic changes in cost estimates or the divergence of estimated and realized costs on these two projects. In all likelihood, however, physical changes in project design are the most responsible; i.e., changes in the nature of the dam and reservoir and the related change in the area benefitted primarily caused increases during the 1950's:

	1949*	1954**
Dam and Reservoir	$ 665,000	$ 14,420,090
Distribution System	770,000	11,610,000

Why these changes were undertaken is another question.*** In Table 6 we present some of the features that altered through time.

*Peruvian Times, March 25, 1949, Supplement, p. 4.

**Cotton and McGee, op. cit., p. 107.

***Several reasons why the dam site and size were changed were presented on page 8.

Table 5

SAN LORENZO SETTLEMENT AND LOWER PIURA CONSTRUCTION COST ESTIMATES

Year	Stage I	Stage II	Stage III	Total
1943				$ 3,900,000[a]
1947				4,615,000[b]
1948				5,780,000[c]
1951				8,000,000[d]
1952				10,000,000[e]
1953	$ 12,543,000[f]	$ 28,500,000[g]		41,043,000
1959	12,543,000	34,007,000		46,550,000
1962	12,543,000	34,007,000	$ 18,278,000[h]	64,828,000
1964[i]	12,543,000	34,007,000	36,045,000[j]	82,595,000

NOTE: Project costs were not split into Stage I and Stage II until 1953.

[a] Peruvian Times, April 16, 1943, p. 2.

[b] Peruvian Times, Oct. 17, 1947.

[c] Peruvian Times, Oct. 22, 1948, p. 4.

[d] Peruvian Times, Oct. 26, 1951, p. 4.

[e] Peruvian Times, Dec. 12, 1952, Supplement III.

[f] Actual realized cost

[g] H.T. McGee and J. S. Cotton, Report on Río Quiroz--Piura Irrigation Project, Ministerio de Fomento y Obras Públicas, Lima, Peru, 1953 (reproduced in Denver, Colorado, June 1955), p. 11.

[h] Informe: Irrigación y Colonización San Lorenzo, Lima, Peru, 1962, pp. 136-137.

[i] Omits spending during 1960-1963 interregnum.

[j] Informe al Banco Mundial, San Lorenzo, Peru, 196

In December 1952, a press report tells of increased costs of the project because of "increased work."* In October 1952, the Peruvian government allocated S/. 27,522,000 (about $1.8 million) for the increased cost of cement and a greater amount of work, and a few months later provided an additional S/. 24,800,000 (some $1.6 million), alledgedly to obtain more equipment and men to finish the work ahead of schedule.**

Table 6

PROJECT ALTERATION THROUGH TIME

Year	Dam Capacity (cu m)	Lined Canals (km)	Tunnels (km)	Area Benefitted (has)	Distribution System (lined) km
1949[a]	50,000,000	(b)	5.0	51,000	(c)
1951[d]	50,000,000	(b)	9.6	51,000	(b)
1956[e]	250,000,000	15.5[f]	8.6	76,000	70[g]
1962[h]	250,000,000	19.8	8.6	76,000	166[i]

[a] Peruvian Times, March 25, 1949, Supplement.

[b] Not available.

[c] In the 37 million soles budget was a 5 million soles allocation for the distribution system on the 20,000 newly cultivated hectares.

[d] Peruvian Times, October 26, 1951, p. 5 (map).

[e] Irrigaciónes en el Peru,1948-1956, Lima, Peru, pp. 16, 19, 28.

[f] 2.3 km of these were covered canals, substituted for tunnels.

[g] Projected.

[h] Informe: Irrigacion y Colonizacion San Lorenzo, Lima, Peru, 1962, pp. 27-31.

[i] D[illegible] ot include 476.9 km of laterals and sublaterals.

Land development also accounted for some of the increases. In 1949, there was no budget item covering land development, unless the "indirect expenditures" of $745,000 were for this purpose.***

*Peruvian Times, Dec. 12, 1952, Supplement III.

**Irrigaciones en el Peru, op. cit., p. 15.

***Peruvian Times, March 25, 1949, Supplement, p

In 1953 it was estimated that land preparation on the 45,000 hectares to be newly cultivated would cost $3,130,000.* While the project was originally intended to have little social impact, its nature altered late in the Prado administration, and it came to be treated as an "agrarian reform" activity.

We are unable to account completely for the near doubling of the estimated costs of Stage III between 1962 and 1964, but a good part of this increase is shown in Table 7.**

Table 7

COST BREAKDOWN FOR STAGE III
(millions of soles)

Activity	1962	1964	Increase
Service Centers	28.9	50.7	21.8
Roads	100.9	110.6	9.7
Hydroelectric Station	24.5	50.0	25.5
Tablazo area development		62.4	62.4
Soil conservation		22.6	22.6
Canal rehabilitation	4.5	19.4	14.9
Reparcellization	9.0	14.9	5.9
Experimental stations	3.0	25.9	22.9
Construction and light industry	60.0	119.4	59.4
Various studies	2.6	46.4	43.8
Total			288.9

These increases in Stage III amount to almost $11 million. Additional factors that may have caused the 1964 estimates to climb are the increased costs of land development and the construction of housing for the colonists. Thus, as the nature of the project changed from one intended for the benefit of medium and large farmers who would purchase the newly irrigable area and develop it to one meant for small peasant cultivators with scanty resources, its costs rose steeply, although some of this may merely have been caused by internalizing some costs previously not considered as part of the project.

*Cotton and McGee, op. cit., p. 11.

**Calculated from Informe: Irrigación y Colonización San Lorenzo, op. cit., pp. 136-138, and Informe al Banco Mundial, op. cit., "Esquema General de Inversiones," n.p.

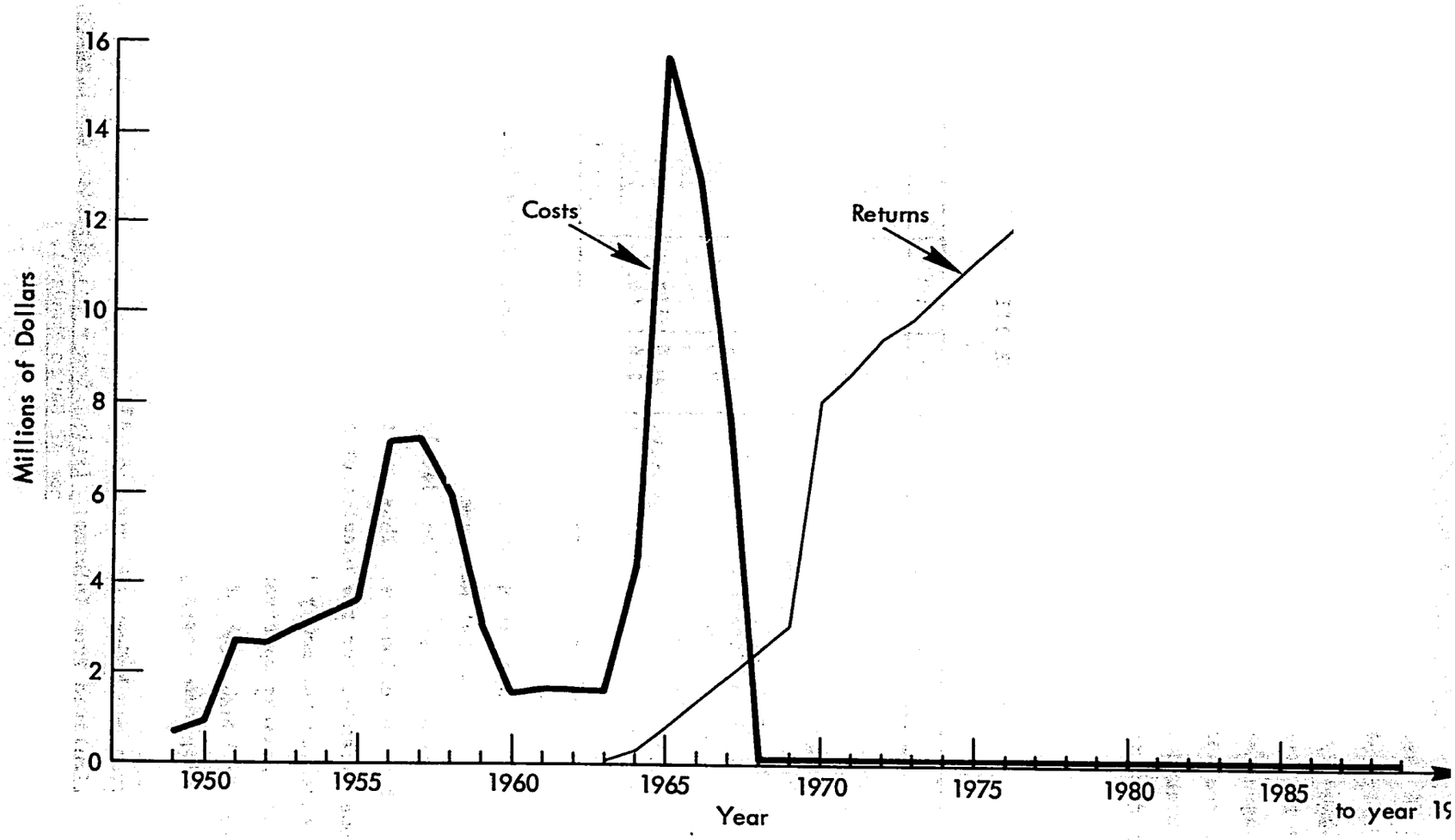

Fig. 2 -- Time Stream of Benefits and Costs: San Lorenzo Irrigation Settlement

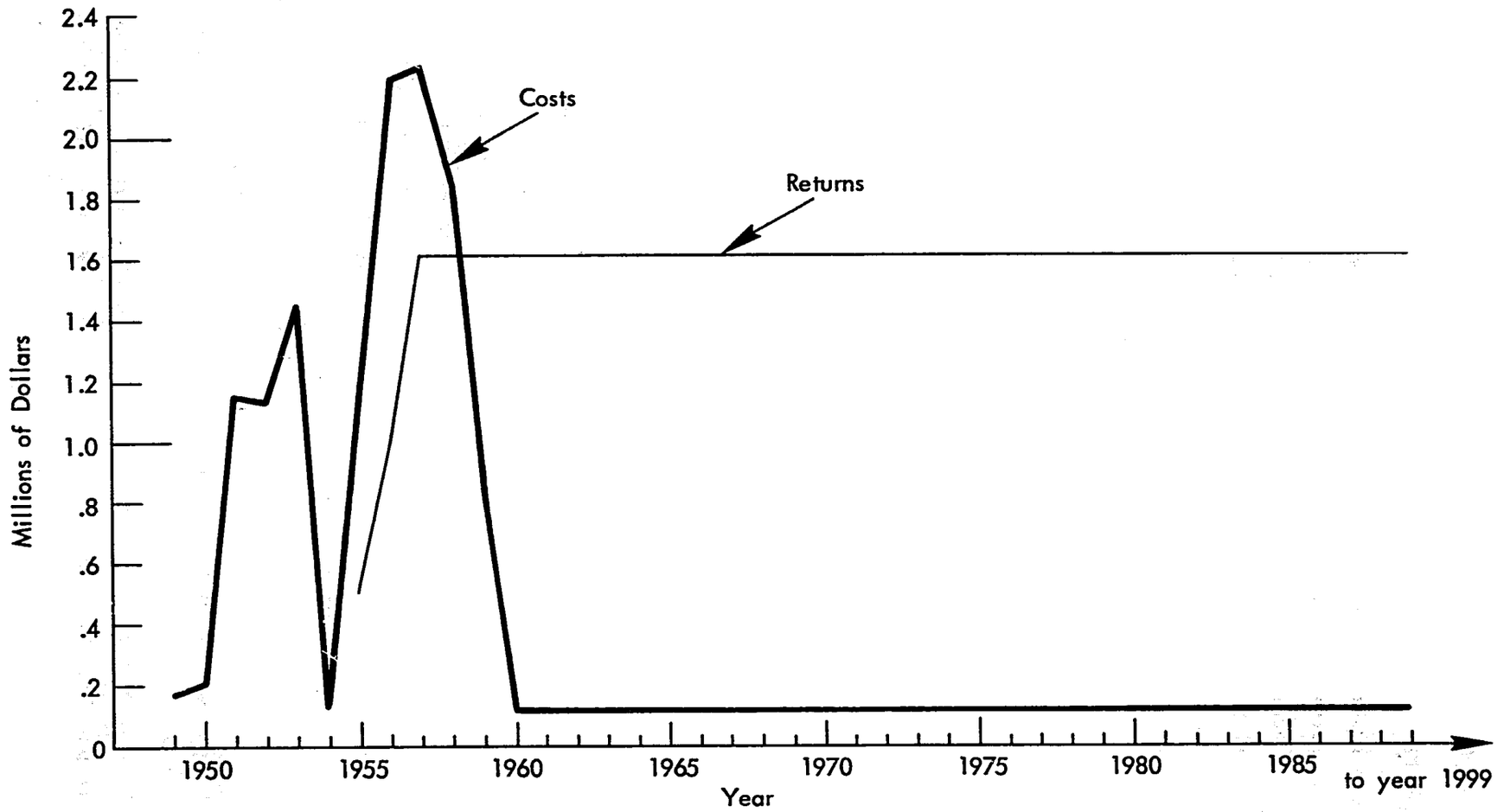

Fig. 3 -- Time Stream of Benefits and Costs: Lower Piura Irrigation Project

THE PAYOFFS

If costs appear to have been difficult to account for and allocate, returns in the form of the value of increased net farm output are probably even harder to estimate. For the lower Piura Valley we (like the World Bank) have used the estimates of Cotton and McGee appearing in their 1953 study, a date reasonably close to the year (1954) in which the effects of the water supply regularization project were realized. However, unlike them, we have assumed a three-year running-in period for the value of net farm output to reach its predicted level, rather than their assumption of an immediate reaction. Moreover, it appears that these authors did not deduct any project operating costs; we have done so. The payoff stream (as well as the cost stream) appears in Fig. 3.

Estimates of the net value of farm output on the irrigation settlement are developed by relating the realized (1961-1964) and planned rates of settlement to examples of net farm output on the project. As output is predicted to stabilize in 1977 at $12.326 million we interpolated up to that figure for that year. (It appears that this growth curve, appearing in Fig. 2, could be approximated by a cubic function.)

Messrs. Cotton and McGee estimate the value of incremental output from the lower Piura Project by assuming the net output is 49 percent of gross output. The calculation of operating costs on the irrigation settlement applied by the government to arrive at a net output figure may not have properly evaluated the farm labor input and rather only focused on the plot operator's cash outlays. One might argue that under the rural unemployment or underemployment conditions apparently typical in Peru, the value of incremental labor inputs (in terms of opportunity costs) is low and hardly significant to our analysis. For currently established farmers in the lower valley, it may be that the opportunity costs of their incremental labor inputs are close to zero. However, the settlers on the irrigation project are probably somewhat atypical as they are likely to have been successful operators elsewhere and their participation in the project does involve some alternative cost, especially if selection standards are set high and rigidly followed

(as a conscientious project administration aiming for success would be likely to do). Thus there is a possibility -- we might say almost a probability -- that owing to the inadequate valuation of the labor input for the San Lorenzo irrigation settlement, its payoff estimates are biased upwards.

CONCLUDING COMMENTS ON SAN LORENZO

Literature on the project prepared by Peru, the IBRD, and others, often mentions the intangible benefits of the project owing to the training and experience colonists receive as small entrepreneurs and its consequent contribution to economic advance and social stability. This may be so, but it should first be shown that actual plot recipients are those most receptive to or needy of such training and experience. We might also question the individual's scope for exercising independent judgment and decision-making when his activities are closely supervised and/or controlled.

In any case it is a very expensive training ground. If all 45,000 hectares can ultimately be cultivated, the investment cost is about $1,666 per hectare or $41,000 per farm. If only 37,750 hectares can be cultivated, the cost will be $1,986 per hectare. The regularization activity in the Lower Piura and Chipillico Valleys (about 33,500 hectares) cost about $352 per hectare.

Many who have observed some of the LDC's have noted the often prevailing scarcity (in terms of needs, not necessarily with respect to current salary levels) of local technically trained individuals. Our impression is that Peru is one such country. For that reason we might object to concentrating skilled individuals on a single narrow activity, such as San Lorenzo.* At the end of 1964 there were 96 professionals working at the project: 37 agricultural engineers,

*Alternatively, San Lorenzo might be considered a fine training ground for the staff of future projects. Future San Lorenzos?

18 civil engineers, and 41 others (lawyers, social workers, teachers, doctors, etc.). When the project is in full swing there will be 199 professionals. We wonder whether returns might have been as great or greater if these people had been distributed over the country as part of a program to increase output through an input package to presently settled farmers, including supervision and credit, fertilizer, pesticides, improved water utilization and control and improved marketing facilities.

III. THE COAST PROGRAM

THE PROJECT AND ITS COSTS

An alternative development strategy, recently initiated by the Peruvian Ministry of Agriculture, will provide loans and backup technical assistance to small and medium-sized farms in Peru's coastal valleys.* The project is aimed at 53,778 agricultural units with fewer than thirty hectares,** which account for 176,000 hectares under cultivation and from which 82,266 families obtain their incomes.*** This is the first time the Peruvian Governmeht has organized such an activity on a large scale and it holds a great deal of promise. The activities comprising the project are:

1. Increases in agricultural loans.****
2. Expansion of extension services.
3. Seed selection and distribution.
4. Expansion of fruit tree nurseries.
5. Soil improvement and better water use.
6. Expansion of storage facilities for grains and beans.
7. Expansion of demonstration program on plant pest control.
8. Expansion of agricultural machinery pools.
9. Expansion of breeding and reproduction center for swine.
10. Expansion of artificial insemination services.
11. Expansion of veterinary services.

*Ministerio de Agricultura, Oficina Nacional de Reforma y Promoción Agraria, Programs Presented for Foreign Financing to Increase Productivity of Small and Medium-Sized Farms on the Coast as well as in Agrarian Reform and Colonization Areas and Forestry Development of the Central and Southern Sierra and the Jungle Areas, Lima, 1963.

**According to the 1959 Padrón de Regantes, 96 percent of the coastal plots were less than 30 hectares, accounting for about 18 percent of the irrigated (ergo, cultivated) land.

***Whether or not these families are all full-time farmers is not specified.

****The annual amount planned when the program is fully operating is about 50 percent of the value of small and medium-sized agricultural loans on the coast in 1962-1963 granted by the Banco de Fomento Agropecuario.

The cost of this program is estimated at $4.6 million, to be allocated between Stages I and II (the two time streams visualized) in the following manner:*

Item	Stage I	Stage II	Total
Equipment	$ 1,151,832.18	$ 2,059,978.41	$ 3,211,810.49
Building facilities	560,367.82	687,308.39	1,247,676.21
Breeding stock	70,167.60	80,446.95	150,614.55
Totals	$ 1,782,367.60	$ 2,827,733.75	$ 4,610,101.35

Almost 86 percent of this amount was proposed for external financing, while the main Peruvian contribution was to be in building facilities. Operation of Stage I will cost $821,000 annually; when the program is fully operative, this yearly figure will increase to $1,757,900.

In the loan application, the time streams of cost and benefits (given in $ millions) are presented as follows:**

	Investment Costs		Operating Costs		Net Farm Output	
Year	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
1	0.89		0.83		2.04	
2	0.89		0.83		2.04	
3		1.41		1.78		5.11
4		1.41		1.78		5.11
5				1.78		5.11
etc.						

It is anticipated that Stage I will produce 40 percent of the total predicted output.

The assumptions about when the projected spending rates will be realized and output will respond are probably unreal. So to evaluate the project we assume Stage I investments are spread over three years, while operating costs move upward to the anticipated level.

*Ministerio de Agricultura, op. cit., p. 74.

**Ibid., pp. 81-85.

Stage II investments are still spread over two years, but operating costs move up in two steps after a year's delay. Farm output reaches Stage I predicted levels in four years and Stage II levels in three years. This altered schedule of costs and returns (given in $ millions) is as follows:

	Investment Costs		Operating Costs		Net Farm Output	
Year	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
1	0.59		0.50		0.50	
2	0.59		0.65		1.05	
3	0.59		0.83		1.55	
4		1.41	0.83		2.04	
5		1.41		1.28		3.14
6				1.76		4.10
7				1.76		5.11
etc.						

A graphical illustration of the time streams of costs and returns appears at the end of this section.

THE PAYOFFS

Once the program is in full operation, it is estimated that net returns to farmers (profits) will increase by about $5.1 million annually. Of the total area falling within the project (176,000 hectares), about 22 percent are planted in sugar cane and cotton. Sugar cane is grown on about 5,600 hectares, and as the techniques used to raise it, even by the smaller producer, are relatively advanced, it is not given emphasis in the program. Cotton covers the largest area (33,600 hectares) of all crops considered. A 10-percent increase in cotton yields is projected, owing to a 14-percent increase in fertilizer inputs, an 8-percent increase in insecticides, a 10-percent increase in tools and materials, and a 25-percent increase in services.*

Corn covers 28,160 hectares; its yield will increase by 30 percent due to increases in seed input (30 percent), fertilizers and

*Yields are in terms of kilograms per hectare; inputs are in value terms.

insecticides (50 percent each), and services (22 percent). accounts for 21,120 hectares; its yield will increase 13 percent because of increases in fertilizers and service inputs (21-22 percent each), and tools and materials (10 percent each).

The above data and others for less important crops in the area are summarized in Table 8. The inputs receiving special stress are fertilizers and pesticides. While this does not go against our impressions of the area, the fact that the salary and wages bill increases

Table 8

STRATEGIC INPUTS IN THE COAST PROGRAM

Crops	Percent of Area	Percentage Increase in					
		Yield	Seeds	Fertilizer	Insecticides	Tools and Materials	Services
Cotton	19.0	10		14	8	10	25
Corn	16.0	30	30	50	50		22
Rice	12.0	13		21		10	21
Chick-peas	3.4	20			37		
Vegetables	3.2	4		9	25		
Bananas	2.7	15		(b)	(b)		8
Potatoes[a]	2.1	60	28	60	50	40	22
Citrus[a]	0.5	50	3	36	800	45	40

SOURCE: Ministerio de Agricultura, Oficina Nacional de Reforma y Promoción Agraria, op. cit., Charts 3 and 6.

[a]Potatoes and citrus are included merely to show the projected large increases in yields and accompanying inputs.

[b]None previously applied.

by only 5 percent does not suggest that the program will go far toward alleviating any possible rural unemployment or underemployment in the area.*

*This is so if the labor bill includes the imputed value of family labor on the farm. If not, we can say nothing definite, unless family labor is a complement to other inputs that have increased. On the other hand, as the opportunity costs of additional family labor inputs are probably rather low, there is little need to reduce the project payoffs by any significant amount. In this respect, the situation is similar to that of the lower Piura Valley, discussed on page 24.

The personnel requirements by stage are:*

Type	Stage I	Stage II
Agricultural technicians	46	38
Veterinarians	9	4
Home economists	17	21
Administrators	25	30
Practical technicians	179	245
Total	276	338

*Ministerio de Agricultura, Oficina Nacional de Reforma y Promoción Agraria, op. cit., p. 14.

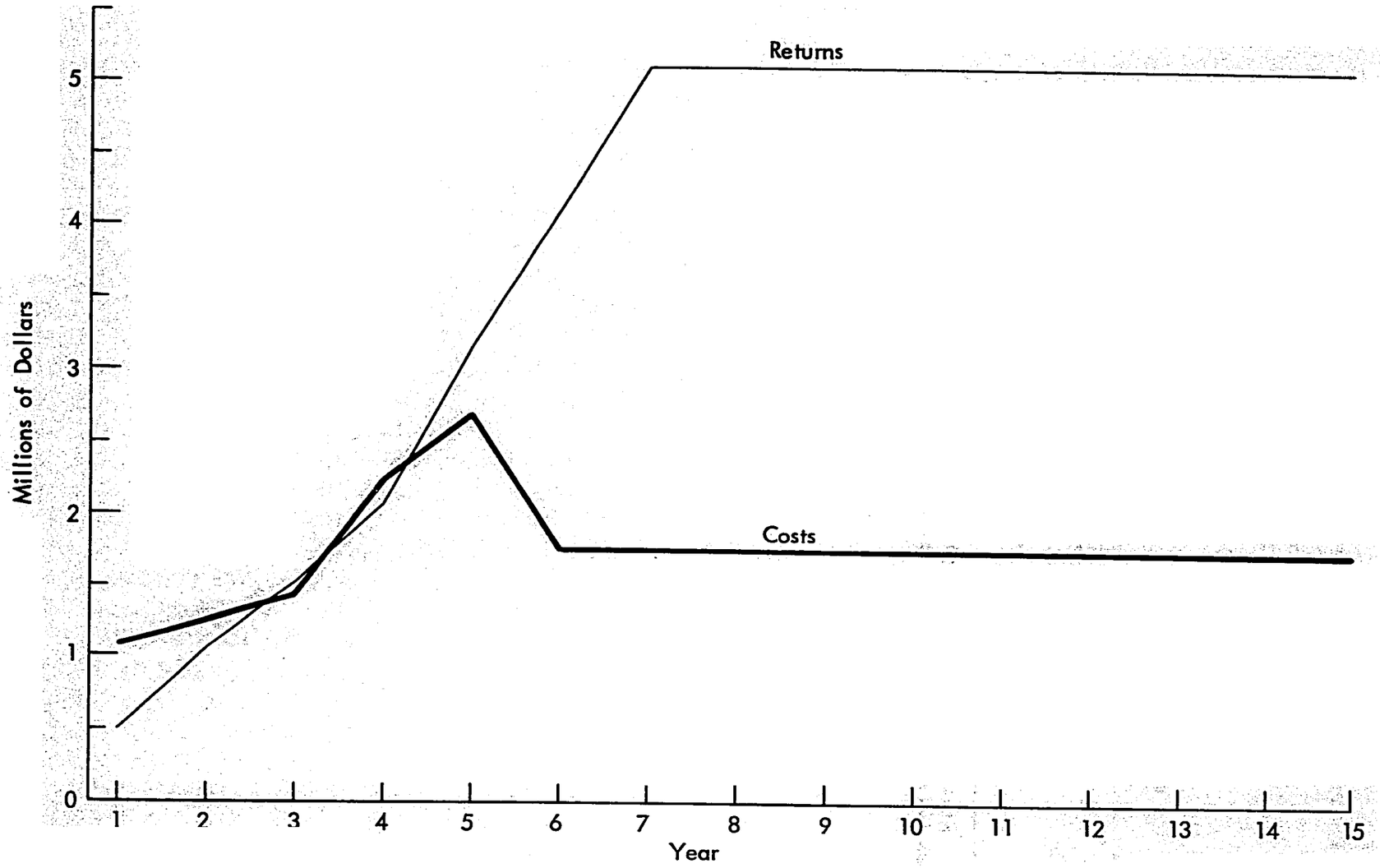

Fig. 4 -- Time Stream of Benefits and Costs: Coast Program

IV. THE TINGO MARÍA-TOCACHE SETTLEMENT PROJECT

Nearly 63 percent of Peru is classified as selva, or jungle. This is the Peruvian frontier where some 12 percent of the population (about 1.25 million people) live. While there have been a number of attempts to establish viable organized settlements in these regions, the record is not a bright one. Settlers have sporadically entered such areas on their own, however, at times behind or even in anticipation of a road; occasionally they come as seasonal agricultural workers on a coca, tea or coffee plantation, etc. There has been considerable interest in the zone's future, e.g., the Plan Peruvia of the previous government and the Carretera Marginal project of the current administration. The Tingo María-Tocache proposal discussed here exemplifies the type of activity that may be applicable to the jungle regions.

The Tingo María-Tocache project is a program to settle 10,760 families in a 110,000-hectare region in eastern Peru. The area extends along the Central Huallaga River from Tingo María to Tocache Nuevo, a narrow strip 150 km (90 miles) long, dropping from about 1,800 feet to some 1,200 feet above sea level. This descent is accompanied by a decline in precipitation from some 122 inches to about 94 inches a year.

Tingo María is 564 km from Lima, across the Andes. While only two hours from Lima by DC-3, the land journey requires 24 hours or more, in part depending on whether road traffic is allowed up or down between Tingo María and Huánuco in the Andes on the final stretch of the road (the direction permitted alternates daily). During the rainy season, slides are common and may block the road from Huánuco for any number of hours. There is not yet a road on the Huallaga below Aucayacu, where the proposed settlement area starts. Below this point, all traffic is by canoe or raft on the river, which may be a quarter of a mile wide and running very heavily during the rainy season.

HISTORY

While the 1961 urban population of Tingo Maria was about 5,200, over 30 years ago it was merely a cluster of thatched-roof huts whose inhabitants did little more than subsistence-level farming. Then in 1932, the government of General Sanchez Cerro started constructing a 424-kilometer road from Huánuco in the Andes to Pucallpa on the Ucayalí River. The prime reason for the road was to enable the Government to assert hegemony over the heretofore dismembered part of the Amazon basin that Peru claimed.*

By 1936, the 138-kilometer stretch from Huánuco (previously the end of the road from Lima) to Tingo María was completed. In 1938, the land adjoining the road was expropriated -- most had been held idle in large tracts granted during the rubber boom early in the century -- and the Official Colonization Center in Tingo María and the Agricultural Experimental Station at Tingo María were established. Three general classes of farms were established for colonists: small (15-30 hectares), medium (not over 100 hectares), and extensive farming-livestock units (not over 1000 hectares).

The zone grew rapidly. The population rose from about 1400 in 1940 to an estimated 2800 by 1943.** (By 1943, the Government's investment was estimated at $150,000 to $200,000, consisting largely of the hospital, hotel, sawmill, experimental station, power plant and school.*** Government spending in that year alone was about $100,000.)**** By 1948 some 600 colonists were cultivating 4000 hectares.***** In this year about 38 percent of the cultivated area was in fruit trees (largely bananas and citrus), 15 percent in foodstuffs (corn, rice, yucca and beans), 12 percent in tea, and 11 percent

*Magdaleno Chira C., Tingo María, Lima, Peru, Imprent Competidor, 1943, p. 5.

**Ibid., p. 18.

***Ibid., pp. 45-46.

****Ibid., pp. 13-17

*****J. Alberto Barreda, "El desarrollo de la Colonización en Tingo María," La Vida Agrícola, Vol. 27, No. 317 (April 1950) p. 295.

in coca.* By the mid-1950's, some 100,000 hectares had been granted or sold, of which about 10 percent were cultivated.**

Since early settlement, cultivation has been basically of the slash and burn, or shifting, variety. Techniques are simple or primitive and soil resources are rapidly depleted. Cultivation has moved up the slopes of the generally rolling terrain; where furrows exist, they are typically vertical rather than contour, and the heavy rainfall rapidly leaches the acid soil.

THE PROJECT AND ITS COSTS

As stated earlier, Tingo María is a program to settle 10,760 families in a 110,000-hectare region.*** About 96,000 hectares are considered utilizable. It was estimated in 1961 that some 10,200

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*Ibid., p. 293.

**W. Drewes, "The Economic Development of the Western Montaña as Related to Transportation," Peruvian Times, April 18, 1956, p. 22. It is claimed that by 1960 some 40,000 hectares were under cultivation, cf., R. C. Eidt, "Pioneer Settlement in Eastern Peru," Annals, Association of American Geographers, Vol. 52, September 1962, p. 266.

***According to preliminary surveys, the project area contains the following soil characteristics. (There may be a significant margin of error here; the overlapping of classes probably reflects the author's uncertainty. All data on the project are drawn from República del Peru, Ministerio de Fomento y Obras Públicas, Servicio Cooperativo Interamericano de Fomento, Evaluación e Integración del Potencial Económico y Social de la zona Tingo Maria-Tocache, Huallaga Central, Lima, Peru, May 1962.)

Classes II and III have soils with slopes of 0-2 percent, moderate fertility and productivity requiring rather careful and intensive practices, adaptable to both annual and permanent crops, 61,038 hectares.

Class III has soils with slopes of 2 to 10 percent, of low fertility requiring intensive care and adaptable to annual or permanent crops, 3,521 hectares.

Classes III and IV have soils with slopes of 0 to 2 percent, subject to periodic flooding, moderate or low fertility requiring intensive care, generally suitable for annual crops, 13,022 hectares.

Class VI has soils with slopes of 20 to 50 percent, low fertility, suitable only for permanent crops, 12,751 hectares.

Class VII has marginal soils with slopes of 50 to 70 percent, suitable for permanent crops when given special and intensive care, 11,509 hectares. Fifty percent of this land is cultivable.

Class VIII is not suitable for agricultural uses, 11,939 hectares.

hectares were already under cultivation, leaving 85,800 hectares remaining.* This is a constantly diminishing area, however, as new settlers are entering the zone. A flight along the Huallaga demonstrates that there are very few uncleared areas along the river bank, while farther back the topography becomes broken. The valley is probably never more than three-quarters to one mile wide. It would appear that much of the more desirable cultivable land is already in use, although the practices applied may result in output far below the potential, and the prevalence of slash-and-burn culture may actually be positively harmful to those plots in use.** Plans are to spread the settlement activity over an eight-year period, at the following pace:

Year	Number of Families
1	1,060
2	2,000
3	2,000
4	2,000
5	2,000
6	1,000
7	500
8	200
Total	10,760

The program is envisioned to last about twenty years, during which time investment will amount to about $22.4 million. Operation costs, e.g., social service, forestry program, crop and livestock experimentation, farm extension and highway maintenance will come to an additional $1.3 million annually.

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*It is estimated that the project area is bordered by another 100,000 hectares of a similar nature susceptible to development.

**Very few of those cultivating have a legal title. As far as many have gotten is to "denounce" the land at the office of the Dirección de Tierras de Montaña in Tingo María or Uchiza. Obtaining a title will usually take several years. Presently the agrarian reform agency is engaged in ascertaining the property lines of small settlers along the Central Huallaga to assist them in obtaining land titles.

Some 39 percent of the total investment is allocated to improving the region's urban infrastructure, almost the entire amount going to present towns and villages. This part of the project may be marginal and should be considered of relatively low priority.

Next come the road construction activities, which account for 32 percent of the investment program. These are almost a sine qua non for further penetration of the area, unless agriculture is to remain on a largely subsistence or commercially marginal basis. In this climate and terrain, road-building is expensive; the projected Aucayacu-Tocache road cost estimates run about $58,500 per mile. According to a recent report, construction on a 47-mile section of the road from Aucayacu to Tocache, reaching as far as La Morada, will cost about $110,000 per mile.*

About 12 percent of the planned investment will go toward the land distribution program, e.g., soil studies, survey of boundaries and construction of neighborhood roads (80 percent of this activity's total).

These three account for 83 percent of the investment budget. The remaining activities include 6 percent for basic regional studies (largely a program of aerial photography), and 4 percent for study and regularization of currently occupied plots. There are also some initial investment expenditures in conjunction with the on-going activities. For evaluation purposes we have altered the investment time schedule of the jungle program, as there is little experience in organizing such activities and delays are to be expected. (The chronology of the San Lorenzo Project certainly suggests this.) Thus we expect the spending planned for years 1-5 to be spread over the first seven years, that for years 6-10 taking place during the eight through thirteenth years, years 11-15 reallocated to years 14-19, and years 16-20 allocated to years 20-25. Benefits -- the net value of farm output -- were similarly changed. The total increase for the

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*Peruvian Times, April 16, 1965, p. 1.

program development period is five years. The time streams of costs and returns appear on a graph at the end of this section.*

*Details on the costs and output predicted for this project appear in Ministerio de Fomento y Obras Públicas, op. cit., pp. 125, 131-137. As output estimates were gross, these were reduced to net figures by considering operating costs to be 50 percent of the value of output. This is hardly a satisfactory manner of accounting for the opportunity costs represented by the farm labor and for other inputs included in this project; it is merely a convenience dictated in part by the paucity of data on the costs and returns of farming in these frontier areas. As with the San Lorenzo colony, the settlement of a farmer and his family in an area does involve an opportunity cost, except in the highly unlikely case that his only alternative is virtual mendacity. The higher the selection standards for a settler to be accepted for the project, the higher this opportunity cost is likely to be.

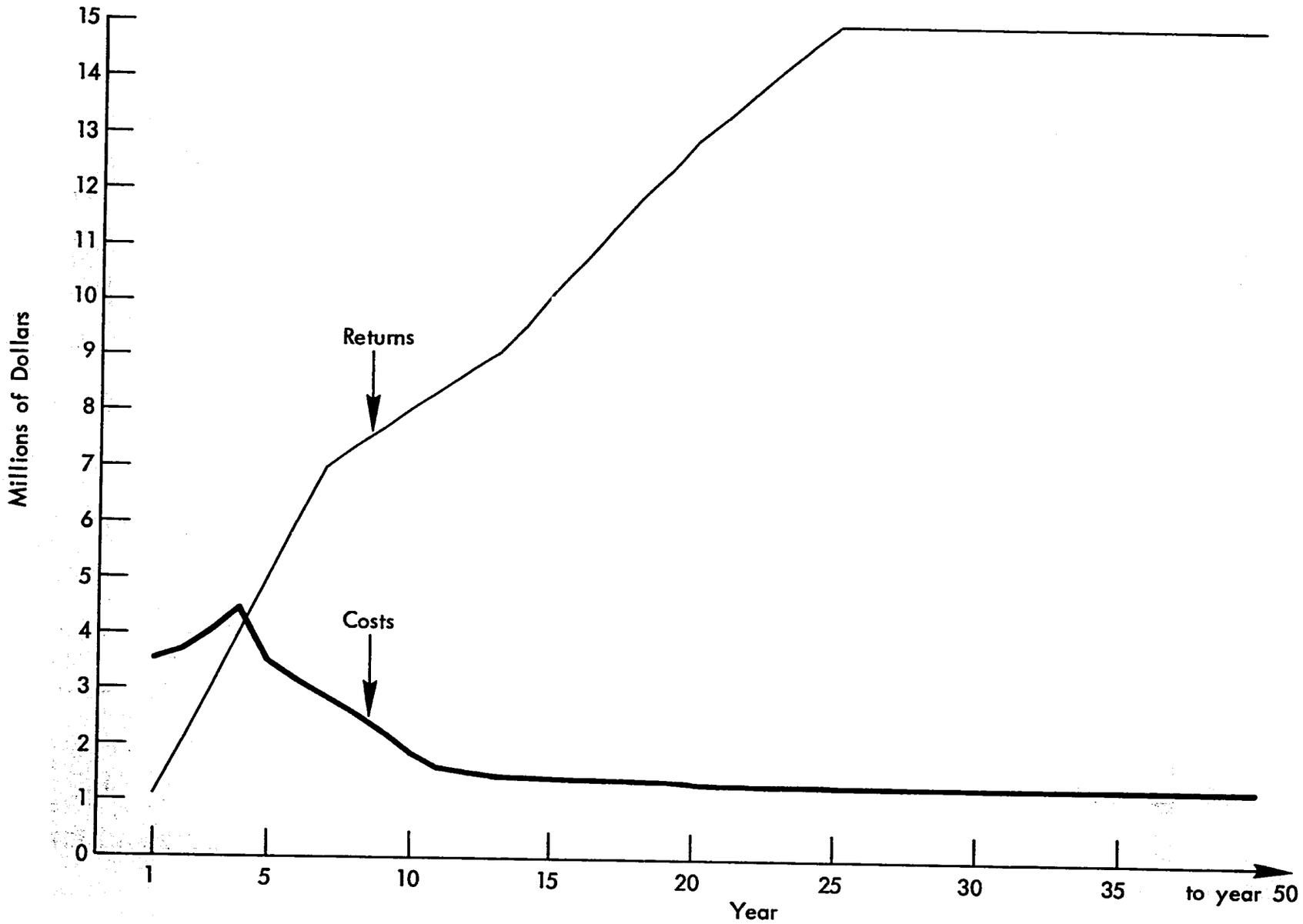

Fig. 5 -- Time Stream of Benefits and Costs: Tingo Maria-Tocache Settlement Project

V. A COMPARATIVE EVALUATION OF THE PROJECTS

THE TECHNIQUES UTILIZED

Uncertainty

There are obviously many pitfalls and uncertainties in estimating the costs (or output) of these projects, which in some instances are of a radically new or untried nature, for periods of up to 25 years or more. This is one weakness common to standard evaluation techniques; it requires a series of heroic assumptions on both the input and output streams with respect to possible changes, shortfalls, and/or overruns in a project's physical characteristics, costs, prices, demand, and the level of farmer proficiency. An occasional project analyst will nod his head in this direction, but then almost nonchalantly proceed to predict the costs and output of the activity as so-and-so dollars; the implication is nearly complete and unequivocable certainty that these predicted figures will be realized, and in the time period outlined. This, however, is not the typical outcome. One author, looking at project cost overruns in India found that for thirteen irrigation and power projects, original cost estimates had to be increased by 5 to 230 percent. For six projects the range of increases was 67 percent to 230 percent.* From examining the record the author concluded that these increases are largely owing to "inadequate geological and technical investigation of the projects in their initial stages" -- similar to part of our indictment of the early (pre-1953) work at San Lorenzo.

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*J. M. Healy, "Errors in Project Cost Estimates," Indian Economic Journal, Vol. XII, No. 1, July-September, 1964, pp. 44-52. Cf. G. H. Fisher, A Discussion of Uncertainty in Cost Analysis: A Lecture for the AFSC Cost Analysis Course, The RAND Corporation, RM-3071-PR (DDC No. AD 279936), 1962; A. A. Alchian, Reliability of Cost Estimates: Some Evidence, The RAND Corporation, RM-481 (DDC No. ATI 210346), October 1950; A. W. Marshall and W. H. Meckling, Predictability of the Costs, Time and Success of Development, The RAND Corporation, P-1821, December 1959.

In even a good project feasibility study, however, point estimates are less desirable than fixing a range of estimates for costs and returns that can be held with some level of confidence. A preferred approach would be to generate a frequency distribution for the value of each of the relevant variables that significantly affects costs and returns (to include the time period of development) and is subject to uncertainty.* A number of calculations may then be made utilizing different combinations of the probable values of these variables. In this manner we may arrive at a frequency distribution of the project's anticipated payoff. This technique provides both an expected value for the payoff function and a range of payoffs that may be held with some level of confidence. (For our purposes, we have taken the simplified approach of assuming across the board equiproportionate changes in all cost or output variables.)

Sensitivity Analysis

In making the calculations described above, we obtain as a by-product a demonstration of the sensitivity of project payoffs, or the extent to which they vary, as assumptions with respect to costs and output are altered. For example, if payoffs appear highly sensitive to small cost overruns and/or output shortfalls, the project should be closely examined for redesign or possible elimination from the package under consideration (depending, of course, on the payoffs of alternative projects).** In addition, we observe the sensitivity of project payoffs to alternative levels of the discount rate.

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*This approach to problems of uncertainty in business investments is described by D. B. Hertz, "Risk Analysis in Capital Investment," Harvard Business Review, Vol. 42, No. 1 (January-February 1964), pp. 95-106.

**In this study we have not engaged in the important question of the optimum scale of a given project. The net present worth approach, however, is also applicable to the problem of evaluating alternative project sizes.

Time Considerations

As most projects involve an absorption of inputs over a number of time periods (years) and a similar but delayed output response, a discounting procedure must be employed. This requires assigning costs and returns to their respective time periods and selecting an appropriate rate or rates of discount. This latter choice is a many faceted question and we wish to avoid it here by applying several different rates.

The discount rate is intended to represent the rate of return of alternative uses of capital in the economy--in this case, the alternative public sector activities that cannot be undertaken if this project is implemented, i.e., it is the opportunity cost of capital. We assume that implementing any one project will not materially affect this rate, so that it is relatively constant. Furthermore, we assume that the same rate is appropriate for evaluating all projects, so that capital is freely transferable from one kind of activity to another, although it does appear that some providers of developmental aid are biased or constrained toward supporting certain types of projects. (Thus the recipient foregoes no alternatives by undertaking the project; if he did not undertake it he would receive no assistance. If he would have undertaken the project anyway with his own resources, he may now devote them to another use--the resource fungibility question. In this case, the opportunity cost of capital is its return to this second project.)

The discount procedure serves two functions. First, it would suggest the elimination of projects with a negative payoff. Second, if projects were mutually exclusive in that available resources are insufficient to undertake all projects with positive payoffs, that bundle of activities with the highest payoffs is preferable. Applying several rates permits us to observe the sensitivity of project payoffs to variations in the discount rate and suggests what biases may arise when inappropriately low or high rates are applied.

As for the criterion used to rank or choose between the various projects, we have chosen the net present worth; that is, the discounted stream of the value of net farm output less the discounted stream of investment and operating costs of the project in question.*

Cf., R. N. McKean, Efficiency in Government Through Systems Analysis,

The first, second, and fourth projects have been assigned discount periods of 50 years each. This is in line with standard practice for activities having a physical plant with a relatively long life expectancy.* As the Coast Program consists of a conglomerate of longer-lived physical facilities (not quite 20 percent of the total investment) and relatively shorter-lived equipment and breeding stock, a more appropriate 15-year discount period was chosen for it.**

A COMPARISON OF PROJECT PAYOFFS

Tables 9 through 12 list the payoffs (net present values) of the four projects for three alternative assumptions about the discount rate. To use a table, one must choose a discount rate (5%, 10% or 15%) and then observe horizontally, for a given multiple of cost (≥ the predicted level) the payoff for decreasing levels of output (≤ that predicted). There might be an objection to our considering here only cost overruns and output shortfalls. In the uncertain world we live in it would seem that the opposite outcomes are also possible. Our review of the Peruvian experience and the study by Healy (cited above) suggest, however, that the cost and output estimates encountered in the typical feasibility study are not means (about both sides of which deviations may occur), but rather the lower bound with respect to costs and the

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John Wiley and Sons, New York, 1958, Chapter 5, and pp. 116-118. The general expression is:

$$PV = \frac{R_1}{(1+r)} + \frac{R_2}{(1+r)^2} + \frac{R_3}{(1+r)^3} + \ldots + \frac{R_n}{(1+r)^n} ,$$

where PV = present value,

R_i = net farm output less construction and operating costs for the year i (1, 2, 3, ..., n),

r = the chosen rate of discount.

*Cf., Benefit-Cost Evaluations as Applied to AID Financed Water or Related Land Use Projects, Office of Engineering, Agency for International Development, Washington, D. C., May 31, 1963, pp. 3-4

**Ministerio de Agricultura, Oficina Nacional de Reforma Promoción Agraria, op. cit., p. 77.

Table 9

PRESENT VALUE OF NET RETURNS FOR THE SAN LORENZO IRRIGATION SETTLEMENT
(In $ Millions)

Multiple of Predicted Cost	Proportion of Predicted Output					
	1	.9	.8	.7	.6	.5
A. 5-Percent Discount Rate						
1.0	19.7[a]	13.1	6.5[b]	0.0	- 6.6	-13.1
1.1	15.1	8.5	2.0	4.6	11.2	17.7
1.2	10.5	3.9	- 2.6	- 9.2	-15.8	-22.3
1.3	5.9	-0.7	- 7.2	-13.8	-20.4	-26.9
1.4	1.3	-5.3	-11.8	-18.4	-25.0	-31.5
1.5	-3.3	-9.9	-16.4	-23.0	-29.6	-36.1
B. 10-Percent Discount Rate						
1.0	-11.7[a]	-13.2	-14.7[b]	-16.3	-17.8	-19.4
1.1	-14.4	-15.9	-17.5	-19.0	-20.6	-22.1
1.2	-17.1	-18.6	-20.2	-21.7	-23.3	-24.8
1.3	-19.8	-21.3	-22.9	-24.4	-26.0	-27.5
1.4	-22.5	-24.0	-25.6	-27.1	-28.7	-30.2
1.5	-25.2	-26.8	-28.3	-29.9	-31.4	-32.9
C. 15-Percent Discount Rate						
1.0	-13.0[a]	-13.4	-13.9[b]	-14.3	-14.7	-15.2
1.1	-14.8	-15.2	-15.6	-16.0	-16.5	-16.9
1.2	-16.5	-16.9	-17.3	-17.8	-18.2	-18.7
1.3	-18.2	-18.6	-19.1	-19.5	-20.0	-20.4
1.4	-19.9	-20.4	-20.8	-21.3	-21.7	-22.2
1.5	-21.7	-22.1	-22.6	-23.0	-23.5	-23.9

NOTE: For sources of the benefit and cost data used to obtain these figures, see pp. 15-25.

[a]These are the "More Likely Payoff" figures in Table 13.

[b]These are the "Low Payoff" figures in Table 13.

Table 10

PRESENT VALUE OF NET RETURNS FOR THE LOWER PIURA IRRIGATION SETTLEMENT
(In $ Millions)

Multiple of Predicted Cost	Proportion of Predicted Output					
	1	.9	.8	.7	.6	.5
A. 5-Percent Discount Rate						
1.0	11.2[a]	9.1	7.0[b]	4.8	2.7	-0.6
1.1	10.2	8.1	6.0	3.8	1.7	-0.4
1.2	9.2	7.1	5.0	2.8	0.7	-1.4
1.3	8.2	6.1	4.0	1.8	-0.3	-2.4
1.4	7.2	5.1	3.0	0.8	-1.3	-3.4
1.5	6.2	4.1	2.0	-0.2	-2.3	-4.4
B. 10-Percent Discount Rate						
1.0	2.1[a]	1.2	0.3[b]	-0.6	-1.5	-2.4
1.1	1.4	0.5	-0.4	-1.3	-2.2	-3.1
1.2	0.7	-0.2	-1.1	-2.0	-2.9	-3.8
1.3	0.0	-0.9	-1.8	-2.7	-3.6	-4.5
1.4	-0.7	-1.6	-2.5	-3.4	-4.3	-5.2
1.5	-1.4	-2.3	-3.2	-4.1	-5.0	-5.9
C. 15-Percent Discount Rate						
1.0	-0.4[a]	-0.9	-1.3[b]	-1.8	-2.3	-2.8
1.1	-0.9	-1.4	-1.9	-2.3	-2.8	-3.2
1.2	-1.4	-1.9	-2.4	-2.8	-3.3	-3.8
1.3	-1.9	-2.4	-2.9	-3.3	-3.8	-4.3
1.4	-2.4	-2.9	-3.4	-3.9	-4.3	-4.8
1.5	-3.0	-3.4	-3.9	-4.4	-4.8	-5.3

NOTE: For sources of the benefit and cost data used to obtain these figures, see pp. 15-25.

[a]These are the "More Likely Payoff" figures in Table 13.

[b]These are the "Low Payoff" figures in Table 13.

Table 11

PRESENT VALUE OF NET RETURNS FOR THE COAST PROGRAM
(In $ Millions)

Multiple of Predicted Cost	Proportion of Predicted Output					
	1	.9	.8	.7	.6	.5
A. 5-Percent Discount Rate						
1.0	19.1[a]	15.3	11.6	7.9	4.2	0.5
1.1	17.3	13.6[b]	9.8	6.1	2.4	-1.3
1.2	15.5	11.8	8.0[c]	4.3	0.6	-3.1
1.3	13.7	10.0	6.2	2.5	-1.2	-4.9
1.4	11.9	8.2	4.4	0.7	-3.0	-6.7
1.5	10.1	6.4	2.6	-1.1	-4.8	-8.5
B. 10-Percent Discount Rate						
1.0	11.7[a]	9.3	6.8	4.3	1.8	-0.6
1.1	10.4	8.0[b]	5.5	3.0	0.5	1.9
1.2	9.1	6.7	4.2[c]	1.7	-0.8	-3.2
1.3	7.8	5.4	2.9	0.4	-2.1	-4.5
1.4	6.5	4.1	1.6	-0.9	-3.4	-5.8
1.5	5.2	2.8	0.3	-2.2	-4.7	-7.1
C. 15-Percent Discount Rate						
1.0	7.4[a]	5.7	4.0	2.3	0.5	1.2
1.1	6.5	4.7[b]	3.0	1.3	-0.5	-2.2
1.2	5.5	3.7	2.0[c]	0.3	-1.4	-3.2
1.3	4.5	2.8	1.0	-0.7	-2.4	-4.1
1.4	3.5	1.8	0.1	-1.7	-3.4	-5.1
1.5	2.5	0.8	-0.9	-2.7	-4.4	-6.1

NOTE: For sources of the benefit and cost data used to obtain these figures, see pp. 27-30.

[a]These are the "High Payoff" figures in Table 13.

[b]These are the "More Likely Payoff" figures in Table 13.

[c]These are the "Low Payoff" figures in Table 13.

Table 12

PRESENT VALUE OF NET RETURNS FOR THE TINGO MARÍA-TOCACHE SETTLEMENT PROJECT
(In $ Millions)

Multiple of Predicted Cost	Proportion of Predicted Output					
	1	.9	.8	.7	.6	.5
A. 5-Percent Discount Rate						
1.0	132.1	114.9	97.7	80.5	63.3	46.1
1.1	128.1	110.9	93.7	76.5	59.3	42.1
1.2	124.1	106.9	89.7	72.5	55.3	38.1
1.3	120.2	103.0	85.8[a]	68.5	51.3	34.1
1.4	116.1	99.0	81.8	64.6	47.4	30.2
1.5	112.2	95.0	77.8	60.6	43.4[b]	26.2
B. 10-Percent Discount Rate						
1.0	46.4	39.2	31.9	24.7	17.4	10.2
1.1	43.8	36.6	29.3	22.1	14.8	7.6
1.2	41.2	34.0	26.7	19.5	12.2	5.0
1.3	38.6	31.4	24.1[a]	16.9	9.7	2.4
1.4	36.0	28.8	21.5	14.3	7.1	-0.2
1.5	33.4	26.2	18.9	11.7	4.5[b]	-2.8
C. 15-Percent Discount Rate						
1.0	20.0	15.9	12.0	8.0	4.1	0.2
1.1	17.9	14.0	10.0	6.1	2.1	-1.8
1.2	16.0	12.0	8.1	4.1	0.2	-3.8
1.3	14.0	10.1	6.1[a]	2.2	-1.8	-5.7
1.4	12.0	8.1	4.2	0.2	-3.7	-7.7
1.5	10.1	6.2	2.2	-1.7	-5.7[b]	-9.6

NOTE: For sources of the benefit and cost data used to obtain these figures, see pp. 35-38.

[a]These are the "More Likely Payoff" figures in Table 13.

[b]These are the "Low Payoff" figures in Table 13.

upper bound with respect to output. To deal with this initial bias, we resort to a countervailing one. (In this vein, it is interesting to note how very rarely a feasibility study will suggest that a project should not be undertaken on economic grounds.)

Let us examine Table 9 which contains information on the San Lorenzo Irrigation Settlement. At a 5-percent discount rate for the predicted level of cost, the payoff varies from $19.7 million if predicted output levels are attained, down to -$13.1 million if actual output is only one-half of that predicted. Alternatively, we observe that given a realized output of 80 percent of that predicted, the payoff varies from $6.5 million if predicted costs are realized, down to -$16.4 million if realized costs are 1.5 times those predicted. Thus we may choose any combination of costs (from 1 to 1.5 times the predicted level) and output (from 0.5 to 1 times the predicted level) and read off the table the resulting payoff. The operation may be repeated for discount rates of 10 and 15 percent. In Table 12 we see that for a 15-percent discount rate, if the predicted output is achieved, the net return to the Tingo María-Tocache project varies from $20.0 million if costs are as predicted to $10.1 million if there is a 50-percent cost overrun.

In Figures 6 and 7, the data for discount rates of 10 and 15 percent are presented more forcefully. Each set of parallel lines is for a single project.* Each line associates the indicated multiple of cost with some multiple of output on the horizontal axis. One may read on the vertical axis the resultant payoff. For example, with the Coast Program in Fig. 6, if costs are 1.5 those predicted and the predicted output is attained, we can read the net return off the ordinate at the left at about $5 million; if output is 90 percent of that predicted, at the 1.5 cost level, the net return can be read off the ordinate as something less than $3 million. That the slope of the lines for the Coast Program is less than that for the Tingo María-Tocache project indicates that net payoffs for the former are less sensitive in a downward direction for cost overruns and/or output shortfalls than for the latter.

*These graphs alone are not sufficient for comparing the projects as they have differing costs.

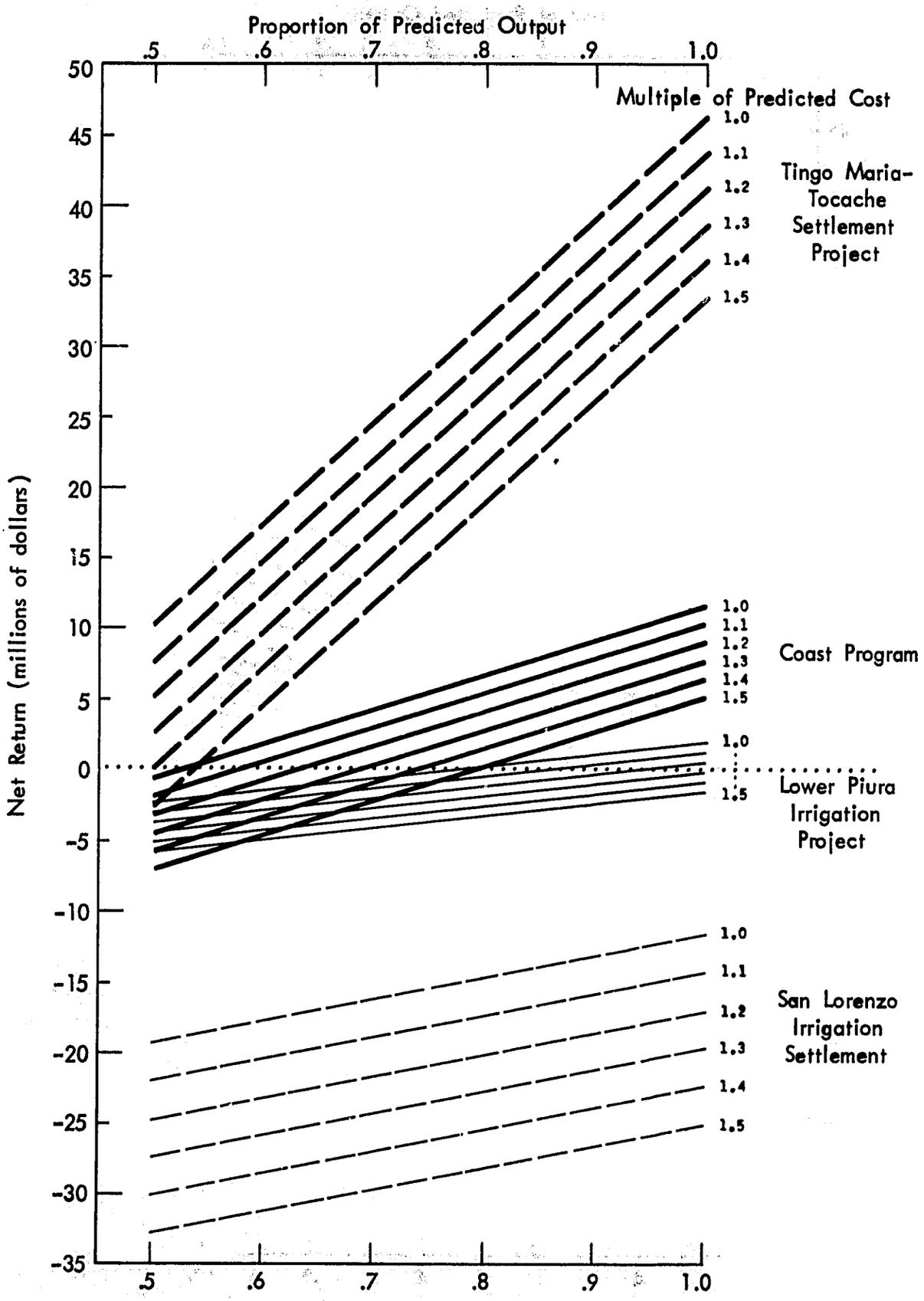

Fig. 6 -- Output-Payoff Tradeoffs at Various Cost Levels: 10% Discount Rate

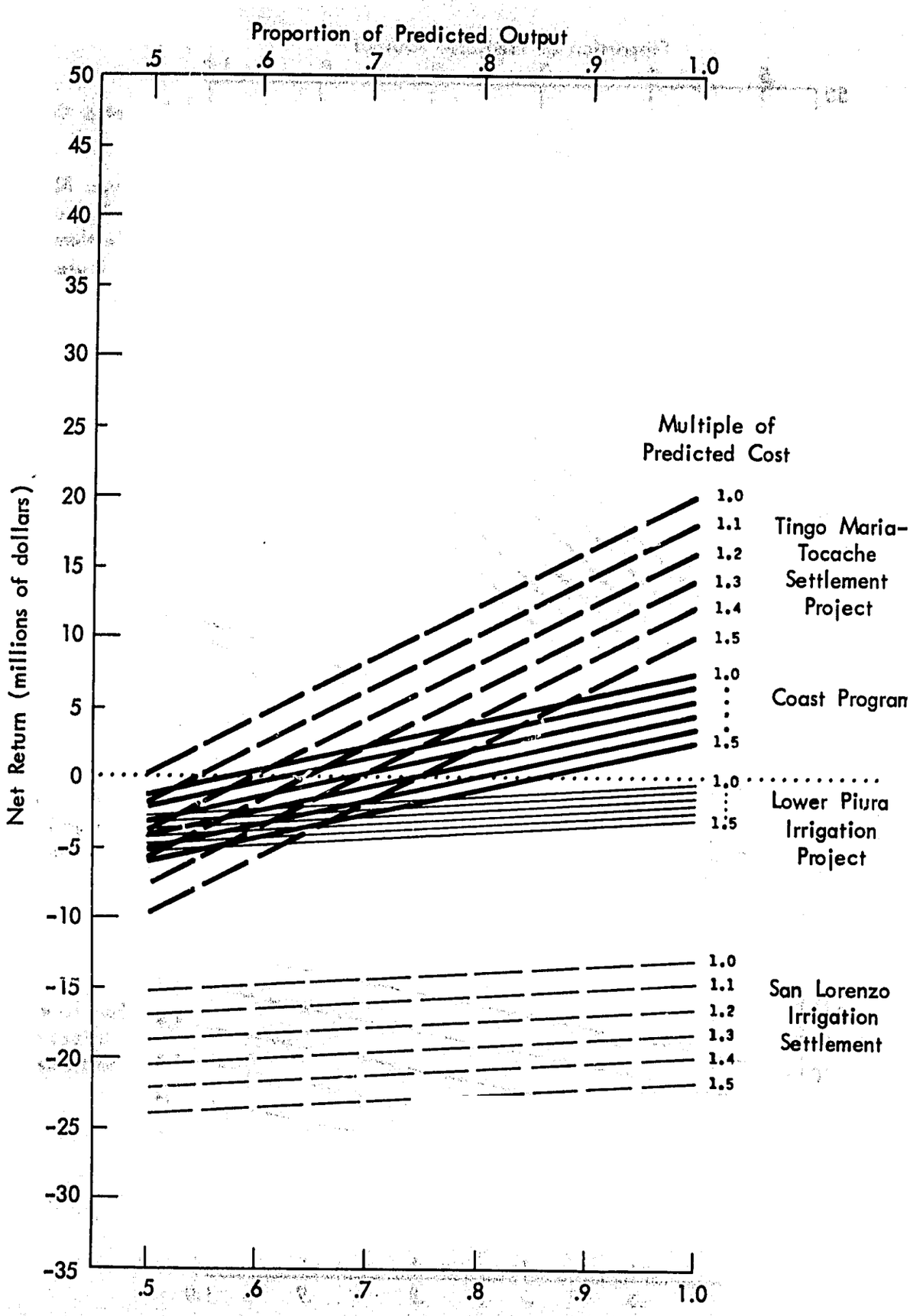

Fig. 7 -- Output-Payoff Tradeoffs at Various Cost Levels: 15% Discount Rate

These data can be reduced to a more informative presentation for the decision-maker as shown in Table 13. This is done by choosing an equally likely combination of costs and benefits for each project under assumptions of favorable cost-output realizations (things go a little better than might be expected), unfavorable cost-output realizations (some unforeseen but significant problems arise), and the normal cost-output realization (the project proceeds as might be expected). In Table 13 these are the high payoff, low payoff and more likely payoff columns respectively.

As these projects are very different, there is no reason to expect the same degree of cost overrun or output shortfall for each one in a given column. For example, problems and lack of experience in developing tropic rainforest settlement projects should cause relatively larger deviations from initially predicted costs and output than problems encountered for technical assistance or agricultural extension activities in already settled areas like the coast. After examining the available data and visiting the projects themselves or the areas proposed for them, we suggest that the following configurations are not unreasonable:*

Project	High Payoff	More Likely Payoff	Low Payoff
San Lorenzo Irrigation Settlement	1953 Cotton-McGee study	1964 cost and output estimates	1964 cost estimates, 80% of 1964 output estimates
Lower Piura Valley	1953 Cotton-McGee study	Realized cost, 1953 output estimates	Realized costs, 80% of 1953 predicted output
Coast Program	1963 predicted costs and output	1.1 times predicted cost; 0.9 times predicted output	1.2 times predicted cost; 0.8 times predicted output
Tingo María Tocache Project	1962 predicted costs and output	1.3 times predicted cost; 0.8 times predicted output (Project lengthened five years)	1.5 times predicted cost; 0.6 times predicted output

*As these assumptions are for illustrative purposes only, the interested reader might apply his preferred set and observe payoff behavior.

Table 13

PROJECT PAYOFFS
(In $ Millions)

Project	High Payoff			More Likely Payoff			Low Payoff		
	Net Present Worth	Discounted Cost	Relative Value	Net Present Worth	Discounted Cost	Relative Value	Net Present Worth	Discounted Cost	Relative Value
A. 5-Percent Discount Rate									
San Lorenzo	15.6	28.0	25.0	19.7	46.0	21.7	6.5	46.0	8.5
Lower Piura	12.4	8.8	62.0	11.2	10.0	58.2	7.0	10.0	42.0
Coast	19.1	18.0	47.8	13.6	19.8	35.4	8.0	21.6	22.4
Tingo María-Tocache	146.5	44.2	146.5	85.8	51.9	85.8	43.4	59.9	43.4
B. 10-Percent Discount Rate									
San Lorenzo	-3.0	17.7	-5.1	-11.7	27.1	-14.0	-14.7	27.1	-20.6
Lower Piura	2.7	6.2	13.2	2.1	6.9	10.3	0.2	6.9	1.1
Coast	11.7	13.0	26.9	8.0	14.3	19.2	4.2	15.6	10.5
Tingo María-Tocache	53.4	30.4	53.4	24.1	33.8	24.1	4.5	39.0	4.5
C. 15-Percent Discount Rate									
San Lorenzo	-6.4	12.4	-12.2	-13.0	17.4	-19.5	-13.9	17.4	-23.6
Lower Piura	0.0	4.6	0.0	-0.4	5.1	-2.0	-1.4	5.1	-8.0
Coast	7.4	9.8	17.8	4.7	10.8	11.3	2.0	11.8	5.0
Tingo María-Tocache	23.2	23.9	23.2	6.1	25.4	6.1	-5.7	29.3	-5.7

In order to assist us in narrowing the range of applicable discount rates, we might note that the rate of (net) profit (on balance sheet capital) for industry in Peru in 1959 was about 13 percent.* While this is certainly less than a perfect measure of the rate of return on alternative investment opportunities in the economy,** it does suggest that we might more properly narrow the appropriate discount rate to the 10- to 15-percent range, as we did with Graphs 6 and 7.

With respect to strategy costs and returns, Table 13 presents the data in a succinct form for the decision-maker, using the alternative cost overrun and output shortfall assumptions described on the preceding page. These alone are not sufficient, however, to provide a basis for comparing the activities, as the project costs are not the same. To approach this problem, we have used Tingo María-Tocache as a base and calculated the returns obtained by devoting the budget this project requires to another type of project.*** The formula for calculating "Relative Value" is

$$\text{R.V.} = \frac{\text{Tingo María - Tocache cost}}{\text{alternative project's cost}} \times \begin{array}{c}\text{alternative}\\ \text{project's net}\\ \text{present worth}\end{array}$$

The resulting figure appears in the "Relative Value" column of Table 13.

Suppose the decision-maker accepted a 10-percent discount rate as appropriate. Depending on the set of assumptions with respect to cost overrun and output shortfall he would accept, if he were "optimistic" he would select a strategy favoring jungle colonization; he

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*Banco Central de Reserva del Peru, La Renta Nacional del Peru: 1942-1959, Lima, Peru, 1961, p. 34.

**The rates in other activities were: agriculture (16 percent), mining (14 percent), and commerce (14 percent), ibid., p. 34. Of course, these rates include some risk premium; as we allow here for uncertainty in the numerator of the present value formula, the discount rate should be a riskless one.

***This assumes that each project is representative of a type or that there is linearity in the behavior of costs and returns as the project's scale changes. Probably the former assumption is more likely.

would do the same if he accepted the "more likely payoff" assumptions; a "pessimist," however, would select the strategy represented by the Coast project. At the 15-percent discount rate, the Coast Project is preferred, unless the decision-maker is "optimistic," then he would select the jungle colonization project. If the projects were not mutually exclusive, i.e., if sufficient resources were available to undertake all of them, depending on his disposition (the column in Table 13 he felt most appropriate) the decision-maker would implement all projects that show a positive payoff. At the 5-percent discount rate they are all acceptable; at higher rates this is not the case.

Thus we observe the double disservice done to underdeveloped countries by considering the opportunity cost of capital to be a perhaps unrealistically low 5 or 6 percent. First, if the supply of resources is adequate to support the entire development program, it is likely that undesirable projects (i.e., those with negative payoffs when capital is valued at its true opportunity cost) will be undertaken. Second, if the supply of capital is limited, the use of an unwarrantably low rate to discount the time streams of costs and benefits may bias payoff estimates in favor of capital-intensive projects with relatively long development periods.

We should emphasize that Table 13, while suggestive, is meant for illustrative purposes only. The reader should find it quite easy, using the data from Tables 9 through 12, to construct for himself such a table using other alternative assumptions with respect to cost and output performance.

The generally unfavorable relative payoffs of the San Lorenzo Settlement Project might be set at several doorsteps, e.g., poor planning, capital intensity, long construction period, many physical changes, etc. Note, though, that even if it would have lived up to its 1953 expectations, at the 5-percent discount rate its favorable ("high payoff") performance would still have been less than the "more likely payoff" of each of the other projects. At the 10- and 15-percent discount rates, even these 1953 ("high payoff") cost and benefit assumptions result in negative payoffs. Thus San Lorenzo did not become a relatively poor project, it was a poor choice from the start.

VI. BROADENING THE SCOPE OF THE EVALUATION

We have chosen a relatively narrow objective function by which to evaluate and compare these projects, i.e., the net increase in farm output. In reality, there are many possible objectives for development projects, a partial list of which might include: (1) increasing the output of agricultural products and/or the quantities coming on the market, perhaps at times approaching autarky; (2) improving the living conditions of the farming population; (3) reducing pressures on the balance of payments by increasing the import capacity via increasing agricultural exports or producing locally items that are currently imported; (4) redistributing the agricultural population from areas of excessive man/land ratios, e.g., colonization or resettlement programs; (5) reducing the migration to (usually already overburdened) urban areas by increasing the attractiveness (or reducing the forces pushing individuals out) of rural economic activities; (6) reducing pressures that lead to economic, social or political discontent (land invasions, renters' strikes, rural violence) in some areas; (7) strengthening territorial claims in actually or potentially disputed areas, etc. As some projects satisfy these various goals better than others, the final choice between projects or groups of projects will largely depend on the weight assigned to the various objectives and the rates at which one objective can be traded off for another.

Given the large variety of considerations, it is neither feasible nor desirable that we claim we have reduced the decision-making problem to one single rule such as "maximize present worth." However, we can perform the very important task of showing the decision-makers what their suboptimizing behavior will cost in terms of farm output foregone if they pursue such shibboleths as "making the desert bloom," or "on to the jungle." This does not mean that decision-makers are behaving irrationally. Perhaps increases in agricultural production may carry a relatively lower weight in their over-all objective function than, e.g., resettling land-hungry peasants from the Andes to the selva to avoid invasions of haciendas, integrating the indigenous population into the national life, political patronage or payoffs, etc.

VII. CONCLUSIONS

We have not intended this Memorandum as a detailed guide for preparing project feasibility studies. We have attempted to demonstrate that attention to the problems of uncertainty, sensitivity analysis, time discounting, choice criteria, and consideration of development projects at the sectoral level, as discussed and applied in Sec. V, would contribute to pre-feasibility and feasibility studies of a more informative and useful nature for decision-makers.

In order to demonstrate the relevance of the above considerations to problems of economic planning or choosing development strategies, we compared four projects in Peru in various stages of operation or planning. By no stretch of the imagination would it appear possible to allege that a rational decision-making process has been operating in Peru in the selection of development strategies.* Only recently, with the implementation of the Coast Program, has there been any suggestion of an optimizing behavior pattern. While we cannot here analyze the basis for or forces conducive to (and the weakness of countervailing forces to) irrational patterns of decision-making, we might suggest that among the candidates are the prestige and impressiveness of large-scale projects (big dams, big hospitals, wide highways, new capitals, etc.); the relative willingness of extranational financing to support these "infrastructure" activities; the preference patterns of foreign economic advisors for "tangible" indications of progress or development; the lobbying by large

*As an example of the inadequate presentation and analysis of data, we might note that in the request for additional financing for San Lorenzo that the Peruvian government sent to the IBRD in the fall of 1964 there appears the following Ouput/Investment ratio:

$$\frac{\text{Annual net output} \times 100}{\text{Investment}} = \frac{400 \times 100}{2056} = 19.5\%$$

The "annual net output" figure is that anticipated for the 1970's when the project's output stabilizes. The "investment" figure consists of the number of soles, unadjusted for changes in purchasing power or exchange rates, invested in the project (or planned for investment) from 1949 to 1967. This meaningless presentation probably received little attention from the Bank's economists.

construction firms; and narrow-mindedness or ignorance. Obviously these are not congenital factors in this country, or any other. The exemplary growth and development of the Peruvian economy in recent years is a source of admiration and envy throughout the hemisphere, and in part demonstrates both domestic and foreign entrepreneurial ability.

Nevertheless, the widely varying payoffs (realized or potential) we have observed leave little doubt that the relevant decision-makers are not receiving the information that is really essential for them to perform their tasks.* And to a large extent, it is not a problem of the quantity of information available but rather its quality or manner of presentation. The costs of improving this information flow and properly accounting for the opportunity costs of capital and labor are probably not excessive, especially in view of the cost of decision errors that might be avoided in the future.**

If we could choose between the San Lorenzo and the Lower Piura projects or the Coast Program, it would seem that both on output (e.g., our net present worth criterion) and simple distribution (number of persons directly benefitting) grounds that the last one is preferable. When we consider that the more highly planned or organized an activity is or intends to be, the more opportunities there are for mistakes or failures (and the Tingo María-Tocache Project is sensitive to this criticism); then an activity like the Coast Program becomes even more attractive. Our study indicates that large-scale capital intensive agricultural development activities should be avoided, the resources devoted instead to increasing the operating efficiency of currently established farming enterprises. The preference for large-scale irrigation projects in Peru becomes all the more irrational when one reflects on the inconsistent and often counter-productive systems currently used in distributing irrigation

*The continuance of irrational behavior patterns in the face of an improved information flow would put the finger on the decision-makers themselves as either inept or dishonest or both.

**No more San Lorenzos, for example

water in the coastal valleys. Unfortunately, it appears that a change in current distribution practices i.e., water reform, would be as hard or harder to implement than a land reform.*

The Peruvian record also suggests that the practice of justifying and evaluating development activities on a project-by-project basis will only accidently lead to a program package that is economically optimal. Two problems AID may face in taking this approach, however, are:

(1) Not all the development projects of an aid-recipient are presented for AID support, so that perhaps only a part of the overall development activity is subjected to rational analysis and the door is opened to the resource fungibility problem.**

(2) The flow into the Agency of adequately prepared proposals for assistance in project financing is so slow that the Agency as often as not may be in the position of wanting to finance as many activities as are presented to it. Until local governments can better identify potential projects and adequately present project proposals, this problem will continue.***

These two considerations do not, however, eliminate the advantages of improving the manner and depth of project analysis as suggested above and, wherever possible, of considering alternatives to a specific project. This Memorandum certainly demonstrates some of the disadvantages of not doing so.

*There is considerable need for an analysis that points up the costs of this (largely political) obstacle to improving the resource allocation pattern in Peruvian agriculture on the Coast. The impact of government price policies on the performance of the agricultural sector and the panllevar decrees (directives requiring proportions of coastal farms and plantations to be planted in food crops) should also be studied.

**For a possible approach to this problem, see L. L. Johnson, Bargaining in AID Program Assistance: The Case of Chile, The RAND Corporation, RM-4522-AID, July 1965 (Limited Official Use, handle as Confidential), pp. 50-51.

***For a possible approach to this problem, see F. T. Moore, et. al., An Appraisal of U.S. Capital Assistance to Less Developed Countries (U), The RAND Corporation, RM-4594-AID, October 1965 (Confidential), pp. 96-104.