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AN AGROECONOMIC LAND RESOURCE ASSESSMENT FOR RICE PRODUCTION IN THE DOMINICAN REPUBLIC

By

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ABSTRACT

AN AGROECONOMIC LAND RESOURCE ASSESSMENT FOR RICE PRODUCTION IN THE DOMINICAN REPUBLIC

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The Dominican Republic has been importing increasing quantities of rice since 1972. In 1978 the government began a program to increase domestic rice production in order to reduce foreign exchange expenditures and to increase employment. As a sub-component of that program, this study was undertaken to assess the agronomic and physical ("agrophysical") and economic ("agroeconomic") feasiability of rice production expansion in each land unit ("GDSS") in the Central Region of the country. The regional study was to serve as a prototype for a national rice land use assessment and for studies of other agricultural land uses.

The analysis was of two types. First, an agrophysical analysis of the land base was carried out in order to identify areas with potential for increased rice production. Rice plant tolerance limits for potentially limiting soil and water characteristics were estimated and cross-tabulated with the corresponding GDSS characteristics. Second, an economic analysis was made of the GDSSs selected in the agrophysical analysis. Benefits and costs of the production of rice and of its two principal competitors for land in the Central Region (sugarcane and

cultivated pasture used for milk production) were analyzed from the producer cash expense ("monetary") and the national opportunity ("unsubsidized") points of view. A typical current set of rice production techniques and an alternative set requiring increased labor and/or decreased foreign exchange used were analyzed. The benefit-cost results were used in partial budgeting of a hypothetical 25,000 ta expansion of rice production area using 11 alternative strategies. The strategies consisted of various assumptions on expansion decision rules (maximization of rice production, maximization of rice monetary and unsubsidized returns to land and management, maximization of rice production labor use, and minimization of rice production foreign exchange use) and policy variables (rice production techniques, number of rice production cycles per year, and expansion in current or potentially available GDSSs).

Conclusions drawn from the study can be divided into policy and methodological conclusions. There are two major policy conclusions. First, irrigated GDSSs 06A and 07A and rainfed 20B have the best prospects for rice area expansion. A 25,000 ta expansion of rice production in those GDSSs under strategy E (maximization of rice monetary returns with free choice of production technique and GDSS) would increase annual labor use by 2.4 million hr and increase brown rice production by 4.4 million qq. The country could save $5.5 million in foreign exchange and $2.6 million total on the 4.4 million qq or rice through domestic production rather than importation. Second, adoption in current rice production areas of the alternative techniques analyzed in this study would both increase labor use and decrease foreign exchange use by about 50 percent.

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There are three major methodological conclusions. First, the study methods seem to be appropriate to the current Dominican planning environment. However, the secondary and judgmental data sources used in the study sould be supplemented by land use surveys at the farm level. Second, several of the critical assumptions made in the study should be given more detailed study prior to use in project planning. Third, other intra- and inter-sectoral production and consumption information in addition to this land use assessment should be incorporated in the rice expansion policymaking process in order to increase the probability that a feasiable and desirable expansion policy and resulting projects can be planned and implemented.

DECIDATED

to

Julie,

Peter,

Erin,

and

SGT Johnny Snelson, RIP

ACKNOWLEDGMENTS

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To my other guidance committee members. Drs. W. Vincent, and P. Strassman of the Economics Department go my thanks for their support and interest in the development of my graduate program. Several members of the Comprehensive Inventory and Evaluation System (CRIES) Project staff deserve a note of appreciation for their role as "devil's advocate" during the early drafting of the study proposal. Carl Montano's comments were particularly incisive.

The study was carried out as part of the overall CRIES/SIEDRA Project in the Dominican Republic, thus thanks for financial and administrative support for the study go both to the CRIES Project (a cooperative endeavor among USDA-ESCS, USAID, and MSU) and to the Subsecretaria de Recursos Naturales of the Secretaria de Estado de Agricultura of the Dominican Republic.

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CHAPTER I

INTRODUCTION

Problem Statement

Rice is the most important staple in the diets of both rural and urban Dominicans. It provides an estimated 25 and 22 percent, respectively, of the daily caloric and protein intake (SEA, 1976). Domestic demand for rice has been increasing rapidly during the past two decades. This increasing demand is due to an average annual population increase of three percent and to a high positive income elasticity at low Dominican income levels coupled with increasing real incomes (Drilon, 1977). Domestic rice supplies have not kept pace with the demand increases, an imbalance resulting in the annual importation of rice since 1972 (Figure 1-1). This problem was exacerbated in 1973-74 when large increases in export prices for sugar caused many producers to shift out of rice and into more profitable sugarcane production (Juma, 1979). A 1979 hurricane contributed to a dramatic decrease in production and is expected to result in the importation of large quantities of rice in 1980.

As a result of the post-1974 weakening of world prices for sugar, a crop which traditionally has accounted for about 50 percent of Dominican foreign exchange, and the continuing rapid rise in petroleum import costs, the use of increasingly limited foreign exchange to import rice came under heavy questioning in the mid-1970s. A vociferous nationalistic

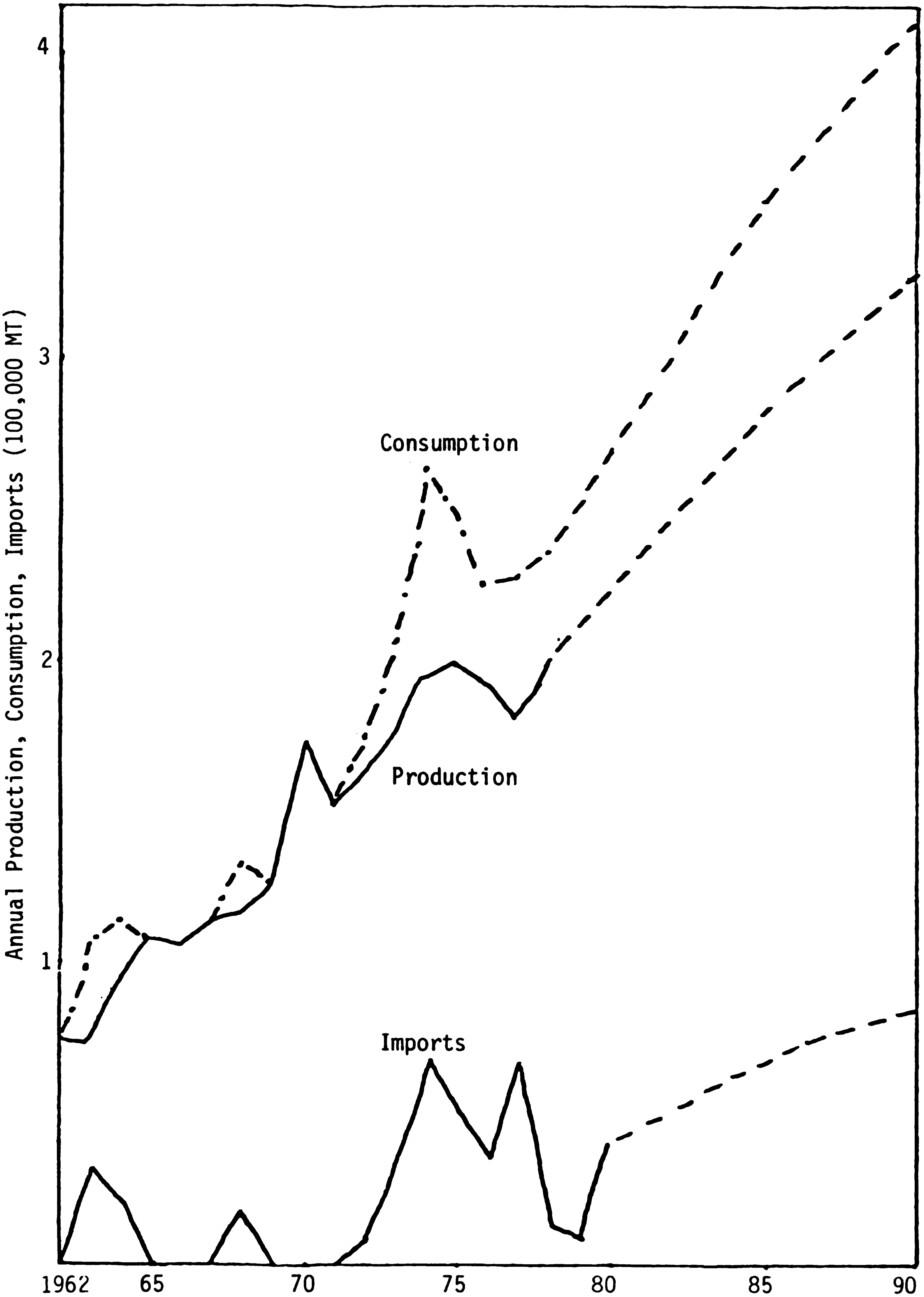


Figure 1-1. Domestic rice production, consumption, and imports for the period 1962-1980 and projections for 1985 and 1990 (SEA, 1977; INESPRE, 1979; AID, 1980).

majority of agricultural spokesmen claimed that the country could become self-sufficient in rice production through implementation of stronger government rice production programs both to increase productivity on current riceland and to expand current production areas (SEA, 1976a, 1976b). Reduction of high levels of rural unemployment and under-employment was consistently cited as a justification for increasing domestic rice production (SEA, 1979b). A small group of spokesmen suggested that continued rice importation was the most efficient alternative for meeting domestic consumption needs, as increased domestic production would require increased foreign exchange use for importation of production inputs, thereby offsetting the savings from discontinuing importation of the rice itself.

In 1978 the controversy was made at least temporarily moot when the Dominican government (GODR) began a multiagency program to promote self-sufficiency in rice production (SEA, 1979b). No documentation of supporting economic or agronomic analysis was published, and though no definition was stated for "self-sufficiency," it is presumed to have meant that the country would attempt to meet its rice consumption needs with domestic production as long as current relative input and output prices remain fairly stable. The specific purpose of the program was to raise the 1978 national average rice yield by 25 percent in four years, from 6.6qq/ta to 8.2 qq/ta (1 qq = 100 lbs.; 1 ta - 1/15.9 ha). This was to be accomplished by increasing irrigated rice area by 18 percent and by eliminating rainfed upland rice production. For the longer term, it has been estimated that at least 25,000 ta must be brought into rice production annually at the proposed 8.2 qq/ta yield level in order to meet projected domestic consumption needs without imports through 1990 (AID, 1980).

To date, the governmental program has benefited little from scientific analysis of either the positive or normative aspects of the multitude of dynamic technical, institutional, and human factors that bear on the problem of sustained rice production increase. Quantitative and qualitative multidisciplinary analyses of such dynamic factors as present and future land resource base capabilities for agricultural production, production technologies, land tenure, input and output marketing, domestic and export demand, input and output substitution, income distribution, price policies, and sectoral and intersectoral comparative advantage are required in order to provide an economically sound and socially desirable answer to the questions of where, when, and how to increase domestic rice production. In view, however, of the limited qualified human resources available for research in the Dominican Republic and of costs of developing each of these kinds of information, research efforts should be focused on developing the priority information known to have a critical bearing on the problem.

Thus, a necessary early step in assessing the options for increasing domestic rice production is an analysis of the supply side of the rice production capacity of the Dominican land (soil and water) resource base as it relates to the critical factors of labor and foreign exchange use. As total production is a function of area and yield per unit area, studies are needed both of land base capabilities for extension of current areas and of alternative techniques to increase per ta productivity on current rice areas. Information on the agronomic and physical ("agrophysical") adaptability of rice plants to each land unit and on the profitability of current and alternative production techniques is needed in order to select priority areas for investment of financial and technical resources. Economic analysis of the benefits and costs of rice production increases both to the producers, in monetary (cash) terms, and to the national as a whole, in unsubsidized (opportunity cost) terms, would aid in providing a foundation on which a more efficient and realistic regional and national rice expansion program could evolve. Very little of these kinds of information on the land resource base production potential was available in the Dominican Republic when the present study was undertaken.

Study Background

Evaluations of projects dealing with the development of economic analysis capabilities in developing countries frequently point out that such projects often attempt to transfer inappropriate and overly sophisticated analytical techniques to the thin veneer of local technicians. These technicians often are unable themselves either to apply these techniques appropriately to the typically rudimentary domestic data bases or to establish their credibility among the bureaucrats and politicians who are asked to support the analytical work (Amin, 1979; Rossmiller, *et al.*, 1977). An alternative approach to developing the capability for economic analysis is to start with less sophisticated static and partial analyses and then to proceed, as local technical capability and reliable data is developed over time, to more sophisticated and complex static and dynamic general equilibrium analyses (Edwards, 1966; Kornai, 1975).

This was the approach taken by the Comprehensive Resource Inventory and Evaluation System (CRIES) project when it initiated work in the

Dominican Republic in 1977. At that time Dominican capability to undertake agaonomic and economic ("agroeconomic") analysis of agricultural land use alternatives was virtually non-existent. The CRIES project was initiated as a cooperative effort among the United States Department of Agriculture's Economics, Statistics, and Cooperative Service, the United States Agency for International Development, and the Michigan State University (CRIES, 1976). The project attempts to strengthen capacity in developing countries for development and analysis of data on land resource base capabilities for agricultural production. This data base will provide information on food and fiber supply options for national and international level decisionmaking. In the Dominican Republic the CRIES counterpart staff is referred to as the Sistema de Inventario y Evaluacion de los Recursos Agropecuarios (SIEDRA).

The author of this paper, while serving as the CRIES resident advisor to the SIEDRA staff during the period 1977-80, recommended to the Secretariat of Agriculture (SEA) that SIEDRA carry out the agroeconomic analysis of the various land areas of the country in order to identify areas appropriate for rice expansion. As this study was SIEDRA's first analytical effort, it was conducted on an experimental basis for the SEA administrative region closest to the SIEDRA offices in Santo Domingo. At that time the Central Region was the only one with sufficient soils and water data on which to base a study of this nature. It was also located near enough to the SIEDRA offices to provide cost efficient, coordinated field and office methodology testing and training for the SIEDRA staff. After review of the regional study results and incorporation of any needed modifications in data collection and analysis methodologies, the rice study was to be expanded to the remaining six

SEA regions. Approval of the regional study was given by the Secretary. Preliminary work began in the late spring of 1979, and was based on the existing SIEDRA benchmark land use data base for the SEA Central Region (Figure 1-2). It is this regional rice study that is the subject of this paper.

Study Objectives

The immediate purpose of the study was to make available to the Secretary of Agriculture information on locations where rice production could be expanded economically. This information was to be provided through an agroeconomic land resource assessment for selected rice production alternatives, with a focus on labor and foreign exchange use. The specific objectives of this study were to:

1. Develop a long resource assessment methodology appropriate to current Dominican technical and administrative capabilities;

2. Determine the agrophysical requirements for selected rice varieties;

3. Identify land areas with the required agrophysical characteristics;

4. Develop, for each suitable land area, rice enterprise budgets for typical current production techniques and for an alternative set of production techniques which would provide increased labor use and/or decreased use of foreign exchange;

5. Develop typical current normal budgets for the major land use alternatives (sugarcane and cultivated pastures) to rice production on the selected land areas;

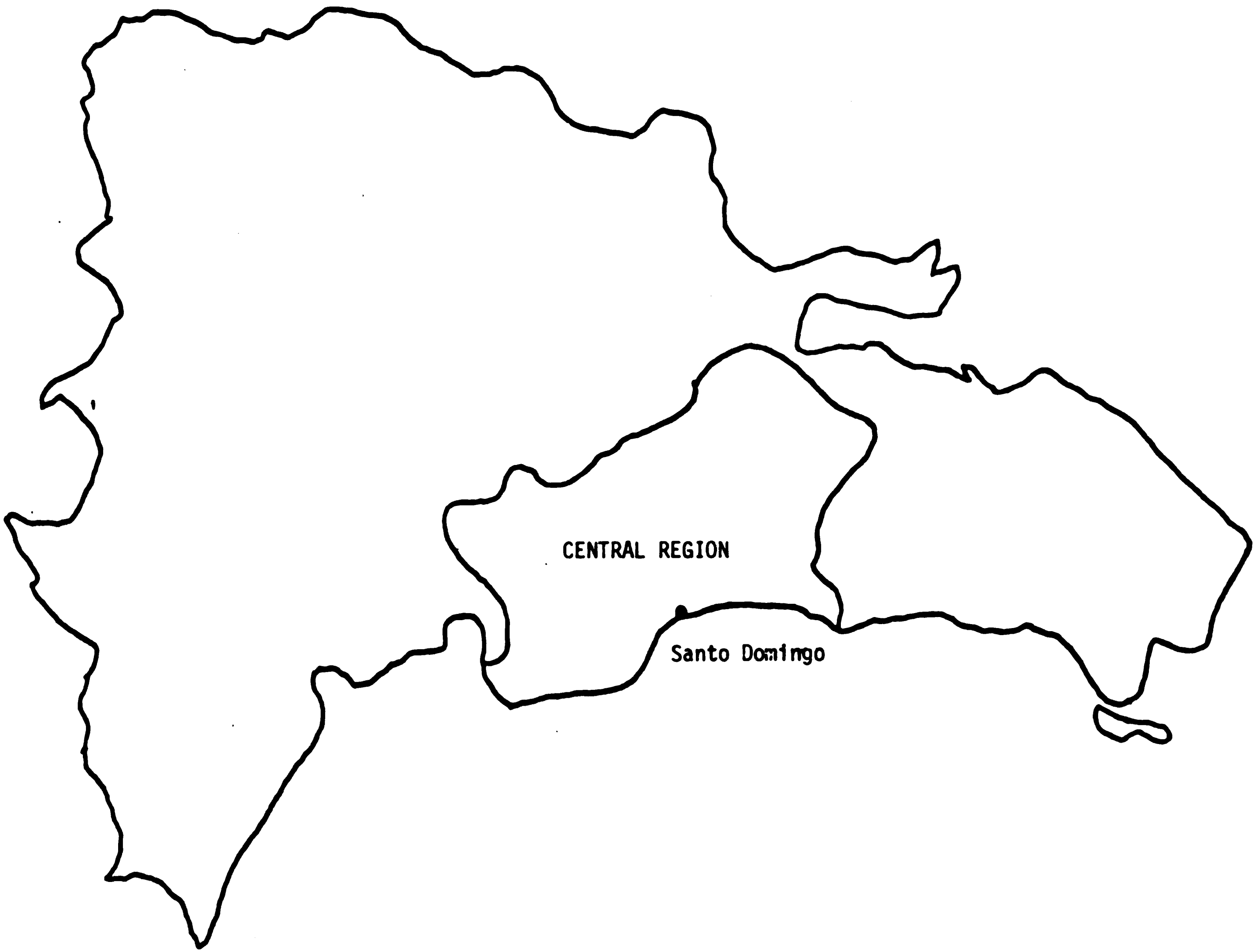


Figure 1-2. Location of the SEA Central Region in the Dominican Republic

6. Carry out monetary and unsubsidized benefit-cost analysis of the production alternatives;

7. Develop partial budgets for 11 strategies for a 25,000 ta expansion of current rice production area, estimating impacts on regional and GDSS-level production, profitability, labor and foreign exchange use;

8. Carry out a sensitivity analysis on selected expansion strategies using two sets of assumptions on potential for rice multiple production cycles.

Major questions addressed by the study include:

a. In what land areas can rainfed and irrigated rice production be expanded?

b. Which expansion areas would be the most profitable from the producers' and the nation's standpoints?

c. Where can employment be increased and foreign exchange use be decreased in rice area expansion?

d. Are alternative rice production techniques available which could increase labor and decrease foreign exchange use?

e. How much are rice production costs currently being subsidized and what would be the impact of subsidy removal?

f. Can a land assessment procedure be developed which is appropriate to the Dominican planning environment?

This land resource assessment is viewed as a necessary, but not sufficient, input into the more comprehensive analyses of alternative policies and policy instruments required to determine how best to increase domestic rice production (Figure 1-3). In addition to SIEDRA's partial assessment of the land resource base, other agencies must continue to develop information to complement the SIEDRA input. Plant varieties appropriate to each land type within the country must be developed or selected. Additional field research is necessary to develop efficient, labor intensive, and foreign exchange extensive production techniques. Marketing studies are necessary for improving the timeliness and efficiency of production input delivery to the rice farmer and of output purchase, processing, transport, storage, and delivery to consumers. The extension service must be improved in order to assure quicker diffusion of production and marketing information. Land tenancy alternatives must continue to be studied in order to identify arrangements which are technically, economically, and socially feasible and desirable. Domestic consumption studies must be continued in order to interrelate population growth, income and price elasticities, cross elasticities for substitute staple foods, and nutritional considerations. It is necessary to know these interrelationships in order to develop targets for production activities. The research should be carried out with specific consideration for the on-farm, sectoral, and inter-sectoral opportunity costs for input and output use if national rice production economic efficiency is to be maximized.

Finally, this production and consumption information should be used to analyze the Dominican Republic's international comparative advantage in rice production, which analysis in turn should be used in periodic reevaluations of the goals of the national policy of rice self-sufficiency. Though policy decisions will continue to be made whether or not any or all of this information becomes available, the development

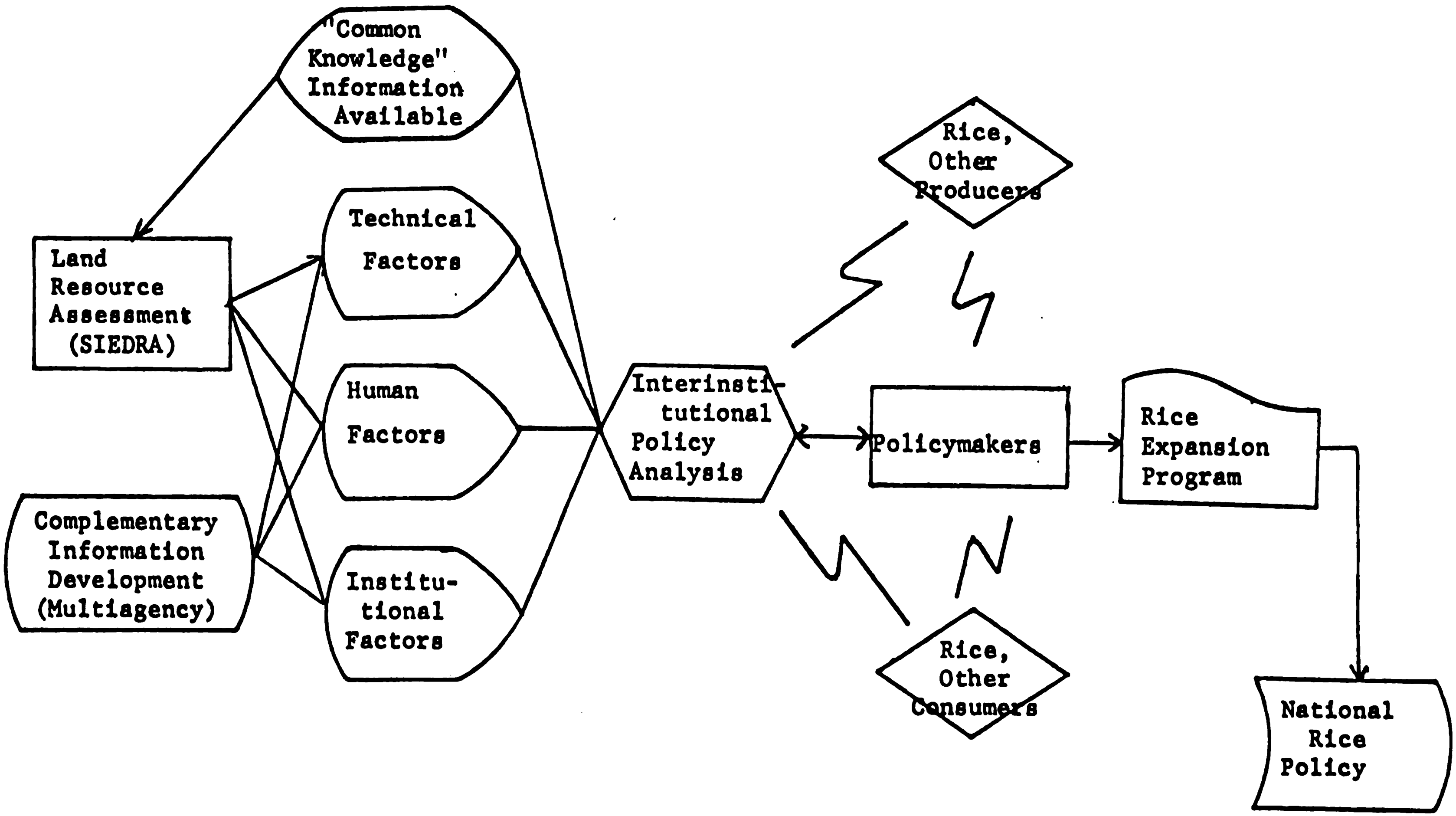


Figure 1-3. Land Resource Assessment as a Single Input Into Rice Policymaking

and periodic updating of the information is crucial to improving the effectiveness and efficiency of the rice policy.

Reader's Guide to the Dissertation

The dissertation is divided into seven chapters plus appended materials. Chapter I, the Introduction, contains a statement of the problem and the background and objectives of the study.

Chapter II provides a general description of the land base of the SEA's administrative Central Region which was analyzed in the study. There is a brief explanation of the CRIES/SIEDRA land classification system and a description of each land unit ("GDSS"), with general information on soils, climate and rainfall, and surface and underground water availability. Land use in the Central Region is described in aggregate terms. There is a section covering the various aspects of rice production and consumption--area, output, irrigation, labor use, imports, and the institutional factors of land tenancy, price controls, and agronomic research. Concluding Chapter II is a similar discussion of the two primary competitors for land suitable for rice production: sugarcane and cultivated pastures.

Economic theory and literature relevant to the study is reviewed in Chapter II, which begins with a discussion of the theoretical framework for analyzing the agroeconomic adaptability of rice plants to their environment and the economics of rice production. There follows a review of significant international and Dominican empirical research and, finally, a section explaining the CRIES/SIEDRA methods used to establish the benchmark land use data with which the study was initiated.

Chapter IV deals with the research methods utilized in the study and begins with an explanation of the overall concept of the research. Data acquisition and refinement into coefficients on which economic analysis was carried out are then discussed. First, the procedure for collection and refinement of the agrophysical data pertaining to rice agronomic requirements for critical soil and water inputs and the availability of those inputs in the Central Region are discussed. Described also are the corresponding rice yields in each land area ("GDSS"). Current GDSS use for the production of rice and its two major land use competitors, sugarcane and cultivated pasture used for milk production, is then covered. Second, the collection and processing of the economic data pertaining to production costs, processing and transportation costs, labor and foreign exchange use, and output prices at the farm gate and import levels are detailed. There is a narrative concerning the application of the national opportunity cost concept to each input and output in order to convert monetary (cash) costs into unsubsidized (national opportunity) costs. Third, there is a discussion of how the agrophysical and economic data were analyzed in order to determine in which GDSSs it would be feasible to produce rice agrophysically and in which of those areas output, monetary and unsubsidized profitability, and labor use could be maximized and foreign exchange use minimized under current normal economic conditions. The chapter closes with a discussion of the means by which selected data uncertainties are tested in the study.

In Chapter V the results of the agrophysical and economic analyses are presented. The GDSSs to which rice is adapted on the basis of agronomic and physical requirements are given, along with the estimates of current rice production area in each GDSS, potential new GDSS area available, number of rice production cycles possible, and expected yields for the current typical and alternative techniques for rice production. Production costs, farm gate income, and resulting returns to land and management (RLM) for the two sets of rice production techniques and for sugarcane and cultivated pastures are given for each GDSS from both the producer's (monetary) and the nation's (unsubsidized) points of view. Labor and foreign exchange use and rice subsidy levels for each production option are presented. Finally, the results of the partial budgeting of the costs, RLM, and labor and foreign exchange use under each of 11 expansion strategies for rice production area are given.

Chapter VI contains a discussion of the implications of the analytical results for addressing the questions relating to regional rice policy which were posed in the first chapter. Consideration is given to the limitations inherent in the data acquisition and analytical methods used in the study. Included is a discussion of methodological modifications needed for a national level land resource assessment for rice production. The chapter closes with a reaffirmation of the need for additional types of information to augment this land resource assessment.

Chapter VII contains a summary of the results of the study. Also, significant conclusions drawn from the study are presented.

CHAPTER II

REGIONAL SETTING OF THE STUDY

The study deals with the SEA administrative Central Region, which has an area of 6,983 km2. The 1970 population was about 1.3 million, almost a quarter of the national total. Included within the boundaries of this region are the country's capital city, Santo Domingo, and two of the principal ports of the country.

Land Resource Base

Land Classification

The land base of the Central Region has been classified according to the CRIES/SIEDRA land classification system (CRIES, 1979b; SIEDRA, 1979a). This system incorporates two interrelated conceptual units: the Resource Planning Unit (RPU) and the Grouping of Dominant Soil Subgroups (GDSS). An RPU is described as follows:

> An RPU is a mappable unit of land relatively homogeneous with respect to climate, vegetation potential, and soil distribution. It is useful for the planning of data collection for national and regional level land use assessment and generally has readily discernible natural boundaries (soils and vegetation types). RPUs commonly consist of contrasting soil bodies, defined elsewhere as GDSSs, that are associated geographically in recognizable and definable patterns.

The RPU is thus a cartographic unit within which GDSSs are identified and is derived by overlaying a climatic zone map on a soils map and delineating each unique soils/climate combination area. A GDSS is described as follows:

> A GDSS is a single, dominant and distinct soil subgroup or a grouping of agronomically similar subgroups relatively homogeneous with respect to climate and vegetation potential. It is characterized by soil parameter values from which predictions can be made about agricultural land use, management practices, and potential levels of production as a basis for national and regional level land resource assessment and agricultural production planning. GDSSs can be represented by single-valued parameter estimates of agricultural factors such as plant adaptability and agronomic input-output coefficients. The GDSSs within individual RPUs are visually distinguishable in the field by agriculturalists on the basis of important agronomic differences such as slope and surface drainage. GDSSs are not mappable nationwide due to limited availability of soils mapping at the individual subgroup level and below, but are identified as percentage components of individual RPUs.

The GDSS is thus the analytical unit which SIEDRA uses for national and regional level resource assessments in the Dominican Republic. Under this classification system the SEA Central Region is composed of 15 RPUs and 29 GDSSs (Figure 2-1 and Table 2-1).

Physiography

Approximately 65 percent of the Central Region is made up of level to rolling plains, the balance being part of the mountainous Cordillera Central. Elevations range from sealevel on the southern Caribbean coastline to almost 2600 m in the northwestern mountains. Most of the agriculturally significant watersheds originate in the western mountains, and all of the region's rivers drain southward into the Caribbean Sea.

Climate

The Central region is located three to four degrees south of the tropic of Cancer. Monthly extreme low and high temperatures typically

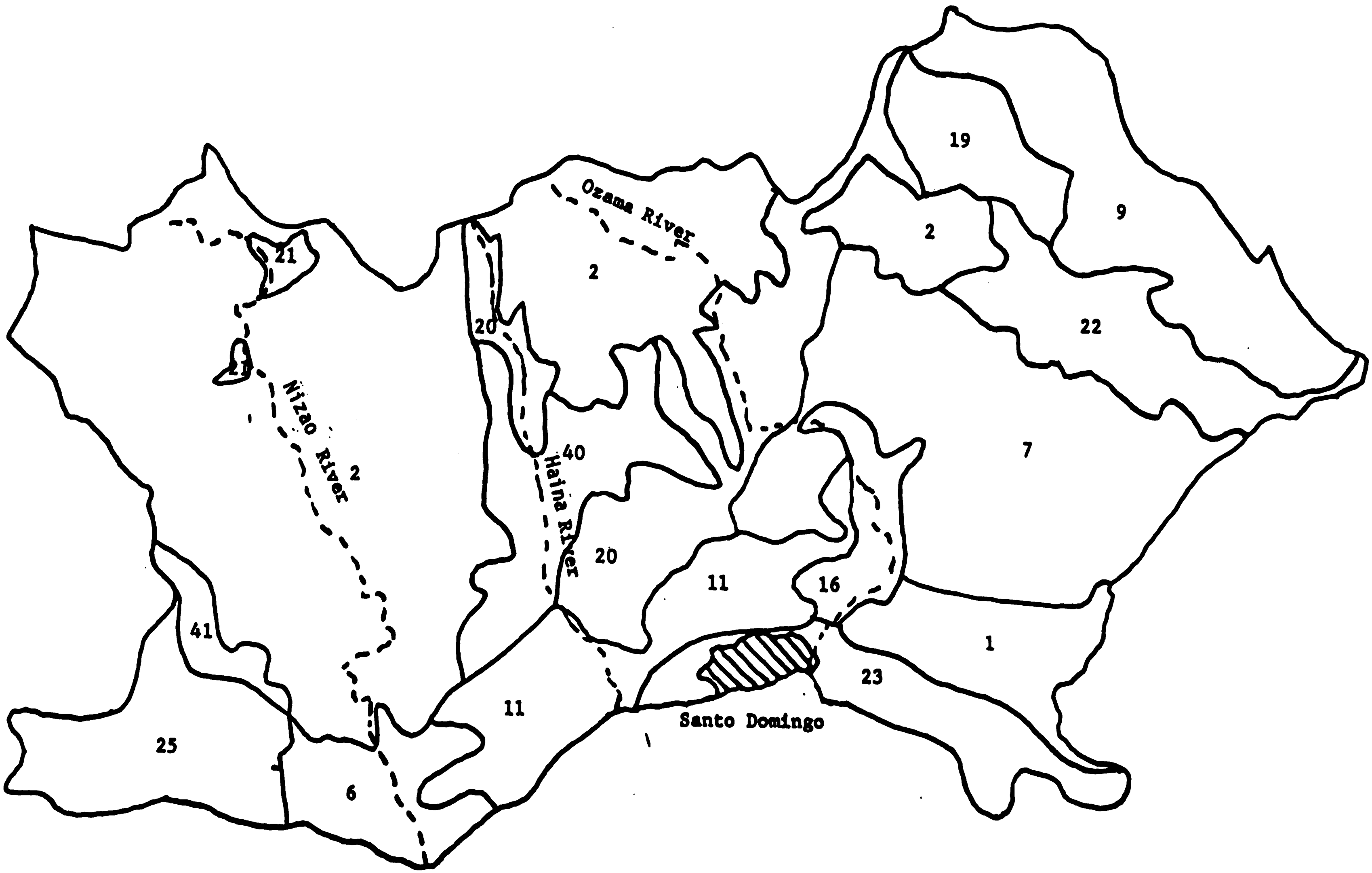


Figure 2-1. Resource Planning Units (RPU) and Major Rivers in the Central Region

Table 2-1. Groupings of Dominant Soil Subgroups (GDSS) in the Central Region, 1979

RPU	GDSS	Major Subgroup	Distinguishing Characteristic	Estimated Area
				(1,000 ta)
01	01A	Typic pellustert	level	240
	01B	Lithic ustropept	hilly	129
02	02A	Lithic dystropept	mountainous	3,020
	02B	Typic dystropept	valleys	1,009
06	06A	Typic pellustert	levels	212
	06B	Lithic ustropept	hilly	141
07	07A	Plinthic tropaquept	poorly drained	855
	07B	Aquic dystropept	well drained	700
09	09A	Lithic eutropept	hilly	676
	09B	Typic eutropept	valleys	255
11	11A	Lithic ustorthent	hilly	46
	11B	Lithic ustropept	valleys	31
16	16A	Aeric fluvaquent	poorly drained	70
	16B	Typic ustifluvent	well drained	129
19	19A	Aquic eutropept	valleys	160
	19B	Lithic eutropept	hilly	131
20	20A	Typic tropudult	undulating	450
	20B	Fluventic dystropept	level	247
21	21A	Aquic dystropept	moderately drained	33
	21B	Fluventic dystropept	well drained	15
22	22A	Aquic dystropept	undulating	242
	22B	Lithic eutropept	hilly	204
23	23A	Lithic ustorthent	shallow	474
25	25A	Typic camborthid	level	227
	25B	Typic camborthid (fans)	hilly	122
40	40A	Typic dystropept	moderately deep	207
	40B	Lithic dystropept	shallow	254
41	41A	Lithic ustropept	hilly	117
	41B	Typic camborthid	undulating	39
Total				11,103

vary from around 15-35 degrees C at the low elevations to 0-25 degrees C in the mountains.

Average annual rainfall varies from about 2000 mm in the northeast to 600 mm in the semi-arid southwest, with monthly peaks in May and October. Annual potential pan evaporation varies from approximately 1500 mm in the southwest to 800 mm in the northeast, with a monthly peak in July (SIEDRA, 1979b).

Soils

Soils characteristics vary widely, with textures ranging from sands to clays, pH from very strongly acid to moderately alkaline, depth from a few mm to over 5 m, and slope from level to over 100 percent. Most plains soils were formed from coral bedrock, while the mountain soils typically were formed from igneous and metamorphic rocks and limestone and shale deposits. There are no volcanic soils in the region nor in the rest of the country. Natural fertility levels vary from very low to moderately high.

Water

In addition to direct rainfall there is surface and underground water available for agricultural production in many parts of the Central Region. There are currently about 43,000 ta under (1 ta - 1/15.9 ha) irrigation in the region. The three major sources of surface water are the Ozama, Nizao, and Haina Rivers (Figure 2-1). The Nizao River is dammed and provides year-round irrigation water except during periods of extreme drought. Underground water currently is used very little for irrigation in the Central Region. The limited hydrogeologic information available on the possibilities of developing further groundwater sources for irrigation in the region indicates high probability of success in several small areas (INDRHI, 1979).

Current Land Use

Recent land use in the Central Region is apportioned approximately as follows: 37 percent for cropland, 22 percent for rangeland and cultivated pastureland, and 13 percent for forestland (CRIES, 1977a). The cropland is devoted largely to sugarcane (60 percent) and to rice (15 percent). Rangeland consists mostly of non-cultivatable former savannahs now dominated by secondary series of brush, grass, and other herbaceous plants, and of dry mountainsides dominated by similar types of vegetation. Cultivated pastureland produces primarily three species of grass forages: guinea (*Panicum maximum* Jacq.), pangola (*Digitaria decumbens* Stent) and African stargrass (*Cynodon plectostachyus* K. Schum.).

Forestland has not been exploited legally for commercial purposes since a 1966 logging ban was imposed, although semi-officially sanctioned "illegal" tree cutting for firewood and charcoal production is widespread. A 1974 FAO study indicates that the major forest species in the Central Region are mahogany (*Swietenia mahogoni* (L.) Jacq.) and Western White Pine (*Pinus occidentalis* Sw.).

The Rice Industry

Rice Consumption

As was noted in Chapter I, Dominican rice consumption has been increasing steadily for over two decades. Annual per capita consumption of rice has increased from less than 0.7 qq (1 qq = 100 lb.) in the mid-1960s to about 1.1 qq in the late 1970s (AID, 1980). By far the largest consumption market in the country is the capital city of Santo Domingo which contains almost 20 and 90 percent, respectively, of the national and regional populations. A 1969 Central Bank survey in Santo Domingo indicated that the average family allocated 10 percent of total food expenditures to rice. The corresponding figure for low income families was 17 percent. Assuming that the Santo Domingo population is representative of Central Region rice consumers, over 90 percent of regional rice production is consumed in this metropolitan area.

Rice Production

Domestic Production and Area

Rice has been produced in the Dominican Republic since before the time of Christopher Columbus' European discovery of the island at the end of the fifteenth century. Commercial rice production, however, began only about 40 years ago (SEA, 1968). In 1977 total commercial white (polished) rice production in the Central Region was approximately 8,200 MT, or 15 percent of the national total. This accounted for about 15 percent of total regional agricultural production value (SEA, 1977a). Although time series data on which to establish trends are highly variable among sources, it is estimated by the World Bank (1978) that national rice production has been increasing annually by about five percent over the past two decades.

Physical area utilized for regional rice production was approximately 51,000 ta in 1977. Over 90 percent of the commercial rice is irrigated, while less than 10 percent of the subsistence rice is produced under irrigation. Nearly 70 percent of the irrigated riceland is double cropped, and about 10 percent produces three crops. Approximately 22 percent of the second and third crops was produced as a volunteer ("ratoon") crop in 1976 (SEA, 1977b). Only about three percent of the riceland is intercropped with one or more additional plant species.

Small farmers with fewer than 80 ta of riceland produce almost 90 percent of the country's rice. A 1972 law called for expropriation of irrigated rice farms of more than 500 ta and resulted in the establishment of 465,000 ta of new collectivized agrarian reform settlements ("asentamientos") with an average family parcel size of 50 ta. The collectivized and single family types of asentamientos are controlled by the Dominican Agrarian Institute (IAD) and currently produce almost half of the country's rice (IAD, 1979). Agrarian reform asentamientos of both types produce approximately 80 percent of the rice crop in the Central Region (SIEDRA, 1979d). While government paternalism and "pork barrel" politics have dominated IAD administration since its inception a half century ago, recent emphasis has been on the fostering of the attitude among reform settlers that they are businessmen operating their own "cooperatives" with reduced government intervention.

Input Use

Irrigated rice paddies are typically quite small and are built with contour ridges, a Chinese innovation unique to the western hemisphere (AID, 1980). These small paddies do not permit the use of large machinery. Land preparation is accomplished by small tractor or draft animal-assisted plowing. Seeds are broadcast by hand on rainfed upland sites. Rice seedlings, of which almost 60 percent were modern varieties in 1976, are hand transplanted from on-farm nurseries to flooded paddies

(SEA, 2979a). Flooding is regulated in order to reduce the need for hand weeding, and insecticides and fungicides usually are applied to assure plant vigor. In 1976 close to 47 percent of rainfed and 94 percent of irrigated rice was fertilized (SEA, 1977a). Harvesting and threshing typically is done by hand.

Thus, rice is a relatively labor intensive crop in the Dominican Republic, requiring approximately 5 man/days/ta annually for production and harvesting. The small farms of fewer than 80 ta use slightly more than average labor, with about 40 percent of it provided by the family. On large, multiple product farms of more than 560 ta only about four percent of the labor is provided by the producer's family (SEA, 1977b).

Credit is provided for rice production primarily through the government's Agricultural Bank (BAGRICOLA). Interest rates are fixed at 9 and 11 percent, respectively, for loans of less than and more than RD$2,000. This rate differential ostensibly was established to benefit small producers. The legal maximum nominal rate of interest chargeable is 12 percent. In recent years BAGRICOLA has been increasing its lending to rice producers, with around 70 percent of its food crop loans going into rice credit in 1978. Repayment for agrarian reform asentamientos have been about 75 and 100 percent, respectively, for individual family and collective farm loans (AID, 1980).

Rice Imports

Commercial rice has been imported annually since 1971, reaching a high of over 70,000 MT in 1974. The 1980 figure is expected to be at least 45,000 MT and could go as high as 90,000 MT. Import prices peaked in 1974 at US$576 per MT, and the 1980 prices are expected to be about

US$450 per MT. Foreign exchange use for rice imports was US$40 million in 1974 and is expected to reach US$19-38 million in 1980 (INESPRE, 1980). These figures represent, respectively, about 25 and 15 percent of total national commercial rice retail value.

The National Price Stabilization Institute (INESPRE) controls all rice importation and coordinates it with its public food marketing and price control policies. All of the rice imports come from the United States. There have been no PL-480 rice shipments to the Dominican Republic to date (Agricultural Attache, 1980).

Rice Marketing

Many aspects of rice marketing are controlled by INESPRE. Since 1974 INESPRE has functioned, as a result of private trade speculation during a period of rice shortages that year, as the monopsony buyer of milled rice from the millers. It also controls rice imports and operates a number of grain silos and warehouses. INESPRE has bought almost 90 percent of market rice production in recent years.

There are over 100 rice mills of various sizes in the country, with an estimated annual milling capacity of 275,000 MT. Five of the larger mills are located in the Central Region. In general the mills produce good to high quality rice with a relatively low percentage of broken grain. Although the mills operate most of the year, their major Central Region processing load comes during the primary harvest period between August and January. Purchasing of rough rice at the farm, except in the case of large growers and IAD asientamientos, is handled by private intermediaries who deliver the rice to mills. Small farmers frequently complain about being cheated by the buyers on moisture content and grading, and several compesino groups have responded by building and managing their own rice mills. Most of these efforts have ended in failure due to lack of adequate management skills and to underestimation of mill operating costs.

Rice Agronomic Research

Rice agronomic research is carried out primarily at the Juma Experiment Station located about 10 km north of the Central Region's northern boundary. Recent research has concentrated on the selection of irrigated varieties of rice adaptable to labor intensive agronomic practices on small farms. Testing of rainfed varieties began in late 1979 (Juma, 1979). To date there has been relatively little use made of research results by the national extension service (Drilon, 1977).

The Sugar Industry

Sugar plays a dominant role in the Dominican agricultural sector and in the national economy. In recent years taxes on sugar exports have accounted for nearly 20 percent of the central government's total current revenues. Sugarcane occupies about 12 percent of national cultivated area and generates about 50 percent (US$100 million) of total exports. In the Central Region sugarcane occupies about 60 percent of cultivated land and accounts for nearly 70 percent of agricultural production value. The industry provides direct employment for an estimated 80,000 workers in production and processing and provides additional indirect employment through input marketing and related services (World Bank, 1979). About 65 percent of all sugarcane is produced on land owned by the State Sugar Council (CEA); the balance is produced on private lands owned by the Dominican Vicini family and the US-based multinational Gulf and Western Corporation.

Annual raw sugar production has averaged about 1.2 million MT in recent years, up only slightly from the 1960 average of 1.0 million MT. Average sugarcane yield declined by nearly 5 percent annually from 1963 to 1975. It has reportedly averaged about 3.8 MT per ta harvested since that time. Due to the use of low cost Haitian labor for hand harvesting of cane, Dominican sugarcane production is more labor intensive than in most other Latin American sugar producing countries. Hand harvesting also results in lower trash content and higher sucrose content than that of machine harvested cane (Bookers, 1975).

In recent years a growing portion of cultivated area has not been harvested because of limited processing capacity. Under normal conditions and full utilization of present milling capacity, CEA and private sugar factories can produce about 1.3 million MT of raw sugar annually. A 1979 World Bank loan is being used to finance an increase of CEA milling capacity from 0.8 million MT to 1.2 million MT.

Approximately 14 percent of the annual sugar production goes into domestic consumption. In addition, dried cane pulp and molasses are consumed domestically, to a limited extent, by the CEA and by livestock producers. Domestic refined sugar prices are controlled by INESPRE.

Sugar exports increased by about one percent annually between 1960 and 1978. Exports have averaged just under 1.0 million MT in recent years, marketed primarily under the International Sugar Agreement. The US bought as much as 93 percent of Dominican sugar exports in the late 1960s, but its market share declined to about 75 percent in the late 1970s. The Dominican Republic recently has diversified its export markets to include Italy, Iran, Portugal, Sweden, and Venezuela.

The Cultivated Pasture/Milk Industry

In 1976 the SEA estimated that approximately 59 percent of the milk produced in the Dominican Republic was consumed as fresh milk, 18 percent was pasteurized, 10 percent was used for cheese and butter, and the remainder was fed to livestock or was discarded as spoiled. Producers sold 65 percent of their marketed milk to wholesalers or retailers, 19 percent to milk processors, 10 percent directly to consumers and retailers, and the remaining 6 percent was sold to the Public Nutrition Program or processed on farm. There is currently a strong trend toward increased sales to pasteurizing plants (Associacion, 1979).

The typical dairy herd produces around 275,000 lt of fresh milk annually. In recent years the number of milk cows with high genetic production potential has been increasing very slowly. Most milk cows do not produce at or near their potential due to poor herd and pasture management, unfavorable input-output ratios, and unfavorable climate.

As a result, production of milk has been increasing at a slow rate for over a decade. Total milk production was 246 million lt in 1960 and about 383 million lt in 1976, an average annual increase of around 3 percent. Based on this trend, milk production is estimated at 415 million lt for 1980 and 500 million lt for 1990.

There were eleven major milk processing plants in the country in 1977, of which four were not in operation. The plants in operation were being utilized at 35 to 90 percent of capacity. Milk processors claim there is adequate demand to allow fuller utilization of capacity if greater supplies were made available.

Current information on imports of powdered milk and processed milk products is very limited. The SEA (1977a) estimated that during the early 1970s approximately 20 to 25 percent of total milk consumed was imported. The value of dairy imports in 1977 was US$1.5 million and consisted largely of 3.2 million kg of powdered milk. Trends indicate that at least 20 percent of total milk consumption will continue to be imported during the 1980s.

INESPRE controls retail milk prices and has kept them low in recent years, ostensibly to protect low income families. Many producers have abandoned dairy farming due to unprofitability, and others claim that the unfavorable price-cost ratios have not allowed them to invest in productivity-increasing inputs. As a result of lobbying efforts by milk producers, INESPRE in late 1979 announced a 30 percent increase in the retail milk price. It also took two additional steps aimed at benefiting low income consumers and at reducing the production-depressing effects of continued imports of powdered milk which were being dumped by exporting countries at less than their costs of production. The first step was to make available at low cost to low income consumers a low fat blend of fresh and reconstituted milk, and the second was to place the importation of powdered milk under the control of INESPRE, which was directed to coordinate the imports with its coverall programs of marketing and price control.

CHAPTER III

REVIEW OF RELEVANT ECONOMIC THEORY AND LITERATURE

Theoretical Framework

There are two bodies of theory of primary relevance to this study: agronomic theory having to do with the plant's adaptability to specific environments and economic theory dealing with the difference between monetary (producer) and unsubsidized (national) benefit-cost analysis and its implications for resource allocation. These theoretical considerations are incorporated in the selection of methods in Chapter IV and in the discussion of study results in Chapter VI.

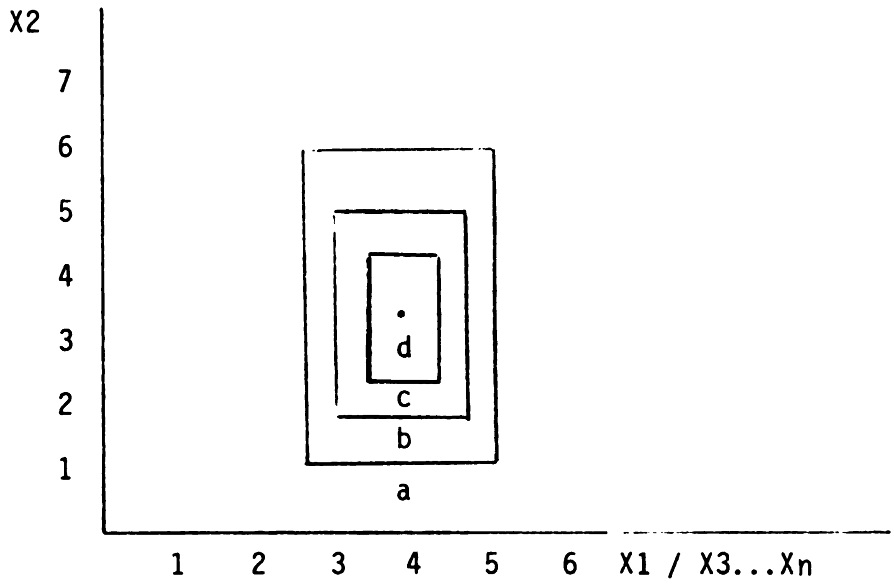
Agronomic Theory

Individual plant varieties have genetically determined physiological input requirements for normal growth and development. Within specific ranges of tolerance for input levels above and below the normal requirements, a plant will grow but will exhibit abnormal growth habits. Outside of these tolerance ranges, plants cannot grow and reproduce (Evans, 1963). The tolerance ranges, together with the corresponding ecological characteristics of the environment, determine the natural distribution of a plant (Holdridge, 1968; Odum, 1971). The major environmental characteristics affecting the natural geographic distribution of plants are photoperiod, temperature, percipitation, evapotranspiration, and soil. Man's manipulation, either consciously or unconsciously, of these physical variables can alter natural plant distribution significantly (Weaver, *et al.*, 1939).

A concept which has been used widely for analyzing plant geographic adaptability is that of "limiting factors" (Odum, 1971). Limiting factors are those inputs necessary to a plant's growth but which are available in quantities falling outside of the plant's tolerance ranges and thus do not permit the plant's growth in a given area. The concept of limiting factors is based on two ecological "laws": Shelford's (1913) Law of Tolerance and Leibig's (1840) earlier Law of the Minimum. Leibig's theory, as expanded by later researchers, states that plant growth is controlled by the physiological input available to it in minimum quantity. Shelford's theory recognized both that too much as well as too little of an input factor and that interaction can affect a plant's tolerance ranges for specific inputs. In production function terms, Leibig's theory assumed perfect complementarity of inputs while Shelford's theory allowed for changing rates of substitutability among inputs and a "Stage III" of the production function (see discussion of stages of production later in this chapter). Limiting factors are those inputs necessary to a plant's growth but which are available in quantities falling outside of the plant's tolerance ranges and thus do not permit the plant's growth in a given area.

The concept of limiting factors is illustrated graphically in the hypothetical response surface in Figure 3-1. In the figure the isoquants represent plant seed production with two variable inputs where: d c b a = 0. Under the assumption of no factor interaction, the isoquants are rectangular. For plant A, the ranges of tolerance for

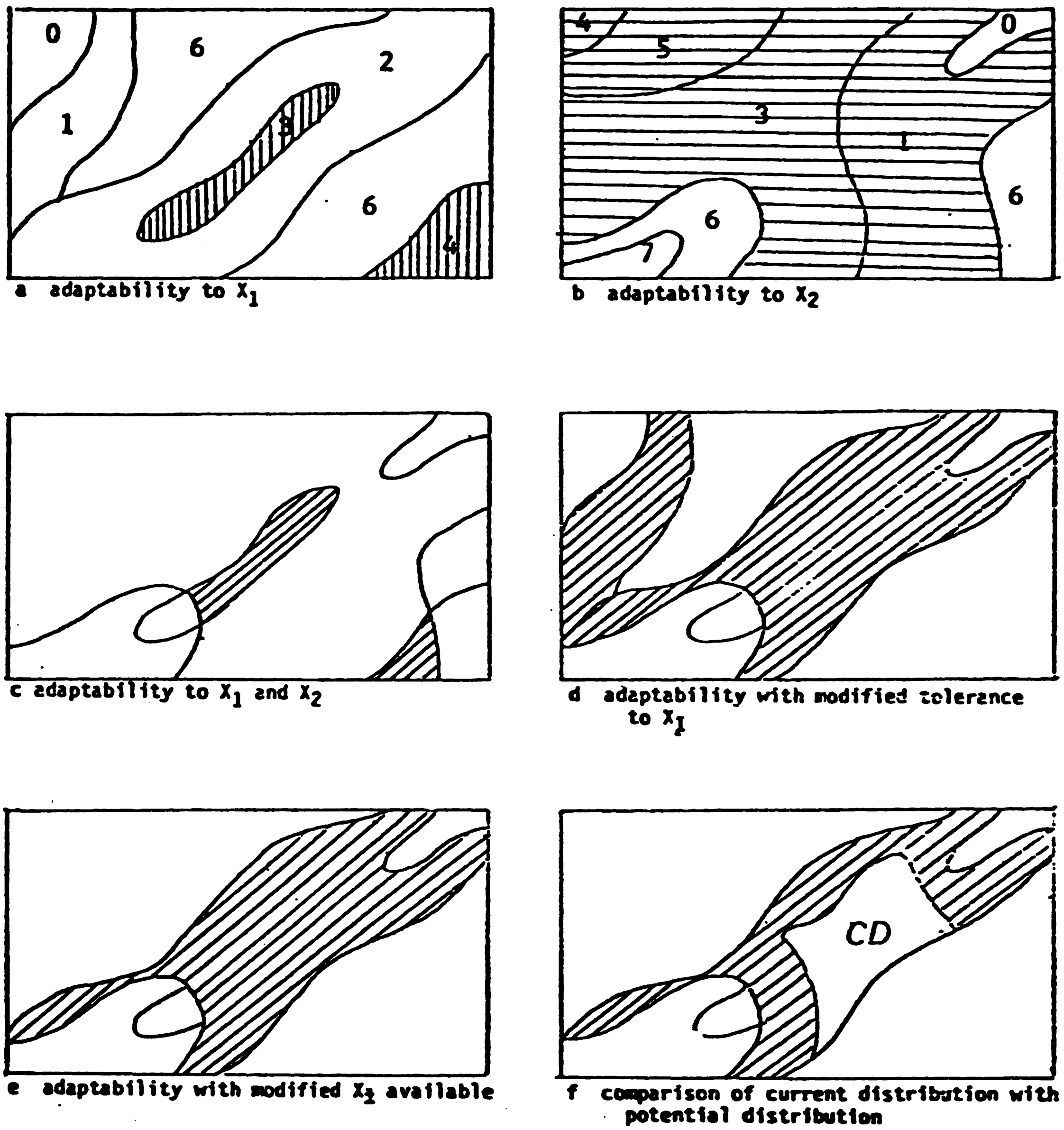
Figure 3-1. Seed Production Response Surface with Two Variable Inputs and the Plant's Tolerance Limits (isoquant a = 0) for the Inputs with No Factor Interaction



inputs X1 and X2 are 3-5 and 1-6 units, respectively. Thus, if plant A were grown in an environment which contained 9 units of X1 and 2 units of X2, the plant would produce no seed, and X2 would be the limiting factor. Along the vertical and horizontal axes of the isoquants the two inputs are perfectly complementary. With Shelford's factor interaction the isoquants would be rounded at the corners as the inputs become imperfect substitutes and as diminishing marginal physical output reduces the tolerable input levels from the plant's tolerance extremes.

The application of these principles to the spatial distribution of plant A is displayed in Figure 3-2. The base map in Figure 3-2a is a map of the soils containing X1 at levels of 0-6 units per unit area. The darkened areas are those areas which have the required 3-5 units of X1 for seed production on plant A. Figure 3-2b indicates soils with

Figure 3-2. Geographic Distribution of Plant A Under Various Assumptions on Tolerance Ranges and Environmental Characteristics



0-6 units of X2. Figure 3-2c is an overlay of the X2 map on the X1 map and indicates the area to which plant A is adapted on the basis of both factors X1 and X2, assuming no factor interaction. With factor interaction the resulting adaptable area in Figure 3-2c would be reduced slightly depending on the marginal rates of substitution between X1 and X2.

This potential distribution of plant A could be modified by man through breeding to select or create genetic varieties with different tolerance limits for specific environmental factors. For example, if a variety of plant A could be selected which could tolerate 1-4 units of X1 and the same amounts of X2, with no factor interaction its potential distribution would appear as in Figure 3-2d. Similarly, the potential distribution of plant A could be modified through environmental modification to adjust the levels of X1 and X2 available to plant A. As an example, if the same geographic area as represented in Figure 3-2c had 1 unit of X1 applied to it uniformly, the potential distribution of plant A would appear as in Figure 3-2e. Again, factor interactions would modify the results.

These principles for determining potential plant geographic distribution have been used to identify areas to which plant species and varieties are adapted but in which they are not currently being produced (Burton, 1968; Kemph, 1973, 1975; Klages, 1942). The reasoning is as follows: if plant A's potential distribution based on inputs X1 and X2 were as in Figure 3-2e, but its current distribution as in the area marked "CD" in Figure 3-2f, then the area that could be considered for expanding plant A's current distribution would be represented by the darkened areas in Figure 3-2f. Factors besides X1 and X2 (i.e., X3...

Xn) which may be limiting to the growth of plant A must be taken into consideration in analyzing current and potential geographic distribution. A current distribution as in Figure 6f may indicate that factors other than X1 or X2 are in fact limiting to plant A's distribution. This would be the case, for example, if an area's soil and water inputs were within a plant's tolerance limits, but no plants were growing there because of biological factors such as insect infestations or weed competition or because of economic factors such as unprofitable input-output price ratios or an unfavorable land tenancy situation.

Economic Theory

Five concepts from the theory of production economics are particularly relevant to this study: (a) efficiency, (b) resource valuation, (c) multiple production goals, (d) stages of production, and (e) input substitution. Each is discussed below.

Efficiency

For the purposes of this study, efficiency is defined as the maximization of the difference between utility and disutility. Utility in turn is defined as the satisfaction of human wants and needs. If utility were measurable in units of common denomination which were comparable among economic agents, efficiency would be attained by simply maximizing the difference between the utility people derive and the utility they give up from alternative actions. However, there is no widely accepted interpersonally comparable common denominator for utility, and actions which provide utility for some people while taking utility from others cannot be analyzed quantitatively from the efficiency standpoint without first defining the utility measure to be used in the analysis.

In a market economy with a given pattern of resource ownership and where economic agents have perfect knowledge and foresight and are free to buy and sell goods and services, prices represent the marginal utility that buyers and sellers receive from trading these commodities. These market prices also represent the marginal utility that a nation derives from the commodity trading. Under these conditions, efficiency in an activity would be attained by maximizing the net income derived from an activity. In an agricultural production activity efficiency would be attained by maximizing the difference between total income and total costs--profit maximization.

Efficient resource allocation on a single-product farm requires that production inputs be allocated such that ratios of the marginal value of the last unit of output (marginal value product, MVP) to the marginal cost of each input used in its production (marginal factor cost, MFC) be equal. For multiple product farms these ratios must be equal among products. Profit maximization takes place where the ratios are all equal to one. If a ratio does not equal one, resource allocation can be adjusted to increase output for a given quantity of inputs. A ratio of greater than one would indicate that production should be expanded to increase profits, while a ratio of less than one would indicate that production should be contracted. For example, if the MVP/MFC ratios for rice and sugarcane were 1.2 and 0.6, respectively, profits could be increased by reallocating sugarcane production resources to rice production. In the long run when all inputs are adjusted to their optimum levels, marginal and average value products and factor costs are all equal for each input, and profit is maximized at zero.

Under conditions of imperfect knowledge and foresight a producer cannot be certain of profit maximization. He must choose a production decision rule which accounts for his inability to know with certainty the outcome of his production activities. In theory, many decision rules are possible, including maximization of expected profits, maximization of the probability of some specific minimum level of income, or the outcome of a coin toss. The rule chosen by each producer depends on his personal and family values and goals and on his aversion to risk. Empirical research indicates, however, that a decision rule of maximization of expected net income typically is used by agricultural producers in production decisionmaking. Consumption values and goals on family farms are discussed in the next section.

Multiple Production Goals and Values

Under conditions of uncertainty a producer may be unsure of the decision rule to use in his search for production efficiency. Maximization of expected profits may be his overall goal, but only to the extent that it is compatible with his other goals such as sufficient leisure time to spend with his family and with values such as the pride and security of owning a new pair of hogs. Until he has a good idea as to the positive and normative implications of the application of each decision rule for each of his goals and values, the producer may be indecisive and inefficient in his actions. For instance, a rice producer would be reluctant to buy a new herbicide without knowing its probable impacts on production costs and output. On small farms where the family is both a producing and consuming unit, production decisions are influenced by family consumption goals and values. For example, profit maximization in production is constrained by often uncertain family consumption needs such as medical care, church contributions, and vacations. A producer on a family farm typically has to reduce his production investment level in order to accommodate family consumption goals. As positive and normative information on these factors becomes available, uncertainty is reduced and the producer can make his decisions with more confidence in the probable outcomes.

When the production decisionmaking unit is a region or a country made up of many individual producers the selection and application of an efficiency decision rule is an even more complicated process than for an individual producer. Many of the factors which are exogenous to the individual producer are endogenous at the higher decisionmaking levels. Taxes and subsidies, foreign exchange rates, interest rates, and domestic commodity prices can all be altered by the national government while, in the absence of monopoly/oligopoly, an individual producer cannot affect these variables. The government must try to satisfy many people, each of whom has his own set of values and goals. Choice of a decision rule which will satisfy one group of people may cause the rest of the people to protest, go on strike, or even to revolt violently against the government. For example, an agricultural minister might be hesitant to endorse a mechanized harvest project without first obtaining information on its probable output, employment, and foreign exchange implications. Yet a government is forced to make many sensitive decisions on a daily basis. This normally is a matter of whether the decisions are implicit or explicit, not whether they are to be made.

A further uncertainty faced by a regional/national government is that of not being able to measure utility on an interpersonally valid basis. If that were possible the government could simply inform its citizens of the aggregate utility and disutility associated with each decision and, as long as the people accepted the decision rule, the decisions would be accepted. However, in the absence of an interpersonally valid utility measure, the best a government can hope for is to estimate and publicize the positive and normative tradeoffs related to each decision alternative and then to apply a decision rule accepted by its people. A government cannot sum the individually derived utilities and disutilities associated with, for example, an expansion of rice production areas and then simply apply a decision rule to determine whether the expansion meets the necessary conditions for efficiency (the sufficient condition being the specific expansion plan chosen provided the highest utility possible for the associated disutility or that the lowest possible disutility would be required to obtain a specified utility level). Yet, a government can estimate the expected impacts over time ("simulation") of a decision on relevant performance variables (e.g., rice production, farmer profit, national profit, employment levels, foreign exchange use) and gradually reduce the uncertainties in the positive and normative information base to the point necessary to reach a decision through application of a generally accepted decision rule.

Efficient development of the information requires that it be collected to the point where the expected marginal cost of each item of information is equal to its expected marginal value in decisionmaking. Expected monetary costs (e.g., human resources, vehicles, data processing) may be relatively easy to estimate, but non-monetary costs (opportunity costs) and expected values are more difficult to evaluate.

Information developed for a specific decision may be valuable in making other current or future decisions not originally anticipated. The value of each bit of information also will vary among decisionmakers with different degrees of management capabilities. Thus, for example, soils information developed for rice production purposes may turn out to be of little value to a mediocre decisionmaker in the rice industry and yet be very valuable to a more competent rice producer or sugarcane producer or rancher. Multidisciplinary professional judgement is required to make reasonable estimates of the expected costs and benefits of information development for analysis of multiple production goals and values.

Resource Valuation

Once a decision rule has been selected for determining production efficiency, a decisionmaker is faced with the task of determining the corresponding values of the inputs used and the outputs expected to be produced in the production activity. This valuation is required whether the decisionmaker is an individual farmer or a national agricultural minister, and it involves both monetary and non-monetary values. For an individual producer in a market economy the input and output values for traded goods are the prices determined by the supply and demand conditions in each market. For non-traded goods and intermediate products the values are determined by estimating the income which those goods could produce in their most profitable alternative use ("opportunity cost"). In the absence of imperfect competition, no producer can affect input or output market prices through his own activities in the markets. He faces perfectly elastic supply curves for inputs and demand curves for his products.

With government intervention in market economies, prices may be altered by taxation or subsidization of input or output prices. When taxes are levied on goods and services, income is transferred from those who pay the taxes to the recipients of the tax revenues. Subsidies represent income transfers from taxpayers to those who buy subsidized products. In resource valuation an individual producer does not concern himself with permanent taxes or subsidies per se. Rather, he takes the government-altered prices as given and proceeds to allocate his resources according to his efficiency decision criterion.

A government, on the other hand, concerns itself with taxes and subsidies and their impacts on production and consumption relations. Relative prices changes for inputs and outputs have both substitution and output/income effects which alter resource use and product consumption patterns. In order for a government to analyze the impacts of its tax and subsidy policies on agricultural production and, hence, on tax revenue generation, it needs information on probable resource allocation patterns in the absence of the tariffs. Then a comparison between the estimated "with" and "without" production coefficients would form the basis for a rational decision as to the desirability of the contemplated price alterations.

Stages of Production

Given the law of diminishing returns, efficient (in the profit maximizing sense) production will take place at the point where the cost of an additional unit of input is just covered by the income derived from the sale of the resulting increase in output. In economic terms the marginal factor cost (MFC) is equal to the marginal value product

(MVP) at the profit maximizing output level on the value product function.

The law of diminishing returns indicates further that a typical value product function can be divided into three sections or "stages" defined by the relationship between MVP and AVP (average value product). Stage I encompasses the area between minimum output and the point where MVP = AVP; Stage III lies between the points at which MVP = 0 and AVP = 0; while Stage II covers the area between Stages I and III. Under the static assumptions of profit maximization with perfect knowledge and foresight, and assuming that neither inputs nor outputs are free, production in Stages I and III is irrational because the producer can increase his profit by either increasing or decreasing, respectively, his input utilization in those stages. Rational production takes place only in Stage II, and profit is maximized in Stage II at the point where MFC = MVP. A number of special cases of the law of diminishing returns which involve the fixing of input levels of substitutable or complementary inputs are possible, many of which result in extreme cases of the production relations discussed here.

In reality uncertainty is the norm in agricultural production and rational production in Stages I and III is possible. For example, production in Stage III for water use would take place if a rice farmer initially flooded his paddies with adequate water for optimum plant-water relations with normal rainfall, then was inundated by a heavy rainfall of 50 year frequency (i.e., hurricane). Given the multitude of uncertainties affecting yields and prices, it is not realistic to assume that all production takes place in Stage II. Rather, for analysis of actual production alternatives it is necessary to establish empirically the ranges of utilization of physical inputs and outputs and their associated prices under expected physical (e.g., rainfall) and economic (e.g., income distribution) conditions for the time period of interest.

Input Substitution

The least cost combination (LCC) of inputs on a continuous function is found where the marginal rates of physical substitution (MRS) among inputs is equal to their price ratios. For each level of input expenditure there is a corresponding LCC, and the locus of points formed by LCCs over a range of expenditures is referred to as the line of least cost combinations (LLCC). The profit maximizing point (PMP) on the LLCC is where the ratios of MVP to input cost for each input is equal to one. A change in input prices will cause a shift in the LLCC and, therefore, in the PMP. The input combination would shift toward the relatively cheaper input. Thus, for example, government subsidization of the foreign exchange rate would make imported inputs cheaper relative to domestic inputs such as labor and would cause static profit maximizing producers to substitute imports for domestic inputs.

With uncertainty, it cannot be asserted that producers operate at the PMP or on the LLCC. Even assuming that the producer's ex ante estimates indicated production at the PMP, changes in physical, biological, and economic conditions during the production cycle invariably lead to inefficient production off of the PMP (due to the fixing of input use at unexpected levels) when viewed ex post. Thus, assuming a profit maximizing motive under conditions of uncertainty, production typically can be characterized as taking place on a subfunction of the production function. To the extent that production on subfunctions is widespread, the implication is that programs which reduce uncertainty in a producer's search for the PMP will increase production efficiency. Well designed and implemented programs in the areas of research, extension, and education can be expected to help producers to produce more consistently at or near the PMP.

Once the actual production function parameters for each production unit under study are estimated and assumptions (projections) are made as to their probable behavior during the relevant time frame, it is possible to estimate the impacts on input use of increases in future production levels. Increased production could be effected through an increase in the productivity of current areas, through an expansion of current areas, or through a combination of the two. Assuming that current producers are motivated by a desire to maximize profits and that current relative prices of inputs and outputs are constant, geographic areas should not be expected to change their output except in the long term as a result of technological changes or resource deterioration. Increased production in the shorter term would have to come from expansion of current areas and, in the absence of suitable unused land (zero opportunity cost), would require the cessation of existing production activities in the proposed expansion areas. The national opportunity (real economic) cost of the new land would be the net income foregone in shifting to the new land use. The opportunity cost principle is equally applicable to other inputs which must be bid away from current activities in order to be incorporated into a new production activity.

Rice Adaptability Research

International Studies

In the early 1970s, as part of a national policy of self-sufficiency in rice production, Korea carried out a study of its land base in order to identify areas suitable for producing a new modern variety of rice Shin, 1978). Agronomic requirements for the plant were determined from experiment station field trials which indicated that highly fertile and moderately well drained soils were needed. These requirements were crosstabulated with the technical soils descriptions developed for a reconnaissance level national soils map, and priority areas for rice expansion were designated. The resulting agrophysical adaptability information then was disseminated through extension agents who were given specialized shortcourses in identifying and developing suitable land areas. The author gives no indication that either water availability or economic factors were studied ex ante, though ex post evaluations indicated that farmers' incomes increased by over 45 percent after adopting the new variety.

Suryatna, et al., (1979) reported a study of the Indonesian land base in 1974, the purpose of which was to identify areas suitable for future expansion of irrigated and dryland rice production. Agronomic requirements were determined from experiment station field trials. These requirements were matched with a national soils map, and a land capability classification was established which indicated soils capabilities and limitations for rice production in each suitable map unit. The authors give no indication of explicit consideration of economic factors or of utilization of the study results by policymakers.

Somasiri, et al., (1979) reviewed Sri Lanka's national land classification and rice adaptability studies carried out under the government's long standing policy of elimination of rice imports. A regional study of land areas suitable for rice production was discussed in detail. The investigation initially used a combination of detailed field-verified soils and climatic data to classify the regional land base, then shifted to more aggregated data when costs of the detailed data proved to be prohibitive. In the modified system, visually identifiable land characteristics and aerial photographs were relied on more heavily than was originally planned for classifying the land base. The authors report that the modified riceland classification system was easily understood and used by the local extension service. No rice production economic information was reported to have been incorporated in the study.

Winch (1976) studied rice area expansion for rice self-sufficiency in northern Ghana. He placed heavy emphasis on economic factors but dealt superficially with agrophysical factors. The land base was divided into "upland" and "bottomland", with an additional subdivision based on water availability. Static economic benefit-cost and partial budgeting analyses were conducted on data derived from a rice farm survey. Producer and national ("financial and economic") input and output prices were estimated. The impacts of machinery and fertilizer subsidies on production, employment, and profitability in each of the land strata were analyzed. On the basis of the study results, the author recommended that the government eliminate subsidies because of their adverse effects on employment and on regional production efficiency.

Domestic Studies

Little domestic work has been done on determining combined agrophysical suitability and economic feasibility of individual plant species in the Dominican Republic. No work of this type has been published specifically for rice.

An FAO (1974a) study of part of the northern Cibao Valley used a land classification system based on climate, water quality, soils characteristics, and benefit-cost analysis to establish priority production zones for major area crops. Lack of documentation of methods and data sources severely limited the credibility and utilization of the report.

National tobacco production was studied recently in the Dominican Republic (INTABACO, 1978). Emphasis was placed on varietal differences in agronomic requirements. Economic factors and geographic distribution of the currently used soils and water resources were discussed only briefly. No consideration was given to identifying new areas with tobacco production potential.

Kenah (1980), using CRIES/SIEDRA land base descriptions, studied the agrophysical adaptability of lime trees to the southcentral part of the country. Lime tree agrophysical requirements were matched with the land unit descriptions in order to identify areas with lime production potential. The author compared his results to 1970 farm census data in order to identify areas with lime production potential but with little or no 1970 production reported. He also noted areas which reported high total production but which did not have high productivity according to his analysis, and he recommended that these areas gradually be shifted over to more productive species. No economic analysis was conducted.

In 1972 Murphrey qualitatively analyzed the national riceland soils and climatic characteristics. He used those characteristics to identify similar regions in the country and reported several possible new areas for rice production. Economic factors were not considered and no mention was made of proposed use of the study results.

Development of CRIES/SIEDRA Data Base

As mentioned in Chapter I, the CRIES project began in 1976 with the purposes of: (a) improving USDA capability to analyze current and potential food and fiber production in developing countries, and (b) internalizing in developing countries the capability for land use data base development and analysis (CRIES, 1976). Implementation of the project was designed to take place in two phases. Phase I was the one-year US-based development, using secondary information sources, of a first generation consistent national data set, economic analysis model, and geoprocessing program (CRIES, 1977b; 1977c; 1977d). Phase II was carried out in the Dominican Republic for two years (since extended to three years at SEA request). This Resident advisor management phase of the project consisted of the transfer, adaptation, and improvement of the first generation CRIES data set and methods by a local counterpart staff ("SIEDRA").

Phase I preliminary analytical units were the Resource Planning Units (RPUs), originally defined as follows (CRIES, 1977a):

> An RPU is specifically defined as a unit of land with components sufficiently homogeneous with respect to agrophysical factors of soil, climate, and water resources to be depicted by single estimates of agricultural factors such as crop adaptability and input-output coefficients.

Early Phase II attempts at field verification of production coefficients met with opposition from agriculturalists who criticized the project for referring to the RPU as a homogeneous unit to which single valued input-output coefficients could be assigned, when in the field one could typically note, for example, that both hills and valleys with large differences in agricultural production potential were lumped within a single RPU boundary.

The CRIES resident manager, after studying the problem and discussing it with a CRIES soils consultant, decided that the grouping of the agronomically similar dominant phases of soil taxonomic subgroups within each RPU would capture the major differences noted in field observation (USDA, 1976). Given the expectation that SIEDRA would have to rely on non-soils trained field technicians for production coefficient estimates, the major soil subgroups within each RPU were grouped on the basis of visibly identifiable characteristics (SIEDRA, 1978). The new analytical units are referred to as Groupings of Dominant Soil Subgroups (GDSS) and are identified as unmapped percentages of each RPU map unit.

Once the analytical units were modified, a program was developed to field verify RPU mapping and GDSS descriptions and to obtain current normal estimates of land use, production techniques, yields, costs, and other coefficients for agricultural land use analysis. Field verification of the RPU map and GDSS descriptions was begun in June, 1978, in the SEA Central Region and resulted in the modification of the original map by the inclusion of two new RPUs.

It was decided, based on both US experience and a lack of funds for a farm level SIEDRA land use survey, to interview regional level SEA agricultural specialists in order to obtain judgmental estimates of needed coefficients. In each of the SEA regional offices there are two types of specialists: subregional geographic experts who are responsible for all agricultural production within their areas and individual product experts who are responsible for all geographic areas in which their particular product grows. These technicians were believed by the SIEDRA staff to be the best available source of data in the absence of a farm level land use survey.

Questionnaires and explanatory documents were developed for collecting crop yield estimates by GDSS and were field tested in July, 1978. Based on this pretest, the original questionnaires and supporting documents were modified and expanded to include limited information on pasture, range, and forest land use. In December, 1978, after brief training on interview techniques, SIEDRA personnel conducted interviews of Central Region SEA personnel and collected preliminary estimates of typical ("current normal") product yields, area, intercropping combinations, and production budgets for the major crops (excluding, for political reasons, sugarcane and cultivated pasture) for irrigated and non-irrigated GDSSs (Niehaus, 1978; SIEDRA, 1979c). The Central Region was selected for preliminary interviews because of its proximity to Santo Domingo. This permitted relatively inexpensive followup interviews to fill data gaps resulting from initial lack of SIEDRA interview and data base development experience.

Central Region interview results were checked for completeness and consistency, and followup interviews to complete the estimates were conducted in early January, 1979. Interview results were compared with original CRIES estimates and with the most comparable published SEA estimates in order to determine the reliability of each source of data

(SIEDRA, 1979d). The SIEDRA regional interview results were judged to be of acceptable accuracy for CRIES/SIEDRA purposes, and interviews in the other six SEA regions were planned for the 1979-80 period.

Chapter III's Relation to the Dissertation

In this chapter, agronomic and economic theories relevant to the proposed rice production study were reviewed. A sample of related international and Dominican empirical research was then discussed. This information will be used in the following chapter to establish a methodology for the agroeconomic analysis and in Chapter VI to assist in the interpretation of the analytical results.

CHAPTER IV

RESEARCH METHODS

Concept

The overall procedure of this study is, first, to conduct an agrophysical analysis for identification of Central Region land units (GDSSs) with potential for rainfed or irrigated rice production. Second, an economic analysis is carried out in order to identify those GDSSs in which expansion of rice production would be profitable from both the producers' and nation's standpoints under specific production parameter assumptions using alternative expansion decision rules.

In the agrophysical analysis, agrophysical tolerance limits of rice for potentially limiting environmental factors are determined and crosstabulated with GDSS characteristics in order to identify those GDSSs with potential for rice production. For each selected GDSS, estimates are made of physical area with potential for rice production, current land use, and area with potential for rice expansion. Possibilities for multiple rice production cycles are analyzed.

Definitions of two key terms are necessary to an understanding of the economic analysis: monetary costs and benefits, and unsubsidized costs and benefits. Monetary costs and benefits are those production and marketing values based on market prices reflecting producer opportunity costs and shadow prices for inputs and products, though they may include governmental price alterations (income transfers) such as taxes or subsidies. They establish the cash expense/income ratios used by maximizing agricultural producers to allocate inputs.

Unsubsidized costs and benefits are those production and marketing values calculated by removing implicit (due to governmental price alterations) and explicit (direct government payments to producers) subsidies and taxes in valuation of inputs and products from the nation's standpoint. National government price alterations are netted out. Price alterations made by foreign governments on exports (such as milk) to the Dominican Republic may be involved but are not consiered quantitatively. National values provide the basis for estimating real economic costs and benefits to which monetary costs and benefits are compared in order to evaluate the impacts of government price alterations.

In the economic analysis, production techniques and yields, producer and unsubsidized costs of production and income, and producer and unsubsidized returns to land and management (RLM) for rice and its two primary land use competitors (sugarcane and cultivated pasture as an intermediate input in milk production) were estimated for each selected GDSS at the farm gate level. A yield matrix relating rice yields to GDSS characteristics was synthesized to provide reasonable rice yield estimates on GDSSs with production potential but no current production. Monetary input and output prices were converted to unsubsidized prices by removing implicit subsidies. An alternative set of rice budgets requiring increased labor and/or decreased foreign exchange use was established.

This benefit-cost information was then employed in analyzing the regional and GDSS-level impacts on rice production, labor and foreign exchange use in production, and monetary and unsubsidized RLM for 11 alternative strategies for a hypothetical expansion of current rice areas, using five alternative expansion decision rules. Sensitivity analysis of the assumptions on multiple production cycles for rice was carried out on two selected strategies.

Data Acquisition and Refinement

Judgmental estimates by agricultural field specialists played a major role in data acquisition. If farm level empirical data had been available for all production coefficients of interest in the study, quantitative statistical estimates of population parameters and confidence intervals could have been made. Use of consensus judgmental estimates (specifically, estimates of population modes) does not permit statistical analysis of data reliability. In effect, these estimates were "experience based", single "educated guesses" about population modes; hence, mechanical statistical estimates could not be made of their accuracy.

However, the judgmental estimates as well as other coefficients used in the study were crosschecked with secondary data and field verified by the SIEDRA staff whenever possible. This procedure was intended to improve data acquisition and processing reliability by giving the staff a down-to-earth feeling for the strengths and weaknesses of the various sources of data by establishing qualitative confidence intervals on the data as time and other resources permitted. It was also intended to increase study credibility among both the government administrators supporting the study and the field technicians at the project implementation level by demonstrating that SIEDRA was making a critical effort to obtain realistic data rather than simply using the first "wild guess" that came along.

Agrophysical Data

In this section the collection and iterative refinement of data relating to rice agrophysical input tolerance limits and corresponding GDSS characteristics are discussed. These agrophysical data provide the basis for the agrophysical analysis leading to the final selection of GDSSs in which rice might be profitably produced.

Rice Agrophysical Tolerance Limits

Agrophysical tolerance limits for rice varieties "adaptable" to the GDSSs of the Central Region were determined both from field interviews of production specialists at the Juma national rice experiment station and from published documents (Juma, 1979; IRRI, 1978; 1979; SEA, 1975). Rice was assumed to be adaptable to a GDSS if its expected yield in that GDSS was greater than the lowest current normal yield reported as commercially marketed by the region's rice producers (SIEDRA, 1979d). Even though rice undoubtedly could be produced with a yield greater than zero in all GDSSs, this assumption allowed research efforts to be concentrated on those GDSSs with expected yields sufficiently high to indicate a reasonable possibility of profitable production. Thus, no arbitrary assumption of production in Stage II was assumed in establishing minimum acceptable yields (Heady, 1952). See Chapter III for a discussion of stages of production.

This screening procedure resulted in the preliminary identification of seven rice varieties as being currently or potentially usable in the region (Table 4-1). Major agrophysical factors identified initially as being potentially limiting to rice production were: water (cycle and salinity), soils (slope, pH, depth, water holding capacity, and salinity), photoperiod, and air temperature extremes. Variety level data for these factors were obtainable only for crop cycle water use. Water input ranges were estimated for five of the seven varieties for which quantitative data were available. Species level requirements were estimated for the remaining eight characteristics.

Tolerance limits for water use during the crop cycle for commercially marketed output levels were derived from experiment station estimates of water quantity required to produce maximum (i.e., beginning of Stage III) yields (Juma, 1979). This was accomplished by multiplying these estimates for each variety by a constant factor of 0.7 which was obtained by dividing the estimated production cycle "dependable" precipitation (532 mm) in the GDSS of lowest commercial yield by the corresponding experiment station Stage III water input level for the same rice variety (758 mm). Dependable precipitation is defined by Hargreaves (1977) as that which occurs with 75 percent probability.

Land Resource Base

Collection and refinement of data on the land resource base (GDSS) characteristics which correspond to the potentially limiting agrophysical factors identified in the previous section are discussed below.

Water:

Two water input requirements were used to screen RPUs (and their associated GDSSs) for appropriate water quantity and quality for rice production: water availability during the crop cycle and water salinity

Table 4-1. Nine Agrophysical Input Requirements for Seven Rice Varieties, Central Region, 1979

Requirement	Units	Input Requirements						
		Juma57	Juma58	Tono Brea	Mingolo	IR6	Tanioka	Ingles Largo
Water during cycle	mm/cycle(max)	553	591	574	NA[1]	NA[1]	531	962
	cycle length (days)	117	121	114			109	171
Water salinity	$mmho^{-1}/cm^3$	0-8						
Soil slope	%	0-15						
Soil pH	pH	4.5-7.5						
Soil depth	m (min)	0.5						
Soil water holding capacity	texture	not coarse						
Soil salinity	$mmho^{-1}/cm^3$	0-8						
Photoperiod	hr/day	11-13						
Air temperature extremes	^oC	16-30						

[1]data not available

(Table 4-2). Water sources considered were rainfall, surface, and underground water (INDRHI, 1976, 1978; SIEDRA, 1979b).

Rainfall availability was estimated on the basis of dependable monthly rainfall (Hargreaves, 1977). The minimum production cycle water requirements (138 mm/mo for 4 mo) for the most drouth tolerant rice variety, Juma-57, was used as the criterion for minimum acceptable rainfall. Use of this criterion meant that GDSSs eventually selected as acceptable for "rice" production might in fact be usable only for the most drouth resistant variety. This factor is considered in Chapter VI.

Surface water availability was deemed acceptable if surface flows from rivers or dams were at least 3 m3/sec in GDSSs with areas large enough for the construction of secondary irrigation canals of at least 4 km in length. Lower surface flows and smaller irrigable areas were assumed, on the basis of local experience, to be economically unviable for public investment (INDRHI, 1976).

Underground water acceptability was determined on the basis of water table depth, chloride content and yield. Specific criteria were: depth to water table less than 80 m; chloride content less than 100 ppm; and yield of at least 600 gpm. Water with characteristics beyond these limits was assumed. on the basis of Dominican Water Resources Institute (INDHRI, 1979) studies, to be uneconomical for use on public irrigation projects.

Water loss through evapotranspiration was not considered quantitatively because of constraints on data availability. However, this factor was given qualitative consideration in the estimation of potential physical production area in GDSSs with potential for rice production, as explained later in this chapter (Reyna and Paulet, 1979).

Table 4-2. Water Availability from Three Sources and Adaptability for Rice Production in 15 RPUs, Central Region, 1979

RPU	Rainfall		Surface Water		Underground Water			Overall Adaptability
	Periods with $\geq$138 mm/mo for 4 consecutive months		River	Periods with $\geq 3\ m^3/sec$ for 4 consecutive months	Depth	Yield	Quality	
					(m)	(gpm)	(ppm chlor.)	(period)
01	-	-	Ozama, Yabacao	May-Oct	-			May-Oct
02	-	May-Aug	Osama, Haina	May-Oct	-			May-Oct
06	-	-	Nizao	May-Oct	-			Jan-Dec
07	-	May-Aug	Ozama, Tabacao	May-Oct	< 75	800	100	Jan-Dec
09	-	May-Aug	-	-	-			May-Aug
11	-	-	Ozama	May-Oct	20-50	800	40	Jan-Dec
16	-	-	Ozama	May-Oct	-			May-Oct
19	-	-	-	-	-			-
20	Apr-July	Aug-Nov	Haina	May-Oct	-			Apr-Nov
21	-	-	Nizao	May-Oct	-			May-Oct
22	-	-	-	-	-			-
23	-	-	-	-	-			-
25	-	-	Nizao	May-Oct	-			May-Oct
40	-	-	Haina	May-Oct	-			-
41	-	-	-	-	-			-

Soils:

Soils data were taken directly from SIEDRA (1979a). Only the GDSSs selected as having acceptable water availability were further screened for tolerable slope, pH, waterholding capacity, salinity and depth to bedrock or water table (Table 4-3). Specific tolerance ranges were: slopes 0-3 percent for irrigation and 0-15 percent for rainfed production; pH 4.5-7.5; texture (as a proxy for waterholding capacity) non-coarse; salinity 0-7 mmoh-1/cm3; and depth to bedrock or water table at least 0.5 m. Slopes over three percent had previously required uneconomical investments for leveling or terracing for irrigation. Slopes over 15 percent for rainfed production were assumed to pose an unacceptable erosion hazard under economically feasible conservation practices (Paulet, 1979).

Photoperiod and Temperature:

Photoperiod was eliminated as a potentially limiting factor for the seven rice varieties studied, as all seven had proved in field trials to be adapted to the 18 degrees south latitude of the Central Region. This factor is considered again in Chapter VI, however, in a discussion of the possible introduction of new rice varieties. Temperature extremes were handled in the same manner.

Use of Agrophysical Data

The refined agrophysical data obtained through the procedure described above is used in the agrophysical analysis to make final selection of GDSSs with characteristics within the tolerance limits for rice production and to estimate the physical areas potentially usable for rice area expansion. The agrophysical analysis is discussed later in this chapter.

Table 4-3. Soils Characteristics of the GDSSs with Adequate Water for Rice Production, Central Region, 1979

GDSS	Distinguishing Characteristic	Slope (%)	Depth (m)	Texture	pH	Salinity ($mmho^{-1}/cm^3$)
01A	flat	0-3	1-3	fine	neutral	0
B	hills	3-15	0.2-0.5	fine	sl. alcal.	0
02A	hills	>15	0.1-0.5	mod. fine	strong acid	0
B	valley	5-15	0.5-2.0	mod. fine	strong acid	0
06A	flat	0-3	1-3	fine	neutral	0
B	hills	3-15	0.2-0.5	fine	sl. alcal.	0
07A	poor drain	0-3	2-5	fine	very s. acid	0
B	well drain	3-8	2-5	fine	very s. acid	0
09A	hills	>15	0.1-0.5	mod. fine	mod. alcal.	0
B	valleys	8-15	1-5	mod. fine	mod. alcal.	0
11A	hills	8-30	0.1-0.5	mod. fine	mod. acid	0
B	valleys	3-5	0.1-0.5	mod. fine	mod. acid	0
16A	poor drain	0-3	>5	med.	sl. acid	0
B	well drain	0-3	>5	med.	sl. acid	0
20A	undulating	3-15	2-5	fine	strong acid	0
B	flat	0-3	>5	mod. fine	mod. acid	0
21A	poor drain	0-3	2-5	mod. fine	strong acid	0
B	well drain	0-3	2-5	mod. fine	mod. acid	0
25A	flat	0-3	1-5	med.	mod. alcal.	0
B	hills	3-15	0.2-1	med.	mod. alcal.	0
40A	shallow	15-20	0.1-0.5	mod. fine	strong acid	0
B	mod. deep	20-30	0.5-2	mod. fine	strong acid	0

Economic Data

Methods for collecting and processing raw economic data into coefficients usable for the economic analysis of rice expansion strategies in the GDSSs selected in the agrophysical analysis are discussed in this section. Estimation of typical and alternative production techniques and yields, monetary costs of production, and monetary income at the farm gate for rice, sugarcane, and cultivated pasture used in milk production are presented. All estimates are on a per tarea (ta; 1 ta = 1/15.9 ha) basis because of study emphasis on land productivity and supply response. The economic analysis methods are explained later in the chapter.

Production Techniques and Yields

GDSSs with Current Rice Production:

The data on typical rice production techniques are in terms of current normal physical input use and yields per ta. They were drawn primarily from SIEDRA (1979d) budget data for each GDSS with rice production reported in 1979 (Table 4-4). Interview results from which the budgets were derived indicated that typical rice producers operate on agrarian reform (IAD) cooperative asentamiento farms and contract for rather than purchase their own machinery and equipment. The SIEDRA data provided estimates of machinery and equipment activity (i.e., plowing, disking) costs but did not identify the physical input components (e.g., tractor size, operator's labor hours) of those costs. Because estimates of the input components were required in order to calculate labor utilization and foreign exchange use, local rice production specialists and equipment dealers were asked to identify the machinery and equipment

Table 4-4. Sample SIEDRA Production Budget for Rice, Central Region, 1979 Typical Production Techniques

Product: rice   Variety: IR-6   GDSS: 06A   Irrigated?: yes
Yield: 5.4 qq/ta   Area: 5000 ta   Tenancy: IAD   Farm size: 10 ta
Price: 12.00 qq   Site: Nizao   Source: reg spec   Date: Mar 79

Costs	Unit	Quant /ta	Unit Mon	Cost Unsub	Total Mon	Cost/ta Unsub
1. Land prep (incl labor)						
Plowing	times	1	3.00	3.19	3.00	3.19
Disking	"	1	2.00	2.29	2.00	2.29
Harrow	"	1	2.00	2.29	2.00	2.29
Levelling (ox)	"	1	2.00	2.00	2.00	2.00
Ditching					0	0
Terracing					0	0
Mud Plow					0	0
2. Inputs						
Seedling trans	ta	0.1	50.40	59.40	5.40	5.94
Insecticide	lt	0.25	12.00	13.54	3.00	3.39
Fungicide					0	0
Herbicide	gal	0.25	18.00	20.90	4.50	5.23
Fertilizer	qq	0.80	10.00	11.48	8.00	9.18
Water	ta	1	0.20	4.93	0.20	4.93
3. Labor (incl fam)						
Transplant	times	1	6.00	6.00	6.00	6.00
Weeding	"	2	2.00	2.00	4.00	4.00
Irrigation	"	1	0.24	0.24	0.24	0.24
Appl. pest	"	3	0.30	0.31	0.90	0.93
fert	"	2	0.30	0.30	0.60	0.60
herb	"	1	0.30	0.31	0.30	0.31
Cut, thresh	"	1	9.00	9.00	9.00	9.00
(Family-40%)					(-8.42)	(8.42)
4. Admin/mgt					0	0
Total Var Cost					42.78	59.52
5. Interest on VC			80%	100%	1.48	5.36
Total Costs					44.26	64.88

typically bought by rice production contractors. Engineering coefficients such as size, speed, and fuel consumption were obtained from local equipment dealers and from an FAO (1974b) cost of production study which was reviewed and determined to have selected coefficients of acceptable accuracy for this study.

Estimates of labor coefficients for each rice production activity were obtained from the FAO study and from interviews with SEA rice specialists (Table 4-5). The labor coefficients were assigned to their corresponding activities in each enterprise budget and summed to an enterprise labor total.

Sugarcane is recognized as a major competitor for land suitable for rice production and is produced largely on state-owned CEA lands in the Central Region (Juma, 1979; World Bank, 1979). In this study the assumption was made that substitution of rice for sugarcane as a result of GODR policy directives would take place on CEA land through establishment of IAD cooperative asentamiento farms. That assumption is consistent with GODR expressed interest in diversifying land use on current CEA lands through agrarian reform activities (Tilmann, 1979; World Bank, 1979).

Physical input coefficients for sugarcane, except for labor, were not estimated because of lack of usable data. In the best available data, aggregate categories of input costs for each CEA sugarmill producing area were reported (Bookers, 1975). Sugarcane rainfed yields by GDSS were estimated from sugar colony (mill area subdivisions) maps which indicated six year average yields and which included soils descriptions for each colony. The soils descriptions were used to classify each colony according to predominant GDSS. Due to lack of empirical data on irrigated cane production in the region, the simplifying assumption

Table 4-5. Labor Use per Cycle in Rice Production Activities, Central Region, 1979 Current Normal

Activity	Power Source	Time
		(min/ta)
moldboard plow	tractor	12
	animal	90
disk	tractor	10
	animal	50
harrow	tractor	10
	animal	27
terracing	tractor	6
	animal	30
ditching	tractor	20
	animal	180
leveling	tractor	45
	animal	90
mud plow	tractor	18
	animal	125
row-making	tractor	12
	animal	50
seeding	transplant (hand)	350
	broadcast (hand)	15
clearing	manual	150
weeding	manual	240
cleaning	manual	90
appli. pesticide	moto block	20
appli. herbicide	moto block	30
appli. fertilizer	manual	20
appli. irr. water	manual	60
harvest & thresh (4 qq)	manual	480
transport on farm	animal	18
seedling nursery		480
adm. activities		120

was made that irrigated yields were 10 percent higher than rainfed yields in each GDSS, a figure considered reasonable by sugarcane specialists. Sugarcane establishment ("renovation") activities were reported by Bookers (1975) to take place every seven years, with maintenance activities during the other six years.

National average CEA labor use coefficients for each sugarcane production activity were obtained from Morales (1979) and the 1975 Bookers report (Table 4-6). The assumption was made that production techniques had changed little since the Bookers data was collected. This assumption is consistent with observations made by the World Bank (1979). Harvest labor use was estimated under the assumption that workers could cut 2.5 mt of cane per 8 hr day (Morales, 1979). Distribution to GDSS level was made by adjusting yield-related labor coefficients by the cane yield index.

Cultivated pasture is another typical alternative use of land suitable for rice production (AID, 1980). Livestock marketing studies by SEA (1977a) indicated that milk production was the major use of cultivated pasture in the Central Region. The typical farm had about 2,000 ta of land and sold 400-1,000 lt of fresh milk daily. Recent trends in milk marketing are toward increased sale of milk for pasteurization rather than for use in crude form (Associacion, 1979). Pasteurized milk producers typically store milk on-farm in cooling tanks prior to pickup by refrigerated tank trucks.

These factors were kept in mind when approximating the current normal production coefficients for cultivated pasture utilized as an intermediate input in pasteurized milk production. Estimates were based on survey data from a 1973 Interamerican Development Bank (IDB)

Table 4-6. Current Normal Annual Labor Use in Sugarcane and Cultivated Pasture/Milk Production, Central Region, 1979

Land Use	Labor Input[1]	Time
		(min/ta)
Sugarcane	Activity:	
	Land preparation	92
	Seeding	144
	Agrochemical application	58
	Weeding (3 times)	852
	Harvest (3 MT)	576
Cultivated Pasture/Milk	Employee:	
	Supervisor	88
	Assistant supervisor	165
	Milker (132 lt)	44
	Part-time	42

[1]Sugarcane weighted 1/7 for establishment and 6/7 for maintenance labor; cultivated pasture/milk weighted 1/10 establishment and 9/10 maintenance labor.

study. The assumption was made that milk production techniques had not changed significantly since the IDB study. This assumption is consistent with recent dairy industry reports (Associacion, 1979; FAO, 1978).

As in the case of sugarcane, cultivated pasture/milk physical input coefficients, except for labor, were not estimated because of lack of empirical data. The IDB study reported only costs of input categories and yields of milk and cull animals for a representative 1994 ta dairy farm which sold an average of 720 lt of raw milk daily. Milk yields were distributed to each GDSS using the sugarcane yield index. This required the simplifying assumptions that cultivated pasture forage species (grasses) would respond to soil and water inputs in proportion to sugarcane response in each GDSS and that dairy herd management levels were uniform among GDSSs so that milk yields were directly proportional to pasture yields. One of the consequences of the assumption of proportional yields for sugarcane and cultivated pasture is that real yield related differences in production parameters (e.g., variable production costs) for the two land uses at the GDSS level may be distorted. The significance of this assumption to study results will be discussed in Chapter VI. Annual production inputs which vary with milk output were adjusted from the base budget by using the milk yield index. Dairy cow cull rates were assumed constant in all GDSSs.

Labor coefficients for cultivated pasture/milk production were taken from the IDB (1973) study (Table 4-6). Labor use was distributed to GDSS level by adjusting handmilking labor coefficients by the milk yield index. Other labor inputs were assumed to be constant among GDSSs.

GDSSs with Potential But No Current Rice Production:

Typical production techniques and current normal yield estimates for GDSSs identified as having characteristics within the tolerance limits for rice production were required for the analysis. Estimation of these parameters for GDSSs with current rice production was discussed in the previous section. In this section estimation of rice, sugarcane, and cultivated pasture/milk yields and production techniques in GDSSs selected as having rice potential but with no current rice production is explained.

Matrix of Potential Rice Yields: A matrix of single cycle rice yields by species was synthesized from SIEDRA (1979a; 1979b) data in order to estimate current normal potential yields in GDSSs identified as having rice production potential but no current production (FAO, 1976; Knox, 1976). Variety level ordinal productivity scales were constructed, under an assumed set of technological standards, on the basis of water availability, soil slope and depth (Table 4-7). These agrophysical factors were the only ones for which judgmental yield response estimates reasonably could be made. Input levels corresponding to minimum commercial yield and to the beginning of Stage III of the production function were calculated for the three factors, and a linear approximation of the midpoint between the extremes was calculated for water availability. These ordinal scales established the range of GDSS characteristics over which a commercially marketable yield of rice could be expected. The assumption of a set of technological standards was intended to fix the input levels of the factors which were not studied in the agrophysical analysis and thereby to isolate yield responses due only to agrophysical factors (FAO, 1976).

Table 4-7. Inputs of Water and Soil Slope and Depth Required to Attain Specified Levels of Yields for Five Rice Varieties, Central Region, 1979 Current Normal

Rice Varieties	Yield Levels						
	I	II	III	A	B	1	2
	Water			Slope		Depth	
	(mm)			(%)		(m)	
Juma57	790	672	553	0-3	3-15	1-5	0.5-1
Juma58	844	714	591	"	"	"	"
Tono Brea	820	697	574	"	"	"	"
Tanioka	759	645	531	"	"	"	"
Ingles largo	1383	1163	963	"	"	"	"

Technical assumptions:
a. Transplanted seedlings
b. Fertilizer and insecticide applied
c. Cultivation done on a timely basis
d. No soils or water characteristics besides those noted are limiting factors

The ordinal scales were combined to produce current normal cardinal yield estimates for each combination of water availability and soil slope and depth (Table 4-8). Cell values in the yield matrix were taken directly from SIEDRA (1979d) yield coefficients for current rice areas or were interpolated between the SIEDRA estimates. The yield matrix then was used to assign current normal rice yields to the GDSSs selected in the agrophysical analysis as having rice production potential but with no current production. Factors other than the three utilized in constructing the yield matrix but which were believed by the SIEDRA staff to be important factors in specific GDSSs were used judgmentally to adjust the estimates obtained from the yield matrix. These adjustments are noted in the next chapter.

Table 4-8. Rice Yields Attainable with Various Combinations of Water and Soil Slope and Depth, Central Region, 1979 Current Normal

Slope	Depth	Water Regime		
		I	II	III
		------------------qq/ta/cycle------------------		
A	1	5.5	5.0	4.5
	2	4.8	4.4	4.0
B	1	4.0	3.7	3.5
	2	3.7	2.7	1.6

Technical assumptions:

a. Transplanted seedlings
b. Fertilizer and insecticide applied
c. Cultivation done on a timely basis
d. No soils or water characteristics besides those noted are limiting factors

Production Techniques: Rice production techniques for GDSSs with rice production potential but no current production were derived judgmentally from those used in GDSSs most similar in terms of the three agrophysical factors (water use and soil slope and depth) used in the rice yield potential matrix. The synthesis of that matrix was explained in the previous section of this chapter.

Sugarcane and cultivated pasture/milk yields and labor use for the rice potential GDSSs were estimated according to the methods described in the previous section.

Alternative Rice Production Techniques:

An alternative set of rice production techniques requiring increased enterprise labor and/or reduced use of foreign exchange-using (imported) inputs was derived from the SIEDRA budgets (Table 4-9). Input substitutions and adjustment of corresponding yields were done judgmentally because of the lack of empirical data on incremental (marginal) input-out relations in rice production. Rice production specialists from SEA made the substitution estimates based on field experience. Yields generally were reduced as labor was substituted for such imported inputs as fertilizer, herbicides and insecticides, the local feeling being that hand and animal operations would be less timely and effective than the more capital intensive operations.

Table 4-9. Comparison of Input Differences Between Representative Rice Production Budgets with Typical and Alternative Production Techniques, 1979 Current Normal

Input	Units	Typical	Alternative
		quantity/ta	
Insecticide	lt	0.25	0.17
Herbicide	gal	0.25	0
Fertilizer (15-15-0)	qq	0.80	0.30
Urea	qq	0	0.10
Labor			
Weeding	times	2	1
Cleaning	"	0	1
Irrigation	"	1	4
Pesticide applic.	"	3	2
Herbicide applic.	"	1	0

Monetary Production Cost and Income Estimates

The definitions of the key concepts of monetary and unsubsidized values are critical to the understanding of the economic data collection and analysis undertaken in this study. They are explained at the beginning of this chapter.

The primary distinction between the two concepts is that monetary values are cash expenses and income, while unsubsidized values are cash values adjusted for implicit subsidies. The cash values are market values based on producer opportunity costs and shadow prices and may include governmental price alterations in the form of subsidies or taxes.

Implicit subsidies are due to governmental fixing of resource prices at levels different from their marginal productivity and are estimated through application of the opportunity cost principle at the national level. Implicit subsidies considered in this study are those on agricultural credit, unpaid family labor, irrigation water use, and foreign exchange.

In the case of irrigation water, for example, the government fixes irrigation water charges at the flat rate per tarea irrigated, rather than charging by volume of water used. The opportunity cost of applying irrigation water to rainfed rice is the value of the alternative product (i.e., sugarcane, cultivated pasture) foregone in using the water on rice instead of on the alternative product. In this case, the implicit subsidy is the difference between the national opportunity cost (product foregone) and the governmentally established flat rate per tarea. Those producers who forego irrigated sugarcane or cultivated pasture production subsidize those who benefit from irrigation of rice.

Monetary Production Costs:

Current normal production costs for rice were calculated by multiplying monetary prices by the physical input coefficients determined in the previous section (Table 4-4). Current normal prices for most variable inputs in rice production were taken from the SIEDRA (1979d) budgets. The SIEDRA budgets indicated that most rice in the region is produced on government-owned IAD cooperative asentamientos and that all machinery and equipment services are contracted for by IAD producers. Contract services were priced at the local custom hire rate for equipment and labor. Manual labor was priced at the local non-skilled wage rate.

In the original SIEDRA budgets, unpaid family labor was not separated from paid labor but was included implicitly as part of the contracted labor and thus was overpriced in terms of monetary costs. Therefore, based on SEA (1977c) farm survey results for rice farms less than 80 ta in size, total labor costs in each of the budgets were allocated as follows: 40 percent to unpaid family labor and 60 percent to paid labor. Accordingly, the SIEDRA producer monetary cost estimates were reduced by 40 percent of total labor costs in order to better reflect cash outlays for labor. The assumption was made that all labor was paid at the local unskilled wage rate. That assumption seemed reasonable in that undervaluation of machine operators' labor is offset by overvaluation of child labor.

SIEDRA budgets did not include interest charges on variable costs, which resulted in an understatement of monetary costs in irrigated production budgets. The state-owned Agricultural Bank (BAGRICOLA) does not extend credit for rainfed rice production. Therefore, the current normal BAGRICOLA small farmer rate of nine percent annual interest was applied to 80 percent of all non-interest variable costs for six months in order to obtain a representative monetary interest charge for the irrigated production cycle. This procedure was based on information obtained in discussions with BAGRICOLA personnel and with local IAD rice farmers.

Because asentamiento producers typically do not own their own machinery and equipment, there were no estimates of producer fixed costs in the SIEDRA budgets. However, in order to estimate unsubsidized costs of machinery use, current normal machinery and equipment costs were calculated by converting stocks to annual flows of services using standard accounting methods and 1979 retail market prices (Brown, 1978; Castle, et al., 1972). Depreciation on machinery, on which private owners must pay import taxes, was calculated on a straightline basis assuming a salvage value of 5 percent (Tables 4-10 and 4-11). Interest on average cost over the assumed life of the equipment was charged at the current normal BAGRICOLA annual rate of 9 percent (FAO, 1974b). Repairs and maintenance were estimated at 150 and 100 percent, respectively, of original tractor and implement purchase prices. Tractor fuel costs were based on fuel consumption rates and field operating speeds as estimated by local machinery dealers. Lubrication costs were calculated as 15 percent of fuel costs. Labor use was computed at 1.2 hr of operation and maintenance for each hour of tractor use and was priced at the local unskilled labor wage rate (Junt, 1977).

Sugarcane annual monetary costs at the GDSS level were derived from Bookers (1975) report estimates for each CEA sugarmill area (Table 4-12). Mill level costs were allocated to GDSS level by adjusting all yield-related inputs by the cane yield index for each GDSS. The assumption was made that production techniques had not changed since the Bookers data

Table 4-10. Annualized Monetary Costs for State Owned and Privately Owned Machinery for Rice Production, Central Region, 1979

Cost	Tractor 78 HP		Plow 4 boards		Disk 16-24"		Mud Plow	
	State	Pvt.	State	Pvt.	State	Pvt.	State	Pvt.
Fixed costs								
Depreciation	0.99	1.35	0.50	0.79	1.56	2.64	0.03	0.04
Interest[1]	0.50	0.68	0.13	0.20	0.39	0.67	0.01	0.01
Total FC ($/hr)	1.49	2.03	0.63	0.99	1.95	3.31	0.04	0.05
Variable costs								
Fuel[2]	1.31	1.31	-	-	-	-	-	-
Lubrication[3]	0.20	0.20	-	-	-	-	-	-
Repair/maint.[4]	1.57	2.14	0.53	0.83	1.64	2.78	0.03	0.05
Labor[5]	0.94	0.94	-	-	-	-	-	-
Total VC ($/hr)	4.02	4.59	0.53	0.83	1.64	2.78	0.03	0.05
Total cost ($/hr)	5.51	6.62	1.16	1.82	3.59	6.09	0.07	0.10
Total cost ($/ta)	1.38	1.66	0.29	0.46	0.90	1.52	0.02	0.03
Assumptions:								
1. Original cost ($)[6]	13185[7]	17900[8]	1108	1750	2947	5000	550	81
2. Salvage value ($)[9]	659	898	55	88	147	250	3	4
3. Useful life (hrs)	12600		2100		1800		1800	
4. Annual use (hrs)	2100		700		600		600	
5. Fuel use (gal/hr)	1.5							
6. Labor use (hr/tractor)	1.2							

[1] 9 percent annual
[2] $0.87 gallon
[3] 15 percent of fuel cost
[4] 150 percent of original tractor cost, 100 percent of original equipment cost
[5] operator salary $165 per month
[6] machinery used 264 days/year, 8 hr/day
[7] FOB
[8] FOB, tax, profit
[9] 5 percent of original price

Table 4-11. Current Normal Monetary and Unsubsidized Costs for Typical Private and State-Owned Rice Production Machinery, Central Region, 1979

Machinery	Monetary Costs		Unsubsidized Costs
	Private	State	
	($/ta/yr)	($/ta/yr)	($/ta/yr)
Tractor, 78 hp	1.66	1.38	1.78
Plow, 4-board	0.46	0.29	0.44
Disk, 16-24"	1.52	0.90	1.54
Mud plow	0.03	0.02	0.03

Table 4-12. Monetary Costs of Sugarcane Production for Three Sugarmill Areas, Central Region, 1973 Costs Indexed to 1979

Cost	Haina[1]	Ozama[2]	Catarey[3]
Variable cost			
Cultivation	2.87	2.65	3.33
Maintenance	1.14	1.22	1.30
Field, general	1.21	1.14	1.12
Harvest	3.49	3.16	3.23
Total VC (1979 $/mt)	8.71	8.17	8.98
Yield (mt/ta)	3.1	3.3	3.2
Total VC (1973 $/ta)	27.00	26.96	28.74
Fixed cost (1973 $/ta)	2.78	2.82	5.38
Total cost (1973 $/ta)	29.78	29.78	34.12
Total cost (1979 $/ta)[4]	50.63	50.63	58.00

[1]corresponds to irrigated GDSS 11B

[2]corresponds to irrigated GDSS 16A

[3]corresponds to rainfed GDSS 20B

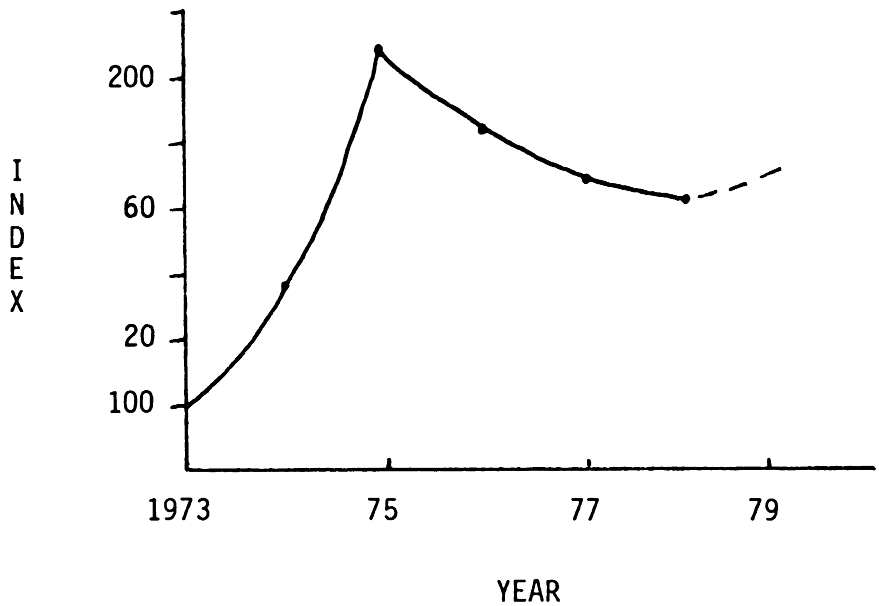
[4]1979 price index = 170, 1973 = 100

made that production techniques had not changed since the Bookers data was collected (World Bank, 1979).

The costs were annualized using a seven year rotation cycle. Establishment ("renovation") costs were assumed to recur every seven years, so that on an annual basis 1/7 of the total costs were weighted for establishment costs and 6/7 for maintenance costs. Machinery and equipment were depreciated on a straightline basis to zero salvage value. No monetary interest charge was made on the assumption that CEA finances its operating expenses out of current revenues. Repairs and maintenance were charged at 100 percent of import price (Bookers, 1975). Bookers cost estimates for 1973 were updated to 1979 costs through the use of an input price index. The index was derived from BAGRICOLA (1979) time series data for a composite average of diesel fuel and agrochemical costs (Figure 4-1).

Cultivated pasture total annual monetary costs at the GDSS level for pasteurized milk production were derived from an IDB (1973) report which was reviewed and judged to be of acceptable accuracy for the study. IDB production costs for a 1994 ta farm selling 720 lt of raw milk daily were used as the base from which GDSS level costs were derived (Table 4-13). Pasture establishment costs were reported to occur every ten years, with annual maintenance costs occurring in the intervening years. Annualized total pasture costs were weighted 1/10 for establishment costs and 9/10 for maintenance costs. The assumption was made that milk production techniques had not changed since the IDB study (Associacion, 1979; FAO, 1978). Milk production costs were distributed to GDSS level by using the sugarcane yield index. Annual production costs which vary with milk output were adjusted from the base budget by using the milk

Figure 4-1. Derivation of 1979 Input Price Index from BAGRICOLA 1973-78 Data (1973 = 100), Dominican Republic



The points corresponding to 1973-78 are from BAGRICOLA (1978) data. A judgemental estimate of the 1979 index was made as follows: (a) the period 1973-75 was essentially ignored due to the abnormally high prices for petroleum products in those years, (b) the curvilinear trend between 1975-78 was extrapolated to 1979. The data are for a composite of diesel fuel and agrochemical costs.

Table 4-13. Monetary Costs of Production of Cultivated Pasture Used for Pasteurized Milk in Rainfed GDSS 07B, Central Region, 1973 Costs Indexed to 1979

Variable Cost (1973)	($/ta)
Pasture maintenance	4.07
Supplemental feed	11.83
Veterinary expenses	1.14
Equipment maintenance	2.63
Repairs	1.10
Labor	3.28
Other	1.32
Total	25.37
Interest on VC[1]	1.90
Total VC (1973)	27.27
Fixed cost (1973)	6.00
Total cost (1973)	33.27
Total cost (1979)[2,3]	43.25

[1] 8% per annum

[2] 1979 price index = 130, 1973 = 100

[3] corresponds to milk yield of 132 lt/ta/yr

yield index. Herd animal maintenance and replacement costs were assumed constant among GDSSs. One-tenth of the bulls and cows were assumed to be replaced annually and sold as slaughter animals. Interest was charged at 8 percent (Associacion, 1979). All costs were updated to 1979 using a dairy input price index derived from IDB (1973) and Associacion (1979) data. Total production costs for 1973 were $0.20 per lt, and those for 1979 for a composite of Central Region farms with similar output (744 lt/yr) were $0.26. Therefore, the 1979 input price index was 130 using 100 as the 1973 base year index.

Monetary Income:

Monetary income for each land use was calculated by multiplying current normal monetary prices at the farm gate by the yields estimated for each GDSS (Table 4-14). Use of current normal fixed prices implies that there is no variation in prices over time. This rather rigid assumption is discussed in Chapter VI. Estimates of current normal monetary prices at the farm gate and import prices were made for rice and milk using INESPRE (1979) data. Rice prices were weighted by volume for the four qualities of rice defined by INESPRE.

Based on the fact that the CEA is a vertically integrated organization which does not conduct field level market transactions for the cane produced on its own land, monetary prices at the "farm gate" were derived from import (CIF) prices (World Bank, 1979). The sugarcane farm gate price was derived by subtracting a representative marketing charge from the CIF import price and converting sugar weight to sugarcane equivalent (Table 4-15).

A representative monetary charge for processing sugarcane to sugar and for marketing services was based on Bookers (1975) report estimates for the Haina sugarmill (Table 4-16). Factor machinery was depreciated over a 30 year period. No interest was charged on the assumption that the state owned CEA finances all of its expenses out of current income. The costs were then adjusted to 1979 costs by utilizing the BAGRICOLA input price index described in the previous section. Sugarcane transportation costs from field to mill were taken from Bookers (1975) report estimates and indexed to 1979 using the BAGRICOLA input price index. Capital items were depreciated over a 30 year period and no interest was charged.

Table 4-14. Monetary and Unsubsidized Product Prices, Farm Gate and CIF Import, Central Region, 1979 Current Normal

Product	Level	Units	Monetary	Unsubsidized
			-----------$/unit------------	
Rice	Farm gate	qq,rough	12.00	13.12
	Import	qq,white	NE[1]	26.28
Sugarcane	Farm gate	mt,cane	26.00	33.00
	Import	mt,sugar	NE[1]	397.00
Milk	Farm gate	lt,cooled	0.29	0
	Import	lt,reconst	NE[1]	0.12
Cull animals	Farm gate	lb,live	0.19	0.23
	Import	lb,meat	NE[1]	1.03

[1]not estimated in the study

Table 4-15. Derivation of Farm Gate Monetary and Unsubsidized Prices for Sugarcane, Central Region, 1979 Current Normal

	Monetary	Unsubsidized
CIF import price (RD$/mt)	331	331
For. exch. conversion (RD$/US$)	x -	x 1.2
Marketing charge (RD$/mt)	- 96	- 102
	235	295
Conversion factor, sugar to cane	x 0.112	x 0.112
Farm gate price (RD$/mt)	26.00	33.00

Table 4-16. Derivation of Unsubsidized Marketing Costs from Monetary Marketing Costs for Sugarcane, Central Region, 1973 Costs Indexed to 1979

Monetary costs:	
Processing, sales	
Variable cost	32.76
Interest on VC	0
Total VC (1973 $4/mt sugar)	32.76
Yield (mt sugar/ta)	0.35
Total VC (1973 $/ta)	11.47
Fixed cost (1973 $/ta)	1.16
Total processing cost (1973 $/ta)[1]	12.63
Transportation	
Variable cost	2.16
Interest on VC[2]	0
Total VC (1973 $/mt cane)	2.16
Yield (mt cane/ta)[3]	3.1
Total VC (1973 $/ta)	6.70
Fixed cost (1973 $/ta)	0.43
Total transportation cost (1973 $/ta)	7.13
Total marketing cost (1973 $/ta)	19.76
Total marketing cost (1979 $/ta)[4]	33.60
Yield (mt sugar/ta)	0.35
Total marketing cost (1979 $/mt)	96.00
Unsubsidized costs:	
Imported input charge (30%)	28.80
Domestic component (70%)	67.20
Foreign exchange adjustment (1.20)	34.56
Unsubsidized marketing cost (1979 $/mt)	101.76

[1]based on Haina sugarmill costs

[2]no monetary interest charges were made

[3]irrigated

[4]1979 price index = 170, 1973 base year = 100

A cull milk cow price at the farm gate was derived, through linear regression, from time series data of the CEA livestock subdivision, CEAGANA (1979). A marketing charge of 56 percent of retail price was subtracted from the retail price, and a 48 percent factor was applied to convert from live weight to meat (Table 4-17).

Table 4-17. Calculation of Farm Gate Monetary and Unsubsidized Prices and Income for Livestock, Central Region, 1979 Current Normal

Prices:	(Monetary)	(Unsubsidized)
CIF import price (RD$/lb)	0.86	0.86
For.Exch. conversion (RD$/US$)	-	1.2
		1.03
Marketing charge (56%)	- 0.48	- 0.58
	0.38	0.45
Conversion factor, meat to live animal	x 0.48	x 0.48
Farm gate price (RD$/lb)	0.19	0.23
Income:		
Yield, meat (lb/ta)	23.5	23.5
Price (RD$/lb)	x 0.19	x 0.23
Income (RD$/ta)	4.47	5.40

Monetary Returns to Land and Management:

Monetary RLM were calculated by subtracting monetary costs of production from monetary income.

Data Analysis

This section of the chapter covers the agrophysical and economic analyses carried out on the data collected and processed as explained earlier in the chapter.

Agrophysical Analysis

The refined data obtained through the methods explained in the earlier sections of this chapter are analyzed in this section in order to select the GDSSs believed to have potential for rice production. Methods for selecting those GDSSs and determining the possibilities for multiple production cycles within them are presented. Procedures for estimation of GDSS physical area with rice potential, current rice production area, area with potential for expansion of current production, and current land use in that potential expansion area are discussed.

Perfect complementarity of agrophysical inputs is assumed in order to simplify the quantitative analysis. The implications of this assumption for study results is discussed in Chapter VI.

Selection of GDSSs with Rice Production Potential

Rice agrophysical requirements were crosstabulated with GDSS level land base characteristics in order to identify those GDSSs with characteristics within the tolerance limits for rice production. The GDSSs selected through this crosstabulation were subjected to the further analyses presented below.

Estimation of Potential Area for Rice Production

Although the GDSS analytical units were defined in Chapter II as "relatively homogeneous," there are a number of reasons why they could not be considered completely homogeneous for area estimation purposes in this study. In classification systems in general, taxonomic units are only considered to be homogeneous with respect to those criteria used to define each taxon. That implies that within a given taxonomic unit there can be heterogeneity of other criteria not used in taxon definition. A GDSS may be quite homogeneous with respect to the soil and water characteristics used in its classification, but heterogeneous with respect to other characteristics such as micronutrient availability, evapotranspiration, or light intensity.

Another, related, factor contributing to non-homogeneity of GDSSs for the purposes of this study was the inclusion of relatively small pockets of dissimilar soils and microclimates within each GDSS. The acceptance of "inclusions" was an operational imperative for keeping the number of taxonomic units within manageable limits. Research efforts were focussed on the dominant characteristics of the GDSSs of importance in the study, while less attention was given to the relatively unimportant inclusions.

These factors were taken into consideration in estimating the physical area potentially adaptable for rice production within each GDSS selected in the earlier analysis. The original CRIES (1977a) soils documentation indicated that up to 30 percent of a given GDSS may be made up of inclusions of contrasting soils. More recent information indicated that only about 20 percent of the area of the selected GDSSs in the Central Region (10 percent of GDSS 06A) had an acceptable evapotranspiration level for rainfed rice production (Reyna and Paulet, 1979). Thus, total physical area (ta) for each rainfed and irrigated GDSS was multiplied by a 0.7 factor to eliminate possible unusable inclusions. Then the resulting area estimates for each rainfed GDSS were multiplied by 0.2 (0.1 for GDSS 06A) to eliminate areas with unacceptable evapotranspiration levels.

Potential for Multiple Rice Production Cycles

Monthly water availability data was used to determine the feasibility of producing more than one rice crop per year in each selected GDSS. A minimum water availability from rainfall, surface, or underground sources of 138 mm/mo for four mo was the criterion for feasibility selection for each crop cycle. That criterion is based on water requirements for the most drought tolerant rice variety studied, Juma-57.

Current Land Use

The current normal rice production area by GDSS for each production cycle was taken directly from SIEDRA (1979d) data. No GDSS level quantitative data were available for sugarcane or for cultivated pastures. However, discussions with regional sugarcane and livestock production specialists indicated that there were at least 25,000 ta (as assumed in the hypothetical rice expansion strategies discussed later in this chapter) of each of these land uses in each of the screened GDSSs.

Potential Area for Rice Expansion

Physical area (ta) with potential for expansion of current rice production in each GDSS was calculated by subtracting the area of current rice production from the total area with potential for rice production. The analysis of the economic feasibility of production expansion in these areas is discussed in the next section.

Economic Analysis

Benefit-cost and partial budgeting of rice production alternatives were selected as the techniques for economic analysis of land resource use for five primary reasons. First, the producers who eventually may be asked to expand rice production will likely base their decision on a comparison of the expected benefits and costs of the proposed rice production alternatives with those of other land use options, such as sugarcane and cultivated pastures. Second, sufficient preliminary SIEDRA data were available with which to begin these analyses. Third, the approaches and their results can be communicated relatively easily to technicians and to decisionmakers. Fourth, several land use change impacts can be monitored simultaneously. Fifth, benefit-cost and partial budgeting information can form a basis for more comprehensive static and dynamic analyses.

Major limitations of the benefit-cost and partial budgeting techniques as used in this study include: (a) both are forms of comparative static analysis which ignore the dynamics of the transitions between static equilibria; (b) both ignore aggregation bias in input and output pricing; and (c) benefit-cost analysis lacks a widely accepted, consistent set of definitional and procedural standards among its various proponents. The implications of these limitations for the use of study results are treated in Chapter VI.

Benefit-Cost Analysis and Input Accounting

The procedure for converting the monetary production cost and income estimates discussed earlier to unsubsidized estimates is discussed first in this section. There follows a discussion of the comparisons made among the various production coefficient estimates.

Unsubsidized Production Cost and Income Estimates:

Unsubsidized Production Costs: Monetary variable costs for rice production were adjusted for the inflated official exchange rate on imported production inputs and for the implicitly subsidized costs for unpaid family labor, money tied up as operating capital, and irrigation water (Table 4-4). Instead of the official exchange rate of RD$1.00 = US$1.00, a current normal unsubsidized rate of RD$1.20 = US$1.00 was used. This rate was based on Central Bank (1979) time series data for the government sanctioned "parallel" or black market for foreign currency and was applied to the CIF import price of all imported inputs. Data on 1979 import prices were obtained from SEA (1979b) and from local importers. The sum of the adjusted costs of imported inputs was used as the estimate of foreign exchange use for rice.

The unsubsidized cost of unpaid family labor was computed at the local wage rate for unskilled labor, the same rate as that used for calculation of monetary cost. No adjustment of monetary wage rate was deemed necessary as the local labor markets are relatively competitive during the rice production cycles.

The unsubsidized cost of operating capital for rice production was calculated at 18 percent per annum for a six mo production cycle on both the 80 percent of variable input costs that typically are financed by the BAGRICOLA and the 20 percent of operating capital that the producers pay out of their own pockets. The 18 percent figure was based on an agricultural credit study carried out in 1979, which found that banks get around the legal 12 percent limit on interest rates by charging additional service fees in order to cover their real costs of loan servicing.

The unsubsidized cost for irrigation water was imputed on the basis of the marginal value of its most profitable alternative use, which was assumed to be sugarcane production in the GDSSs selected in the agrophysical analysis. It was further assumed that the diversion of irrigation water would reduce irrigated sugarcane and sugar yields by 10 percent and that the volume of water required to irrigate optimally 1 ta of riceland was equivalent to that required to irrigate 2 ta of sugarcane land. An average irrigated sugar yield of 3.0 mt/ta was used to calculate the imputed water cost.

Unsubsidized machinery fixed costs for rice production were calculated according to the procedure explained in the monetary cost section of this chapter, with the exception that the CIF import prices were adjusted for the inflated exchange rate.

Foreign exchange costs for sugarcane and cultivated pasture/milk were obtained by adjusting monetary costs of imported inputs for the inflated exchange rate (Tables 4-18 and 4-19). The simplifying assumption was made that 34 percent of total costs for rainfed and irrigated production was expended on foreign exchange-using inputs and the remaining 66 percent was spent on local labor and general overhead. This assumption was based on the average of the corresponding estimates for rice production. It was also assumed, because of lack of data, that all three land uses required equal proportions of imported inputs. Total foreign exchange use for sugarcane and cultivated pasture/milk was the sum of these adjusted input costs.

An unsubsidized interest rate of 16 percent per annum was charged on all sugarcane production costs on the assumption that the state owned CEA was a slightly better credit risk than were rice asentamientos and dairy farms which were charged a rate of 18 percent. Labor was priced at the local unskilled wage rate, as explained for the rice cost estimates.

Table 4-18. Derivation of Annual Monetary and Unsubsidized Costs of Production per Tarea for Sugarcane, in Four Rainfed and Four Irrigated GDSSs, Central Region, 1973 Indexed to 1979

Variable	Rainfed				Irrigated			
	07A	07B	20A	20B	07A	11Bi	16A	16B
	Base Mill Budget[1]							
	0	0	C	C[2]	0	H[2]	0[2]	0
Monetary Costs:	-----coefficient estimate-----							
Variable cost								
Cultivation	6.01	6.01	5.75	5.75	6.01	5.22	6.01	6.01
Harvest[3]	2.73	2.97	2.13	3.23	3.06	3.49	3.16	3.48
Total VC (1973 RD$/mt)	7.79	7.98	7.95	8.98	8.07	8.71	8.17	8.49
Yield (mt/ta)	2.9	3.1	2.1	3.2	3.2	3.1	3.3	3.6
Total VC (1973 RD$/ta)	22.59	24.74	16.70	28.74	25.86	27.00	26.96	30.56
Depreciation	2.82	2.82	5.38	5.38	2.82	2.78	2.82	2.82
Total cost (1973 RS$/ta)	25.41	27.56	22.08	34.12	28.68	29.78	29.78	33.38
Total monetary cost (1979 RD$/ta)[4]	43.20	46.85	37.54	58.00	48.76	50.63	50.63	56.75
Unsubsidized Costs:								
Imported input cost (US$/ta)[5]	14.70	15.93	12.76	19.72	16.58	17.21	17.21	19.30
Domestic input cost (RD$/ta)	28.50	30.92	24.78	38.28	32.18	33.42	33.42	37.45
Unsubsidized cost of imported inputd (RD$/ta)[6]	17.63	19.12	15.31	23.66	19.90	20.65	20.65	23.16
Total	46.13	50.04	40.09	61.94	52.08	54.07	54.07	60.61
Unsubsidized irrigation water cost (RD$/ta)[7]	0	0	0	0	4.93	4.93	4.93	4.93
Total	46.13	50.04	40.09	61.94	57.01	59.00	59.00	65.54
Unsubsidized interest cost[8]	6.08	6.72	4.54	7.84	7.04	7.36	7.36	8.32
Total unsubsidized cost (1979 RD$/ta)	52.21	56.76	44.63	69.78	64.05	66.36	66.36	73.86

[1] Yield related costs adjusted from these budgets
[2] C = Catarey, H = Haina, 0 = Ozama
[3] Costs adjusted by sugarcane yield index
[4] 1979 price index = 170, 1973 = 100
[5] 34 percent of total monetary cost
[6] US$1.00 = RD$1.00 unsubsidized exchange rate
[7] Based on sugarcane response to water, as explained in text
[8] 16 percent annual rate on variable costs

Table 4-19. Derivation of Annual Monetary and Unsubsidized Costs of Production per Tarea for Cultivated Pasture/Milk in Four Rainfed and Seven Irrigated GDSS, Central Region, 1973, Index to 1979

Variable	Rainfed				Irrigated						
	07A	07B[1]	20A	20B	06A	07A	11Bi	16A	16B	21A	21B
Milk Yield Index	94	100	68	103	113	113	110	116	129	116	129
Monetary costs:											
Variable cost											
Equipment, pasture maintenance					10.26						
Feed, labor, interest[2]	16.00	17.01	11.57	17.52	19.22	19.22	18.71	19.73	21.94	19.73	21.94
Total VC (1973 RD$/ta)	26.25	27.27	21.83	27.78	29.48	29.48	28.97	30.00	32.20	30.00	32.20
Depreciation, interest on FC[3]					6.00						
Total Cost (1973 RD$/ta)	32.25	33.27	27.83	33.78	35.48	35.48	34.97	36.00	38.20	36.00	38.20
Total monetary cost (1979 RD$/ta)[4]	41.93	43.25	36.18	43.91	46.12	46.12	45.46	46.90	49.66	46.80	41.66
Unsubsidized costs:											
Imported input cost (US$/ta)[5]	14.26	14.70	12.30	14.93	15.60	15.68	15.46	15.91	16.88	15.91	16.88
Domestic input cost (RD$/ta)	27.67	28.55	23.88	28.98	30.44	30.44	30.00	30.87	32.78	30.89	32.78
Unsubsidized cost of imported inputs (RD$/ta)[6]	17.11	17.65	14.76	17.92	18.82	18.82	18.55	19.09	20.26	19.09	20.26
Total	44.78	46.20	38.64	46.90	49.26	49.26	48.55	49.98	53.04	49.98	53.04
Unsubsidized irrigation water cost (RD$/ta)[7]	0	0	0	0				4.73			
Total	44.78	46.20	38.64	46.90	53.99	53.99	53.28	54.71	57.77	54.71	57.77
Unsubsidized interest cost (RD$/ta)[8]	7.59	7.85	6.49	7.97	9.18	9.18	9.05	9.31	9.86	9.31	9.86
Total unsubsidized cost (1979 RD$/ta)	52.37	54.05	45.13	54.87	63.17	63.17	62.35	64.02	67.63	64.02	67.63

[1]Yield related costs adjusted from this base budget
[2]Costs adjusted by milk yield index; interest rate 8 percent annual
[3]Interest rate 8 percent annual
[4]1979 price index 130, 1973 = 100
[5]34 percent of total monetary cost
[6]US$1.00 = RD$1.20 unsubsidized exchange rate
[7]Based on sugarcane response to water, as explained in text
[8]18 percent annual rate

<u>Irrigation Infrastructure Investment</u>: No irrigation infrastructure costs were estimated for the rice area expansion. This was based on the assumptions that there were at least 25,000 ta of irrigated sugarcane and cultivated pasture which could be converted to rice production in each selected GDSS and that sugarcane and cultivated pasture irrigation infrastructure was a close substitute for rice infrastructure. These assumptions are discussed in Chapter VI.

<u>Unsubsidized Income</u>: Unsubsidized income was calculated by multiplying yields by the unsubsidized output prices. The unsubsidized output price for each product at the farm gate was derived from the CIF import price, after that price was adjusted for the foreign exchange differential by netting out marketing charges and converting from processed to unprocessed product (Tables 4-14, 4-15, 4-17, and 4-20).

Table 4-20. Derivation of Unsubsidized Farm Gate Prices from CIF Import Prices for White Rice and Reconstituted Milk, Central Region, 1979 Current Normal

Parameters	Rice	Milk
	(per qq)	(per lt)
CIF import price (US$)	21.90	0.10
Foreign exchange conversion rate, unsubsidized[1]	x 1.2	x 1.2
Unsubsidized CIF import price (RD$)	26.28	0.12
Marketing charge	- 6.10	- 0.12
	20.18	0
Conversion factor, processed to unprocessed	x 0.65	x 1
Unsubsidized farm gate price (RD$)	13.12	0

[1]US$1.00 = RD$1.20

Current normal import prices for rice were estimated from INESPRE (1979) data. Refined sugar CIF import prices were taken from World Bank (1979) estimates of long term expected world prices. In the absence of an import market for pasteurized milk, the unsubsidized cost of milk was estimated on the basis of the CIF import price of reconstituted powdered milk (Associacion, 1979). The assumption was made that reconstituted milk was a close substitute for pasteurized milk and is discussed in Chapter VI.

Unsubsidized marketing charges for rice, sugarcane, and cultivated pasture/milk were derived from monetary cost estimates (Tables 4-16, 4-17, and 4-21). Regional average monetary costs per qq of white rice were calculated from INESPRE (1979) data for five major mills in the Central Region (Table 4-21). Milled white rice with 14 percent moisture content was calculated at 65 percent of rough rice wieght with 20 percent humidity (Murphrey, 1972; SEA, 1977a). Regional average rice transportation costs per qq to the local mill and from there to the Santo Domingo retail markets were calculated from INESPRE (1979) data. Rice wholesaling and retailing charges were estimated at 16 percent of current normal retail price as based on a 1977 SEA marketing report.

Monetary marketing charges for sugarcane and livestock were discussed in the data collection section of this chapter (Tables 4-16 and 4-17). A monetary charge for milk marketing was based on SEA (1977a) marketing margin estimates for 1975. These costs were calculated at 36 percent of the 1979 retail pasteurized milk price.

Unsubsidized charges for marketing the three products were calculated by multiplying estimated monetary costs for imported inputs by the unsubsidized exchange rate of RD$1.20 = US$1.00, and adding an interest

Table 4-21. Derivation of Unsubsidized Marketing Costs from Monetary Costs for Rice, Central Region, 1979 Costs

Monetary costs:	($/qq)
Processing	
Machinery	1.41
Labor	0.35
Total processing	1.76
Transportation	
Farm to mill	0.45
Mill to Santo Domingo	0.30
Total transportation	0.75
Total processing and transportation	2.51
Sales margin[1]	3.24
Total monetary marketing cost	5.75
Unsubsidized costs:	
Imported input charge (30%)	1.72
Foreign exchange adjustment (1.2)	2.07
Unsubsidized marketing cost	6.10

[1]16% of 1979 retail price of $20.25/qq

charge of 16 and 18 percent, respectively, for sugarcane and the other two products. These adjusted costs were added to domestic input costs to obtain total unsubsidized marketing costs. Rice imported input costs were calculated to be 30 percent of total marketing costs. Based on this estimate, unadjusted imported input costs for sugarcane and milk/cull animals were calculated at 30 percent of total marketing costs.

Unsubsidized labor costs were estimated at the local unskilled wage labor rate, as explained earlier.

Unsubsidized Returns to Land and Management: Unsubsidized RLM was calculated by subtracting unsubsidized costs of production from unsubsidized income.

Comparisons of Production Coefficient Estimates:

Comparisons were made among the three land uses of monetary and unsubsidized production costs, monetary and unsubsidized (RLM), and production labor and foreign exchange use on a per tarea (ta) basis. Rice production cost subsidies were calculated, and privately-owned and state-owned machinery costs were compared. The purpose of the comparisons was to characterize production activities in each GDSS as a prelude to the partial budgeting analysis discussed below.

Partial Budgeting Analysis of Rice Area Expansion

The economic data developed in this study was used to analyze the regional and GDSS level impacts on production, labor use, foreign exchange use, and producer monetary and unsubsidized RLM of 11 alternative strategies for a hypothetical 25,000 ta expansion of current rice area (Table 4-22). The strategies were identified from among the various possible combinations of decision rules (maximization of rice production, monetary and unsubsidized RLM at the farm gate, and production labor, and minimization of foreign exchange use) and policy variables (single and multiple production cycles for rice, current normal and alternative production techniques for rice, and increased production on current GDSSs, expansion in current GDSSs, and expansion in potential GDSSs).

The first three strategies (A-c) involved maximization of rice production under various assumptions on the policy variables. The next four strategies called for maximization of rice monetary RLM (D and E) and rice

Table 4-22. Assumptions on Five Decision Variables and Three Policy Variables for 11 Strategies for Exapnsion of Rice Production Area, Central Region

Variable	CN	Strategy A	B	C	D	E	F	G	H	I	J	K
Decision Rule												
Production max	a	x	x	x								
Rtn L&M, Monetary	a				x	x						
Unsubsi.							x	x				
Labor max	a								x	x		
For Exchange min	a										x	x
Policy variable												
Pdn Technique												
Typical	a		x		x		x		x		x	
Alternative		x										
Production Cycles				A		A		A		A		
Current Normal	a	x		N	x	N	x	N	x	N	x	
Potent multiple			x	Y		Y		Y		Y		
GDSS												
Curr Normal area	a	x	x		x		x		x		x	
Expand curr norm												
Potential												

unsubsidized RLM (F and G). The final four strategies required maximization of labor use in rice production (H and I), and maximization of foreign exchange use in rice production (J and K).

Partial budgeting of the net impacts of each strategy (production, RLM, labor, foreign exchange use) were carried out at the GDSS and regional levels (Table 4-23). Added costs and reduced benefits associated with each rice expansion alternative were subtracted from the added benefits and reduced costs which were expected to occur. In each case, rice was assumed to substitute in each GDSS for the least profitable of the sugarcane and cultivated pasture/milk land use alternatives. The strategies then were ranked on the basis of net regional impact on each of the studied variables.

Table 4-23. Sample Partial Budgeting Calculations for Rice Expansion, Central Region, 1979 Current Normal

GDSS	Rain/ Irr	Land Use	Parameters					Solution (change from CN)				
			Expan area[1]	Cycles poss	Rice Yield[2]	RLM[3]		Rice area[1]	Cycles	Rice Pdn[4]	RLM[3]	
						Mon	Unsub				Mon	Unsub
20B	R	Rice, typ	34	2	5.0	35	33		0			
		alt			4.0	28	24		0			
		Sugarcane				25	36		0			
		CP/Milk				0	-49		0			
06A	I	Rice, typ	16	3	5.4	21	6		0			
		alt			5.0	28	17	5	3	75	420	255
		Sugarcane				NA[5]	NA[5]		0			
		CP/Milk				2	-58		1		10	-290
07A	I	Rice, typ	20	3	6.0	31	19		0			
		alt			6.0	36	26	20	3	360	2160	1560
		Sugarcane				34	42		0			
		CP/Milk				2	-58		1		40	-1160
07As	...											
Added rice benefits								25		435	2580	1815
Reduced sugarcane or CP/milk benefits								0		0	50	-1450
Net regional impact								25		435	2530	3265

[1] 1,000 ta
[2] qq/ta
[3] $1,000
[4] 1,000 qq
[5] data not available

Table 4-23 (Continued)

Strategy E assumed maximization of rice monetary RLM with free choice among other production parameters. The computation procedure for determining the net regional impact of the rice expansion was as follows:

1. select the GDSS and rice production technique with the highest annual monetary RLM per ta (i.e., irrigated GDSS 07A using alternative production techniques with 3 cycles/yer x $36/cycle = $108/yr).

2. if there are less than 25,000 ta of expansion area available in the GDSS selected in (1), select the GDSS and rice production technique with the second highest RLM (i.e., irrigated GDSS 06A using alternative techniques with 3 cycles/yr x $28/cycle = $84/yr).

3. calculate added rice production benefits:

   a. for the GDSS and technique selected in (1), multiply number of possible rice production cycles by the expansion area available up to 25,000 ta total, then multiply the result by the parameter values for each of the impacts (rice yield, monetary and unsubsidized RLM in the example) to obtain the added rice benefits in the GDSS (e.g., 3 cycles x 20,000 ta x $36/ta monetary x RLM = $2,160,000 monetary RLM).

   b. repeat (3a) for the GDSS and technique selected in (2) up to 25,000 ta combined total (e.g., 3 cycles x 5,000 ta x $28/ta monetary RLM = $420,000 monetary RLM).

   c. for each impact, sum across GDSSs to obtain the regional added rice benefits (e.g., $420,000 + $2,160,000 = $2,580,000 monetary RLM).

4. calculate reduced sugarcane or CP/milk benefits:

   a. for the GDSS selected in (1), determine whether sugarcane or CP/milk has the lowest monetary RLM, then multiply the expansion area by the corresponding impact parameter to obtain the reduced benefits (e.g., 20,000 ta x $2/ta monetary RLM (cp/milk) = $40,000 monetary RLM).

   b. repeat (4a) for the GDSS and technique selected in (2) (e.g., 5,000 ta x $2/ta monetary RLM (cp/milk) = $10,000 monetary RLM).

   c. for each impact, sum across GDSSs to obtain the regional reduced sugarcane and CP/milk benefits (e.g., $40,000 + $10,000 = $50,000 monetary RLM).

5. calculate regional net impact of the rice expansion: subtract the reduced sugarcane and CP/milk benefits in (4c) from the added rice benefits in (3c) to obtain the net regional impact (e.g., $2,580,000 - $50,000 = $2,530,000 monetary RLM).

A sensitivity analysis of the assumptions on potential for multiple cycle rice production was conducted on two of the "best" overall strategies for rice expansion. The best overall strategies were selected on the basis of most consistent high ranking among the five regional impacts monitored. GDSSs with possibilities for three rice production cycles were restricted to two cycles in the sensitivity analysis. The purpose of the analysis was to determine the effect on study restuls of a possible field determination that a maximum of only two cycles were possible in the Central Region.

CHAPTER V

ANALYTICAL RESULTS

In this chapter the results of the agrophysical and economic analyses are presented. Agrophysical results include the selection of GDSSs with rice production potential, major limiting factors to rice production, and, within each selected GDSS, potential physical area for rice production, rice multiple production cycle potential, current land use, and potential area for rice expansion.

Results of the economic analyses include both per tarea benefit-cost and impact accounting estimates for each GDSS selected in the agrophysical analysis and partial budgeting estimates of the regional and GDSS level impacts of alternative strategies for rice production expansion. The partial budgets monitored, for 11 strategies for a hypothetical 25,000 ta expansion of rice production, regional impacts on rice production, net (combined rice, sugarcane, and cultivated pasture/milk) monetary returns to land and management (RLM), net unsubsidized RLM, net labor use in production, and net foreign exchange use in production. Completing the chapter are results of the sensitivity analysis of two selected strategies as they are applied in testing the assumptions related to potential for rice multiple production cycles.

Agrophysical Results

The agrophysical results begin with the selection of GDSSs with rice production potential and a discussion of the major limiting factors preventing rice production in many of the GDSSs in the region. Then follow the results of the analysis of each of the selected GDSSs for determination of physical area with rice potential, potential for multiple rice production cycles, current land use, and potential area for rice production expansion.

GDSSs with Rice Production Potential

Crosstabulation of the rice agronomic requirements with the water and soil characteristics of each GDSS, considered with additional relevant information, resulted in the identification of four GDSSs as having rainfed rice production potential and six GDSSs and two inclusions of two GDSSs as having irrigated potential (Table 5-1). The four rainfed GDSSs were 07A, 07B, 20A and 20B, and the six GDSSs with irrigated rice potential were 06A, 07A, 16A, 16B, 21A and 21B. In addition, a swampy area of rice production reported in 07A was field checked and determined to be a single area of atypical soils ("inclusion"), which is referred in the rest of this paper as GDSS "07As". A second inclusion occurs in GDSS 11B. Soil descriptions in the SIEDRA (1979a) land resource base document indicate that GDSS 11B has slopes over 3 percent and, therefore, according to the 3 percent maximum slope criterion used in this study, has no irrigation potential. However, SIEDRA (1979c) interview results indicated a current normal area of 10,000 ta of irrigated rice in 11B. A field check of this apparent paradox revealed that the production in this GDSS takes place in a unique inclusion of naturally subirrigated soils. This area henceforth will be referred to as GDSS "11Bi".

Initially GDSSs 01A and 02B were identified as having rice production potential. Field checks indicated that the areas with rice potential

Table 5-1. Agrophysical Adaptability of Rice to Nine Water and Soil Characteristics in 29 GDSSs, and Major Limiting Factors, Central Region

GDSS	Water: Rainfall	Water: Surface	Water: Underground	Soils: Slope: Rainfed	Soils: Slope: Irrigated	Soils: Depth	Soils: Texture	Soils: pH	Soils: Salinity	Major Limiting Factor[1]: R	Major Limiting Factor[1]: I
	---Adaptability[2]---			-----------Adaptability[2]-----------							
01A	n	A	n	A	A	A	A	A	A	w	d
B	n	A	n	A	n	A	A	A	A	w	s
02A	A	A	n	n	n	A	A	Q	A	s	s
B	A	A	n	A	n	A	A	Q	A	d	d
06A	n	A	n	A	A	A	A	A	A	w	A
B	n	A	n	A	n	A	A	A	A	w	s
07A	A	A	A	A	A	A	A	Q	A	A	A
B	A	A	n	A	n	A	A	Q	A	A	s
09A	A	n	n	n	n	A	A	A	A	s	s
B	A	n	n	A	n	A	A	n	A	p	s
11A	n	A	n	A	n	A	A	A	A	w	s
B	n	A	A	A	n	A	A	A	A	w	s
16A	n	A	n	A	A	A	A	A	A	w	A
B	n	A	n	A	A	A	A	A	A	w	A
19A	n	n	n	A	n	A	A	A	A	w	w
B	n	n	n	A	n	A	A	A	A	w	w
20A	A	A	n	A	n	A	A	Q	A	A	s
B	A	A	n	A	A	A	A	A	A	A	L
21A	n	A	n	A	A	A	A	Q	A	w	A
B	n	A	n	A	A	A	A	A	A	w	A
22A	n	n	n	A	A	A	A	A	A	w	w
B	n	n	n	A	n	A	A	A	A	w	w
23A	n	n	n	A	n	A	A	A	A	w	w
25A	n	A	n	A	A	A	A	n	A	w	p
B	n	A	n	A	n	A	A	n	A	w	s
40A	n	A	n	A	n	A	A	Q	A	w	s
B	n	A	n	A	n	A	A	Q	A	w	s
41A	n	n	n	n	n	A	A	A	A	w	w
B	n	n	n	A	n	A	A	A	A	w	w

[1] R = rainfed
I = irrigated
d = dispersion and size
s = slope
w = water
p = pH
L = legal
A = adaptable

[2] A = adaptable
Q = questionable
n = not adaptable

within these GDSSs are very small and dispersed and thus are not appropriate for consideration for a major rice expansion program. For this reason they were dropped from further quantitative analysis.

GDSS 20B also was identified in the preliminary analysis as having irrigated rice potential. However, in the gathering of additional information it was learned that the available surface water in 20B is limited by a 40 year old law to industrial use only. This GDSS was dropped from further consideration for irrigated rice production under the assumption that the law is not likely to be changed in the foreseeable future.

Limiting Factors

The most common limiting factor for rainfed production was water, which eliminated from consideration 21 of the 29 (69 percent) of the GDSSs in the Central Region (last column of Table 5-1). Slope eliminated two rainfed GDSSs and size (dispersion) and pH eliminated one each.

The major limiting factors for irrigated production were slope, which caused 41 percent of the regions GDSSs to be withdrawn from consideration, and water, which precluded 28 percent from further analysis. Size eliminated two GDSS, and pH and legal factors eliminated one each.

Potential Physical Area for Rice Production

Total physical land area in the Central Region with rice production potential was estimated at 314,000 ta rainfed and 106,000 to irrigated (Table 5-2). Potential rainfed land area by GDSS ranged from 34,000 ta in GDSS 20B to 119,000 ta in 07A. Potential irrigated land area ranged from a minimum of 9,000 ta in three GDSSs to a maximum of 21,000 ta in 21A.

Table 5-2. Four Agrophysical Characteristics of the 12 GDSSs with Rice Potential in the Central Region, 1979

GDSS	Physical Area with Potential	Rice Multiple Cycles		Physical Rice Area	Potential Area for Rice Expansion
	(1,000 ta)	(actual)	(potential)	(1,000 ta)	(1,000 ta)
Rainfed:					
07A	119	1	1	4	115
07B	98	0	1	0	98
20A	63	0	2	0	63
20B	34	0	2	0	34
	314			4	310
Irrigated:					
06A	14	3	3	5	16
07A	20	0	3	0	20
07As	14	1	3	14	0
11Bi	10	2	3	10	0
16A	9	2	2	8	5
16B	9	0	2	0	5
21A	21	1	1	1	20
21B	9	1	1	0	9
	106			38	68
Total	420			42	378

Potential for Multiple Rice Production Cycles

Multiple cycle rice production in rainfed GDSSs was determined to be feasible only in GDSSs 20A and 20B between the months of April and November, and then only for rice varieties with production cycles of less than 120 days (Table 5-2). Multicycle irrigated production was identified as feasible in five of the seven GDSSs selected as having irrigated production potential. The mountain valley GDSSs, 21A and 21B, were found to have sufficient water for two rice cycles, but field checks with local agricultural officials indicated that cloudiness and temperature preclude a second cycle with rice varieties currently available.

Double irrigated cycles are feasible in GDSSs 16A and 16B between the months of May and October by utilizing a combination of surface water and rainfall. Triple irrigated cycles were determined to be feasible in GDSSs 06A, 07A, 07As and 11Bi. Year-round water is usually available from the Taveras Dam for irrigation in GDSS 06A. Underground water is available during the entire year in GDSS 07A and in the 07As and 11Bi subirrigated inclusions.

Current Land Use

Rice is produced in one of the rainfed GDSSs and five of the irrigated GDSSs identified as having potential for rice production (Table 5-2). There are currently about 4,000 ta of rainfed rice in GDSS 07A. Current irrigated area ranges from slightly more than 1,000 ta in GDSS 21A to approximately 14,000 ta in GDSS 07As.

Sugarcane and cultivated pasture areas of rainfed and irrigated production were not estimated in the study but were assumed, with three exceptions, to be at least 25,000 ta in each GDSS with rice production potential. The exceptions, encountered during field spot checking of the basic assumption, are: (a) no sugarcane production in GDSSs 07As, 21A, or 21B, (b) no sugarcane analysis on GDSS 06A (all privately owned) due to a lack of available data, and (c) no current production of cultivated pasture in GDSS 07As.

Potential Area for Rice Expansion

Total physical area potentially available for expansion of rice production was estimated at 310,000 ta for rainfed and 68,000 ta for irrigated production (Table 5-2). Area within individual rainfed GDSSs ranged from 34,000 ta in GDSS 20B to 115,000 ta 07A. Potential irrigated area for rice expansion varied from zero in 07As and 11Bi to 20,000 ta in 07B and 21A.

Economic Results

Results of the economic analysis are divided into the benefit-cost results and results of the partial budgeting of the hypothetical 25,000 ta rice area expansion in the GDSSs selected in the agrophysical analysis. Land uses considered are rice, sugarcane, and cultivated pasture used for pasteurized milk production. Presented in the benefit-cost results are estimates of per tarea product yields, monetary costs of production, unsubsidized costs of production, rice production subsidies, production labor use, foreign exchange use in production, monetary returns to land and management (RLM) at the farm gate, and unsubsidized RLM at the farm gate level.

In the partial budgeting results are estimates of the regional impacts of rice expansion on net (combined rice, sugarcane, cultivated pasture/milk) production parameter values. Regional impacts monitored include rice production, labor use in production, foreign exchange use in production, monetary RLM, and unsubsidized RLM at the farm gate level. Finally, results of the sensitivity analysis of changes in the rice multiple production cycle assumptions on the impacts of two selected expansion strategies are presented.

Benefit-Cost Analysis and Impact Accounting

This section presents the parameter estimates associated with rice, sugarcane, and cultivated pasture used for pasteurized milk production in each GDSS selected in the agrophysical analysis. Benefit-cost results include accounting of per tarea (ta) yields, monetary production costs, unsubsidized production costs, rice production subsidies, monetary returns to land and management (RLM) at the farm gate, unsubsidized RLM, production labor use, and foreign exchange use. Closing the section are comparisons between monetary and unsubsidized costs of rice production machinery. This analysis provides both a comparison of GDSS production potential characteristics and data input to the partial budgeting analysis of the next section of the chapter.

In this section the reader should bear in mind that the estimates are on a per cycle and per tarea basis for the rice parameters and on per year and per tarea basis for the other two products. This must be taken into consideration when making comparisons between the rice (a short cycle plant) coefficients and the sugarcane and cultivated pasture (perennial plants) coefficients.

Farm Gate Yields

Estimates of rice yields at the farm level for current normal production techniques ranged from 2.8 to 6.0 qq/ta per cycle (Table 5-3). Rainfed yields ranged from the 2.8 qq/ta in GDSS 07A to 5.0 in 20B. Irrigated yields averaged about 20 percent higher than the rainfed yields, with the highest being 6.0 qq/ta in GDSSs 07A and 07As. Corresponding rice yields for the alternative production techniques generally were slightly lower than those for the current normal techniques.

Table 5-3. Current Normal Farm Gate Yields for Rice Typical and Alternative Production Techniques, Sugarcane and Cultivated Pasture/Milk by Rainfed and Irrigated GDSSs, Central Region, 1979

GDSS	Rice		Sugarcane	Cultivated Pasture/Milk
	Typical	Alternative		
	----qq/ta/cycle-----		(mt/ta/yr)	(lt/ta/yr)
Rainfed:				
07A	2.8	4.0	2.9	124
07B	3.5	3.0	3.1	132
20A	4.0	3.0	2.1	90
20B	5.0	4.0	3.2	136
Irrigated:				
06A	5.4	5.0	NA[1]	149
07A	6.0	6.0	3.2	149
07As	6.0	6.0	0	0
11Bi	3.7	3.6	3.1	145
16A	4.9	4.0	3.3	153
16B	4.0	3.0	3.6	170
21A	4.5	4.0	0	153
21B	4.0	3.5	0	170

[1]Data not available

Sugarcane yield estimates for the GDSSs with rice potential varied from 0 to 3.6 mt/ta per yr. Rainfed sugarcane yields ranged from 2.1 to 3.2 mt/ta and irrigated yields from 0 to 3.6 mt/ta. Sugarcane production was judged to be unfeasible in GDSSs 07As, 21A, and 21B due to soils and temperature conditions. No information was available on sugarcane production for the privately owned GDSS 06A.

Cultivated pasture/milk yields in the rice potential GDSSs ranged from 0 to 170 lt.ta per yr. Rainfed milk yields varied from 90 to 136 mt/ta. Irrigated milk yields ranged from 0 to 170 lt/ta. Livestock live weight yields were estimated at a constant 10 kg/ta for all GDSSs. Cultivated pasture production for dairy purposes was judged to be unfeasible in GDSS 07As.

Monetary Costs of Production

The monetary costs of production are producer cash expenses. Monetary costs of production for rice using typical production techniques varied from $20 to $44 per cycle per ta (Table 5-4). The alternative techniques resulted in lower costs than the typical techniques in three of the four rainfed GDSSs (07A was the exception) and in all of the irrigated GDSSs.

Sugarcane monetary production costs ranged from $38 to $58 per ta per yr. Cultivated pasture/milk monetary costs of production varied from $36 to $50 per ta per yr. Cultivated pasture/milk costs were consistently lower than the sugarcane costs. The differences were slight ($1 to $12) and may have been due more to the cost algorithm used in computations than to real differences.

Table 5-4. Current Normal Monetary and Unsubsidized Costs of Production for Rice Typical and Alternative Production Techniques, Sugarcane and Cultivated Pasture/Milk in 12 GDSSs, Central Region, 1979

GDSS	Monetary				Unsubsidized			
	Rice		Sugarcane	Cultivated Pasture/Milk	Rice		Sugarcane	Cultivated Pasture/Milk
	Typical	Alt			Typical	Alt		
	--$/ta/cycle--		($/ta/yr)	($/ta/yr)	--$/ta/cycle--		($/ta/yr)	($/ta/yr)
Rainfed:								
07A	20	33	43	42	31	44	52	52
07B	32	24	47	43	43	34	57	54
20A	20	15	38	36	26	21	45	45
20B	25	20	58	44	33	28	70	55
Irrigated:								
06A	44	32	NA[1]	46	65	48	NA[1]	63
07A	41	36	49	46	60	53	64	63
07As	34	34	0	0	46	46	0	0
11Bi	41	24	51	45	61	38	66	62
16A	39	26	51	47	57	40	66	64
16B	32	31	57	50	48	46	74	67
21A	34	29	0	47	51	44	0	64
21B	39	32	0	50	55	47	0	68

[1]Data not available

Unsubsidized Costs of Production

The unsubsidized production costs are monetary costs adjusted for implicit subsidies. The unsubsidized cost of estimates for rice using typical production techniques ranged from \$26 to \$65 per cycle per ta, a figure which averaged about 20 to 40 percent higher than the corresponding monetary costs (Table 5-4). In all cases except in rainfed GDSS 07A the unsubsidized production costs were higher for the typical rice production techniques than for the alternative techniques. This was due primarily to the use of fewer imported inputs in the alternative set of production techniques.

Sugarcane unsubsidized costs of production ranged from \$45 to \$74 per ta per yr. Cultivated pasture/milk unsubsidized costs of production were estimated at \$45 to \$68 per ta per yr. In all GDSSs the cultivated pasture/milk unsubsidized costs were slightly (\$0 to \$15) lower than those for sugarcane.

Rice Production Cost Subsidy

The difference between the unsubsidized costs and the monetary costs of rice production are subsidies. They are largely income transfers from taxpayers and consumers to rice producers.

Subsidies for all rice production ranged from \$7 to \$21 per cycle per tarea (Table 5-5). Rainfed subsidies averaged about \$8 per ta less than irrigated subsidies for typical rice production techniques and about \$6 less for the alternative techniques. There was little difference in subsidy levels between production techniques for rainfed GDSSs, but the alternative technique subsidies were slightly lower than the subsidies for typical techniques in irrigated GDSSs. Estimates of subsidies for machinery are discussed later in the chapter.

Table 5-5. Current Normal Rice Production Cost Subsidy for Typical and Alternative Production Techniques, Production Cycles, Area, and Total Subsidy for 12 GDSSs, Central Region, 1979

GDSS	Subsidy		Pdn Cycles	Phys Area	Total Subsidy (typ tech)
	Typical	Alternative			
	----$/ta/cycle------		(no.)	(1,000 ta)	($1,000)
Rainfed:					
07A	11	12	1	4	44
07B	2	9	0	0	0
20A	7	5	0	0	0
20B	8	8	0	0	0
Irrigated:					
06A	21	16	3	5	315
				0	0
07As	18	17	1	14	252
11Bi	29	14	2	10	580
16A	18	14	2	8	288
16B	15	16	0	0	0
21A	16	15	1	1	16
21B	18	16	0	0	0
Regional Total					1,495

Monetary Returns at the Farm Gate

Monetary returns represent the difference between monetary costs and monetary income. Rice monetary returns to land and management (RLM) at the farm gate were estimated at $4 to $38 per cycle per ta using typical production techniques (Table 5-6). Rainfed returns ranged from $10 to $35/ta and irrigated returns from $4 to $38/ta. The highest rainfed returns were in GDSSs 20A and 20B and the highest rainfed returns were in 07A and 07As. In half of the rainfed GDSSs and in all but two of the

Table 5-6. Current Normal Unsubsidized Returns to Land and Management Rice Typical and Alternative Production Techniques, Sugarcane and Cultivated Pasture/Milk in 12 GDSSs, Central Region, 1979

GDSS	Monetary				Unsubsidized			
	Rice		Sugarcane	Cultivated Pasture/Milk	Rice		Sugarcane	Cultivated Pasture/Milk
	Typical	Alt			Typical	Alt		
	--$/ta/cylce--		($/ta/yr)	($/ta/yr)	--$/ta/cycle--		($/ta/yr)	($/ta/yr)
Rainfed:								
07A	13	15	32	-1	6	8	44	-47
07B	10	12	34	0	3	6	46	-49
20A	28	21	17	-6	26	19	25	-40
20B	35	28	25	0	33	24	36	-50
Irrigated:								
06A	21	28	NA[1]	2	6	17	NA[1]	-58
07A	31	36	34	2	19	26	42	-58
07As	38	38	0	0	33	33	0	0
11Bi	4	19	30	1	-13	9	36	-57
16A	20	22	35	2	7	12	43	-58
16B	16	5	37	4	5	-7	45	-62
21A	20	19	0	2	8	9	0	-59
21B	9	10	0	4	-3	-1	0	-62

[1]Data not available

irrigated GDSSs the alternative production techniques provided returns at least as high (difference of $0 to $15) as those for the typical techniques.

Sugarcane monetary returns ranged from $27 to $37 per ta per yr. Cultivated pasture/milk monetary RLM varied between (-) $6 and $4 per ta per yr. The negative returns in some of the GDSSs are consistent with results reported in a recent dairy association report (Associasion, 1979). In all GDSSs both single cycle rice and sugarcane provided higher monetary returns than did cultivated pasture/milk.

Unsubsidized Returns at the Farm Gate

Unsubsidized returns are the difference between unsubsidized costs and unsubsidized income. Rice unsubsidized RLM at the farm gate were all lower than monetary RLM and were estimated at (-) $13 to $33 per cycle per ta using typical production techniques (Table 5-6). Rainfed unsubsidized returns varied from $3 to $33/ta and irrigated returns from (-) $13 to $33/ta. The alternative techniques provided returns at least as high as those for the typical techniques in half of the rainfed GDSSs and in all but one of the rainfed GDSSs.

Sugarcane unsubsidized returns varied from $25 to $46 per ta per yr. Unsubsidized returns to cultivated pasture/milk were all negative and varied from (-) $62 to (-) $40 per ta per yr. The negative returns to milk production result from the assumption that reconstituted imported powdered milk is an acceptable substitute for fresh milk among Dominicans. That assumption results in an opportunity price of $0 at the farm level, which in turn causes all production costs to become negative returns. Sugarcane provided the highest and cultivated pasture/milk the lowest annual unsubsidized returns among the three land uses in all GDSSs, with the exception that rice provided the highest return in rainfed GDSS 20A.

Labor Use in Production

Using current normal rice production techniques, labor use estimates varied from 18 to 41 hr per cycle per ta (Table 5-7). Labor use in rainfed production averaged slightly over half of that for irrigated production. The highest labor use in rainfed GDSSs was in 07B and in irrigated GDSSs was in 06A. In all GDSSs except irrigated 06A the alternative techniques were slightly more labor intensive than the typical techniques.

Sugarcane labor use varied from 26 to 31 hr per ta per yr. Labor use in rainfed production averaged about 10 percent higher than that for irrigated production. Labor use in cultivated pasture/milk production ranged from 5 to 7 hr per ta per yr, and was slightly higher for irrigated production than for rainfed production. Cultivated pasture/milk used only about 20 percent as much annual labor per ta as did sugarcane.

Foreign Exchange Use in Production

Estimates of foreign exchange use in rice production with current normal production techniques ranged from \$5 to \$16 per ta (Table 5-7). Rainfed estimates varied from \$6 to \$10/ta, and irrigated estimates varied from \$5 to \$16/ta.

Foreign exchange use in rice production utilizing the alternative production techniques ranged from \$3 to \$8 per cycle per ta. With the exception of rainfed GDSS 07A, the alternative production techniques used approximately half as much foreign exchange as did the typical techniques. No foreign exchange is produced through rice exportation.

Table 5-7. Current Normal Labor and Foreign Exchange Use for Rice Typical and Alternative Production Techniques, Sugarcane and Cultivated Pasture/Milk in 12 GDSS, Central Region, 1979

GDSS	Monetary				Unsubsidized			
	Rice		Sugarcane	Cultivated Pasture/Milk	Rice		Sugarcane	Cultivated Pasture/Milk
	Typical	Alt			Typical	Alt		
	--hr/ta/cycle--		(hr/ta/yr)	(hr/ta/yr)	--$/ta/cycle--		($/ta/yr)	($/ta/yr)
Rainfed:								
07A	20	34	28	6	7	8	-84	6
07B	28	32	29	6	10	4	-88	7
20A	19	22	26	5	6	3	-52	3
20B	18	23	29	6	9	5	-78	7
Irrigated:								
06A	37	34	NA[1]	6	16	7	NA[1]	8
07A	30	34	29	6	10	5	-90	8
07As	31	33	0	0	5	4	0	0
11Bi	33	34	29	6	16	7	-85	7
16A	34	35	30	6	11	4	-96	8
16B	33	34	31	7	7	5	-102	9
21A	41	40	0	6	9	6	0	8
21B	31	34	0	7	10	5	0	9

[1]Data not available

Sugarcane foreign exchange use was negative in all GDSSs and ranged from (-) \$52 to (-) \$102 per ta per yr. Negative values resulted from the assumption that all sugarcane would be exported as sugar and from the fact that sugarcane income exceeds costs in all GDSSs.

Cultivated pasture/milk foreign exchange use varied from \$3 to \$9 per ta per yr. The cultivated pasture/milk land use produces a small amount of foreign exchange through meat exportation. No milk is exported. Thus, sugarcane is by far the lowest user (i.e., highest producer) of foreign exchange among the three land uses.

Partial Budgeting Analysis

This section compares the current normal (base) annual production coefficients with the results of the partial budgeting of 11 alternative strategies for a hypothetical 25,000 ta expansion of the current rice production area in the Central Region (see Chapter IV for explanation of partial budgeting methods). Results are presented in Table 5-8 according to alternative expansion decision rule: maximization of regional rice production (Strategies A, B, C); maximization of regional monetary returns to land and management (RLM) for rice (Strategies D, E); maximization of unsubsidized RLM for rice (Strategies F, G); maximization of regional labor use in rice production (Strategies H, I); and minimization of regional foreign exchange use in rice production (Strategies J, K). Each strategy had, in addition to a specific decision rule, restrictions on rice production techniques, numbers of production cycles, and GDSS availability as explained in Chapter IV. Regional impacts (changes from current normal) are estimated for each strategy and compared to the current normal coefficients.

Table 5-8. Five Regional Impacts of 11 Rice Expansion Strategies and Two Modified Strategies, Central Region, 1979 Current Normal

Impact	CN	Strategy									
		A	BDFH	C	E	E[1]	G	I	I[1]	J	K
Rice production (100,000 qq)	3.4	3.0	3.4	4.4	4.4	2.9	4.1	4.2	2.6	0.7	0.8
RLM ($ million)											
monetary	1.3	1.6	1.2	2.4	2.7	1.8	2.5	1.9	1.1	0.4	0.7
unsubsidized	0.4	2.4	1.8	3.1	3.3	2.8	3.3	2.4	2.0	1.3	1.5
Labor (million hr)	2.3	2.0	2.1	2.5	2.4	1.4	2.1	2.5	1.7	0.4	0.4
For. exch. use ($ million)	0.8	0.2	0.7	0.3	0.2	0.2	0.2	0.7	0.4	0.0	0.0

[1]Sensitivity analysis modification

In each section, overall regional impacts are presented, followed by impacts at the GDSS level (Table 5-9). Use of the alternative production techniques is discussed (Table 5-10). The section closes with the results of the yield sensitivity analysis of rice multiple production cycle assumptions.

Table 5-9. Current Normal Area and Area of Rice Expansion for 11 Strategies and Two Modified Strategies for 12 GDSSs, Central Region, 1979

GDSS	Base Area (current normal)	Added Area									
		Strategy									
		A	BDFH	C	E	E[1]	G	I	I[1]	J	K
	------------------------1,000 ta------------------------										
Rainfed:											
07A	4	(4)								25	
07B											
20A											25
20B						5					
Irrigated:											
06A	5	16	16	5	5			16	16		
07A				20	20	20	20	9	4		
07As	14										
11Bi	10										
16A	8	5							5		
16B											
21A	1	4	4								
21B											
Total	42	25	25	25	25	25	25	25	25	25	25

[1]Sensitivity analysis modification

Table 5-10. Choice of Typical and Alternative Production Techniques for 11 Strategies and Two Modified Strategies for 12 GDSSs, Central Region 1979

GDSS	Production Technique	Strategy									
		A	BDFH	C	E	E[1]	G	I	I[1]	J	K
		Technique									
Rainfed:											
07A	Typ									x	
	Alt	(x)									
07B	Typ										
	Alt										
20A	Typ										
	Alt										x
20B	Typ					x	x				
	Alt										
Irrigated:											
06A	Typ		x	x				x	x		
	Alt	x			x						
07A	Typ			(x)							
	Alt			x	x	x	x	x	x		
07As	Typ										
	Alt										
11Bi	Typ										
	Alt										
16A	Typ		x								
	Alt	x							x		
16B	Typ										
	Alt										
21A	Typ		x								
	Alt	x									
21B	Typ										
	Alt										

[1]Sensitivity analysis modification

All partial budgeting estimates of rice expansion impacts are net impacts arrived at by adding the rice coefficient changes to those of sugarcane or cultivated pasture/milk. Except for rice production change itself, these net impacts should not be confused with impacts on rice alone.

Rice Production Maximization Strategies

Of the 11 rice expansion strategies, strategies A, B and C incorporated maximization of regional rice production as the expansion decision rule. Strategies A and B assumed current normal parameters except for a specific restriction: A was restricted to alternative rice production techniques and B was restricted to maximum number of potential multiple production cycles. Strategy C allowed free choice of any combination of production techniques, number of production cycles and GDSSs.

All inputs for strategy B were equal to those of D, F, and H. This is accounted for by the fact that the same GDSSs (irrigated 06A, 16A, 21A) had the highest parameter values for each of the four decision rules used in strategies B, D, F, and H. Thus, no other GDSSs entered the solutions, and the aggregate impacts totals were equal.

Strategy C rice production of 441,000 qq was 128 percent more than the current normal production of 343,000 qq, and strategies A and B resulted in close to 100 percent increases, respectively. Production labor use increased roughly in proportion to output for all three strategies. Increases in foreign exchange use for strategy B was slightly less than the current normal $843,000, while A and C resulted in 20-30 percent increases from current normal.

Monetary RLM at the farm gate level increased by 185 percent for strategy C. Strategy A and B returns increased by a much lower percentage. Current normal monetary RLM were about $1.3 million.

Current normal unsubsidized RLM at the farm gate were $435,000. Strategy C increased that value by about $3.1 million, while the A increase was about $2.4 million. The strategy B increase was $1.8 million. These large increases in unsubsidized returns over the monetary returns were due to rice's replacing cultivated pasture/milk, a process which produces unsubsidized losses in all GDSSs under the assumptions of the study.

Strategies A and B resulted in expansion of rice production in currently irrigated GDSSs 06A, 16A, and 21A. Production in rainfed GDSS 07A would have resulted in the same production increase as in 21A; however, net returns were higher in 21A so it rather than 07A entered the solution. Strategy C expanded in currently irrigated 06A and potentially irrigated 07A. The difference between C and strategies A and B was due to the strategy C option of expansion into the potentially irrigated 07A, which had a higher yield than irrigated 16A and 21A.

Strategies A and B were restricted, respectively, to alternative and typical rice production techniques. Strategy C allowed free choice between techniques, and the result was selection of typical techniques in irrigated 06A and alternative techniques in irrigated 07A.

Maximization of Rice Monetary Returns at the Farm Gate

Strategies D and E used maximization of rice monetary RLM at the farm gate as the expansion decision rule. Strategy D was restricted to typical production parameters and E allowed free choice among parameter alternatives.

All impacts for strategy D were the same as those for strategies B, F and H. Increases in monetary RLM for strategy E were about $2.7 million greater than current normal returns of $1.3 million. The strategy E returns increase was $1.3 million greater than the D increase. Increases in unsubsidized returns for strategies D and E were $1.8 and $3.3 million, respectively, over the CN returns of $435,000.

The increase in white rice production for strategy E was about 127 percent over that for current normal and strategy D production. Strategy D impacts were similar to those of E in terms of production labor use. Net foreign exchange use increase for strategy D was slightly less than the current normal value of about $843,000. Strategy E showed a 25 percent increase.

The GDSS level impacts of strategies D and E were the same as those for B and C, respectively. Selection of rice production technique differed, however, in that the alternative techniques were selected in free choice strategy E.

Maximization of Rice Unsubsidized Returns at the Farm Gate

Strategies F and G employed maximization of rice unsubsidized RLM at the farm gate as the rice expansion decision rule. Strategy F was restricted to current normal production parameters. Strategy G allowed free choice among parameter alternatives.

Strategy F results for all coefficients were the same as those for strategies B, D and H, as explained previously. Current normal monetary returns were $1.3 million. These were increased by $1.2 million and $2.5 million with strategies F and G. Current normal unsubsidized returns were increased by about $1.8 million and $3.3 million with strategies F and G. Strategy G impacts were generally similar to those of E.

The implication of this similarity in comparisons between strategies D, E and F, G is that it made little difference at the regional level whether monetary or unsubsidized returns were selected as the expansion decision rule. However, at the GDSS level there was a difference in impacts, with strategies D and F expanding production in irrigated GDSSs 06A and 21A, strategy E expanding in irrigated 06A and 07A, and strategy G expanding in rainfed 20B and irrigated 07A. These differences were relative ones in monetary and unsubsidized RLM at the GDSS level which were offsetting when aggregated to regional totals.

Strategy F was restricted to use of the typical rice production techniques. Strategy G selected typical techniques in rainfed 20B and alternative techniques in irrigated 07A.

Maximization of Rice Labor Use

Strategies H and I assumed maximization of production labor use in rice production as the rice expansion decision rule. Strategy H was restricted to current normal production parameters and strategy I allowed free choice among parameter alternatives.

All impacts for strategy H were the same as those for strategies B, D, and F. Labor use increased by nearly 100 percent for strategies H and I in comparison to the current normal labor use of 2.3 million hr.

Rice production increased 99 and 127 percent over current normal production for both strategies. Monetary returns increased by $1.2 and $1.9 million and unsubsidized returns increased by $1.8 and $2.4 million, respectively, for strategies H and I. Foreign exchange use increased by approximately 90 percent for both strategies.

Both strategies expanded rice production in GDSS 06A, but strategy I also expanded in irrigated 07A rather than in 16A and 21A. This was due to the potential labor use in 07A being higher than the current normal labor use in the other GDSSs. Typical production techniques were forced in strategy H. Strategy I selected typical techniques in irrigated 06A, and alternative techniques in I.

Minimization of Rice Foreign Exchange Use

Strategies J and K assumed a rice expansion decision rule of minimization of foreign exchange use in rice production. Strategy J was restricted to current normal production parameters, and strategy K allowed free choice among production parameter alternatives. An added restriction which required a minimum of a single rice production cycle in each GDSS was placed on these two strategies.

Both strategies resulted in only slight differences from the current normal foreign exchange use of $843,000. Rice production increases for strategies J and K were about 19 percent over current normal production.

Increases in monetary RLM were half or less than half of current normal returns for both strategies. Unsubsidized returns increased about 100 percent over current normal for strategies J and K. Labor use increased less than a half million hours over the current normal level of 2.3 million hr.

All strategy J rice expansion took place in rainfed GDSS 07A, and all of the strategy K expansion was in rainfed 20A. Typical production techniques were forced in strategy J, while K selected alternative production teqhniques.

Ranking of Expansion Strategies by Production Impacts

Rankings of the top three alternative expansion strategies according to their impacts on the studied production parameters differed depending on the expansion criterion selected (Table 5-11). The ranking using maximization of regional rice production as the expansion decision criterion was C, E, I. Rankings using monetary returns as the decision criterion were E, G, and C, and those using unsubsidized RLM were G, E, and C. When making rice labor use the criterion the ranking was I, C, E, and using the foreign exchange criterion resulted in a ranking of E, G, A.

Table 5-11. Ranking of Rice Expansion Strategies on the Basis of Four Impacts, Central Region, 1979 Current Normal

Expansion Impact	Rank		
	1	2	3
	------strategy------		
Rice production	C	E	I
RLM, monetary	E	G	C
unsubsidized	G	E	C
Labor use	I	C	E
Foreign exchange use	E	G	A

Only strategy E ranked among the top three for all expansion decision criteria, and it was ranked first for two of the five criteria. Strategy C ranked in the top three for four of the five criteria, and in three instances G was among the top three.

Results of the Sensitivity Analysis

One of the sets of assumptions believed to be most critical in influencing the outcome of the study was that which led to the estimates of the number of potential multiple cycles of rice production in each

GDSS. Most of the solution GDSSs for each alternative rice expansion strategy were ones with three potential cycles. In order to test the sensitivity of the study results to the multiple cycle assumptions, two of the high ranking expansion strategies, E (maximization of monetary returns) and I (maximization of labor use), were rerun with the following change in the multiple production cycle assumptions: all GDSSs were restricted to a maximum of two production cycles.

The modified strategy E results indicated, as expected, that rice production and net regional monetary returns, unsubsidized returns, and labor use all were reduced over the original strategy results by about 33 percent (Table 5-8). Rice expansion took place in two GDSSs with both strategy E and modified E. Both strategies expanded production in irrigated GDSS 07A. However, expansion also took place in rainfed 20B with modified strategy E compared with the irrigated 06A with original strategy E. The difference was due to rainfed 20B's having a higher total annual production than irrigated 06A when 06A was restricted to two rice crop cycles per year.

Comparisons between strategy I and modified strategy I production parameters are similar to those between E and modified E. At the GDSS level, both the I and modified I strategies expanded rice production in irrigated 06A and 07A, but modified I also expanded production in irrigated 16A (with reduced area of production in 07A).

Chapter V's Relation to Chapter VI

The analytical results presented in this chapter will be discussed in Chapter VI. Their implications for rice expansion policy will be covered in light of the data and methodological limitations of the study.

CHAPTER VI

DISCUSSION OF ANALYTICAL RESULTS

Chapter VI contains a discussion of the analytical results presented in the previous chapter. The discussion is organized in the same order as were the major objective-related questions asked in the first chapter. Each question is restated. Then the implications of the study results for answering each question are discussed. Assumptions used in the study and significant limitations of data quality and analytical procedures, as they might have affected study results, are covered.

Comments are made as to the appropriateness of the study methodology for the Dominican land use planning environment. There is a discussion of methodological modifications required to expand this regional study to the national level. Finally, the need for additional information on intra- and inter-sectoral factors bearing on Dominican rice production and consumption is emphasized.

In What Land Areas Can Rainfed and Irrigated Rice Production Be Expanded?

The results of the agroeconomic analyses indicate that rice potentially can be produced at commercially marketable yield levels in four rainfed GDSSs (07A, 07B, 20A, 20B), six irrigated GDSSs (06A, 07A, 16A, 16B, 21A, 21B) and two subirrigated inclusions (07As, 11B) in the Central Region. The most promising of the potentially available GDSSs are irrigated 06A and 07A. It is to these two areas that priority attention should be directed for future project planning. Among the rainfed GDSSs, the overall agroeconomic results indicate that 20B and 07A should be given priority attention for more detailed field analysis leading to project identification and planning.

Rice currently is produced in one of the four rainfed and three of the six irrigated GDSSs and in both inclusions. There is substantial physical area potentially available for rice expansion in each of the rainfed GDSSs (34,000 to 115,000 ta), a findings consistent with records indicating much greater earlier rainfed production in the Central Region in the 1960s than is current (Murphrey, 1972). Physical area potentially available for expansion of irrigated rice production in each GDSS is much smaller than that for rainfed production, ranging from 0 to 20,000 ta.

Results of the sensitivity analysis of the multiple cycle assumptions indicate the desirability for more detailed study of those assumptions prior to using them in the planning of a rice expansion project. The results confirm the importance of the GDSSs mentioned above as potential rice expansion areas but indicate that irrigated 16A also would be a high priority area for rice expansion if it happened that triple production was not feasible in the other GDSSs.

The term "potentially" should be emphasized here because of the fact that institutional factors such as long ownership, as well as other factors not analyzed in the study might prevent rice expansion or other land use changes in a number of the GDSSs. For example, the analysis assumed current efficiency levels in canal maintenance and water distribution to the field level. Given the many uncertainties in water distribution consistency in many areas, due to lack of disciplined control of canal flood gates and lack of an economic incentive for efficient water use (i.e., pricing of water by volume rather than by area irrigated), this assumption must be given careful attention in future project planning. Soils characteristics must be analyzed in the field at a level of detail much greater than that used in this study in order to identify the specific areas within GDSSs with sufficient homogeneity to allow uniform water distribution and drainage patterns.

In addition to the GDSSs and inclusions identified as having rice production potential, there are other small, dispersed GDSSs and inclusions which have rice potential in the Central Region. These areas may be very useful and appropriate for production of locally consumed rice, but they are believed to be too small to justify consideration for a major governmental rice expansion project. Atypical years of heavy rainfall, too, may give the illusion that additional areas are suitable for rice production. However, those areas would not be suitable in years of typical rainfall and should not be considered for further rice expansion.

Additional areas could become adaptable to production in the future as new rice varieties are developed at the Juma rice experiment station. Increased tolerance ranges for such limiting factors as consumptive water use and soil pH would allow rice expansion in areas not identified in this study as having rice production potential. Varieties with shorter production cycles could open up possibilities for multiple cycle production in areas that currently have only a single production cycle. Such research advances at the experiment station, however, will have to be complemented and coordinated with technical extension services and input and output marketing assistance in appropriate land areas if a rice expansion project is to have any chance of success. Social infrastructure investment in such projects as schools and medical clinics will also have to be given careful attention if a major expansion project is to be undertaken.

Which Expansion Areas Would Be the Most Profitable from the Producers's and the Nation's Standpoints?

In this study, returns to land and management were used to estimate "profitability". More correctly, these are returns to land, management, and all other factors not explicitly specified in the benefit-cost calculations.

Results of the benefit-cost analysis indicate that rice can be grown profitably in all of the GDSSs identified in the agrophysical analysis. The most consistently profitable GDSSs under the expansion strategy alternatives studied were irrigated 06A and 07A and rainfed 20A. Partial budgeting results indicate that profitable rice expansion in those GDSSs could best be achieved through strategies E, C and G. Each of those alternative strategies nearly doubled the regional net monetary returns to land and management and resulted in proportional increases in net unsubsidized returns. Strategies E, which assumed maximization of rice monetary returns, and C, which assumed maximization of rice production, not only resulted in the highest monetary returns and output, respectively, but also ranked very high in terms of the other production expansion impacts. Strategy G also had high returns but had relatively lower rice production and labor use.

Regional net returns increased substantially due to rice substitution for cultivated pasture/milk under all of the alternative rice expansion strategies considered in the study. Cultivated pasture/milk is notoriously unprofitable in the Dominican Republic (Associacion, 1979). Expansion of rice into sugarcane areas would reduce net monetary returns as sugarcane is more profitable than rice in all GDSSs except rainfed 20A and 20B under current normal conditions. Rice expansion into sugarcane areas would not have taken place, from the standpoint of net unsubsidized returns, except in rainfed GDSS 20A.

One of the implications of these net returns impacts is that, from the economic standpoint, the country should rethink its policy of rice self-sufficiency and production area expansion, at least in the Central Region. As long as rice replaces cultivated pasture, the region will be better served in terms of net returns on its resources. However, replacement of both cultivated pasture/milk and rice by sugarcane at current normal relative prices would increase regional net returns even more. Distribution of the returns and regional comparative advantage, among other factors, must be considered, but strictly from the standpoint of regional profitability agricultural planners should consider the loss from sugarcane profits which the region is giving up in order to produce or to expand production of rice.

These comments must be considered in light of several critical assumptions made in the study. Perhaps the most critical assumptions were those which established the relative prices of rice, sugarcane, and milk. Used in the study were current normal prices which did not indicate the volatile instability of sugar and rice prices in international trade. Sugarcane prices, for example, have varied for approximately $150 to over $1000 per mt during the past decade. The current normal price is $331 per mt. At the lower end of the price scale sugarcane production would be unprofitable in all GDSSs. Rice producers can respond fairly rapidly to price fluctuations due to the short three to four month rice production cycle. Sugarcane and milk producers have less flexibility with products which have multi-year production cycles. These price variability factors should be studied thoroughly prior to land use policy changes or project development.

Also important were the estimates of potential for multiple cropping of rice which were tested in the sensitivity analysis. The assumptions that new rice areas can be brought into production with no additional investment costs for irrigation development and no added water costs for dry season pumping of underground water may be unreasonable in specific GDSSs. The large capital investments in sugarmill facilities and the optimum mill operating levels must be considered before proposing any significant change in production in specific GDSSs. Project planners should give attention to those assumptions in more detailed project planning for rice expansion.

Another set of assumptions critical to the economic analysis was the assumption of perfect elasticity of input supply and output demand assumption. Further analysis of those elasticities might in fact indicate that input prices would rise or output prices would decline as rice production was increased in the region. More elasticity input supply and output demand functions would in turn mean that equilibrium among the three land uses would occur with something less than complete replacement of cultivated pasture/milk by rice or complete replacement of rice and cultivated pasture/milk by sugarcane. Considering, however, the relatively small size of the Central Region and the relatively small percentage of national rice production analyzed in this regional study, the assumption of perfectly elastic functions is probably reasonable except on a localized monopoly/monopsony basis.

It should be emphasized before closing this section that maximization of returns to land and management was only one of the expansion decision rules considered in this study. Use of expansion decision rules other than returns to land and management resulted in different ranking of the "best" strategies. For example, Strategy I, which assumed maximization of rice labor use, resulted in the highest labor use but was substantially lower than several other strategies in terms of the other impacts monitored. These different rankings of expansion strategies, depending on the decision rule chosen, points to the importance of decisionmakers' goal identification as the first step in the iterative rice policymaking process. Depending on the specific goal and corresponding decision rule chosen, the study results identify several different GDSSs to which priority attention should be given for rice expansion project planning. Only by clear definition of policy goals early in the planning process can resources be allocated consciously and most efficiently toward the attainment of those goals and the avoidance of undesirable side effects.

Where Can Labor be Increased and Foreign Exchange Use be Decreased in Rice Area Expansion?

The analytical results indicate that current normal labor use of 2.3 million hours per year could be increased by over 100 percent by expansion of rice production in irrigated GDSSs 06A and 07A through application of alternative expansion strategies I, C, and E. All of those strategies resulted in the selection, in one or both of the relevant GDSSs, of the alternative techniques for rice production rather than the typical techniques.

Regional net foreign exchange use per qq produced can best be minimized through expansion in irrigated GDSSs 06A and 07A. Three of the alternative strategies for expansion of rice production led to an increase of at least 100 percent in rice production, with only a 25-38 percent increase in the use of foreign exchange. All of the three strategies selected the alternative rice production techniques over the typical techniques in one or both of the relevant GDSSs. These results clearly indicate that there are land areas and technical production alternatives which could increase labor use and decrease foreign exchange use (per qq of output) in the Central Region. More will be said about the technical alternatives in the next section.

Are Alternative Rice Production Techniques Available Which Could Profitably Increase Labor and Decrease Foreign Exchange Use?

The results discussed in the previous section indicate that there are alternative production input combinations which could profitably both increase labor use and decrease net foreign exchange use per qq of rice produced in the Central Region. Adoption by current rice producers of the alternative techniques analyzed in this study would increase labor use by 46 percent and reduce foreign exchange use by 58 percent.

Rice production planners should take this into account in future project planning and promote the dissemination to producers of information on labor-using and foreign exchange-saving techniques. At the same time, experiment stations should place more emphasis on research to identify and field test alternative rice production techniques which produce these desired impacts and which are profitable both to the local producer and to the national economy as a whole. The alternative techniques analyzed in the study were but an illustrative sample of innumerable options potentially available to rice producers. It is up to the research, extension, and agricultural information specialists to see that that potential is turned into reality.

How Much Are Rice Production Costs Currently Being Subsidized and What Would be the Impact of Subsidy Removal?

Current normal rice subsidies average about one-third of total production costs and amount to about $1.5 million annually in the Central Region. These subsidies are income transfers from taxpayers and consumers to rice producers and are not real economic costs to the national economy. Whether they are viewed as right or wrong is a judgment requiring consideration of both positive and normative information. The results clearly indicate that the Dominican government views rice subsidies as "right." Objectively, the income transfers decrease taxpayer and consumer utility and increase that of rice producers. There are also differential impacts on the producers and consumers of potential rice substitutes which are not subsidized.

A number of possible impacts of removal of rice production cost subsidies can be anticipated. It is worth noting that the government could not remove subsidies only from rice inputs, as many of the inputs are used in the production of other agricultural products. There would be no way to prevent the use of subsidized inputs by rice farmers, who would simply obtain them from their non-rice producing, subsidized neighbors.

Assuming, however, that the government removed the subsidies (i.e., charged full economic costs) on all inputs used in rice production regardless of their eventual use, the empirical results indicate that rice profitability would decrease in all GDSSs and would be negative in several. The ratios of the marginal value products (MVP) to marginal factor costs (MFC) for the formerly subsidized inputs would decrease, leading to a general producer shift away from the use of those inputs and toward the use of inputs with higher MVP/MFC ratios. Producers with economically fixed assets (Pa MVP Ps) would not change input use. Marginal producers would shift out of rice production if their unsubsidized unit costs were higher than the government price support levels or if other land uses (in this case sugarcane) appeared to be more profitable. Production enterprises which used the highest amounts of previously subsidized credit, foreign exchange, and water (e.g., irrigated GDSSs 06A and 11Bi) would be most affected.

Can a Land Assessment Procedure Be Developed Which Is Appropriate to the Dominican Planning Environment?

It is too early to tell whether the land assessment methods developed in this study will be used effectively by the Dominicans after U.S. technical assistance is terminated. A conscious and continuous effort was made by the author to limit the sophistication of the data collection and processing and agroeconomic analysis techniques to a level commensurate with the expected availability of Dominican human and financial resources. It was the belief of the author that if the study methods were to become permanently accepted as useful planning tools, the study's level of technical sophistication had to be matched both to the expected technical understanding of the somewhat transient SIEDRA technical staff, and to that of the highly transient crops of agricultural sector administrators who have to be repeatedly convinced to allocate their scarce resources to support the SIEDRA work.

The multidisciplinary nature of the study and its heavy dependence on secondary and judgmental data necessitated a time consuming continuing effort by the SIEDRA staff to explain project purposes, methods, and data needs to itinerant administrators of the diverse data agencies who provided published or judgmental data for the study. Although these procedures were very beneficial in effecting inter-institutional cooperation that was virtually unheard of previously, there is a real question as to the permanence of the linkages and, therefore, to the viability of these data collection procedures in the future because of the personnel turnovers among administrators and technicians.

As a result of the uncertainties in these delicate inter-institutional linkages critical to the future viability of the study procedures, SIEDRA is being encouraged to integrate farm level land use surveys into its overall data acquisition procedures as resources become available. Early SIEDRA efforts at integration of its data collection efforts with those of a SEA agricultural analysis project (ANSE) have proven fruitless to date because of lack of adequate support for ANSE. The dialogue proposing integration will continue in the interest of eventual strengthening of both SIEDRA and ANSE. Farm surveys should not replace the secondary and judgmental data but should serve to reduce the need for the complicated cooperative relationships required among agricultural institutions with very diverse operational orientations. Agricultural sector surveys, properly designed and executed to fulfill SIEDRA land use data needs, would likely result in much better data quality, particularly for cultivated pasture and sugarcane production and would assure direct compatibility of the complete sector data set.

Because of the complexity and difficulties of the multidisciplinary nature of the SIEDRA work and because of institutional jurisdiction disputes vis-a-vis economic analysis, there has been an increasing feeling among the SIEDRA staff that SIEDRA should concentrate its efforts on agro-physical analysis and relegate the economic analysis to other institutions. That type of "division of labor" could prove beneficial to the extent that inter-institutional coordination could be effected to provide for the economic analysis on a timely basis. However, attempts at such coordination efforts to date have come to nought. The danger in carrying out agro-physical analyses to the exclusion of economic analyses is that resulting recommendations could prove to be economically disastrous. For example, a large expansion of rice production in GDSS 07A, as based on the agrophysical results of this study, could prove an economic boondoggle if no consideration is given beforehand to the economic questions of land opportunity costs for sugarcane production and of the impacts on sugarmill operating efficiency of a reduction of sugarcane production in the mill area.

Modifications Needed in the Regional Study for National Application

There are several types of modifications that would be required in the study methodology in order to apply it at the national level. Five of the more critical considerations are discussed below.

First is the question of improvement in data acquisition procedures, discussed in the previous section. Land use surveys at the farm level, ideally as a component of a more comprehensive sector survey, should become a part of the SIEDRA data collection process as soon as resources can be made available. The agricultural ministry (SEA) already has some limited experience with farm surveys for obtaining agricultural sector data, and the SEA survey personnel could likely administer the land use surveys needed by the SIEDRA staff. Financial support for a separate SIEDRA land use survey has not been available to date.

A second modification that should be considered is that of the assumption of perfectly elastic input supply and output demand functions. This assumption will have to be reevaluated in the light of the magnitude of the contemplated changes in input use and resulting output. The assumption of constant input and output prices is valid only as long as the changes in quantities of inputs and outputs are not sufficient to affect market prices. In the event that production changes are of a magnitude sufficient to affect input and output prices accordingly. Due to the almost complete lack of credible data on either supply or demand elasticities, a separate study is needed to develop information on price responses for key inputs such as labor and each of the major products.

Another consideration for a national study is the relatively greater importance of transportation costs in moving inputs and outputs to multiple consumption markets. In the regional study an average transportation cost for all GDSSs to the Santo Domingo retail market was calculated but was a relatively insignificant component of total costs. At the national level there will be multiple consumption markets for the various products and many more GDSSs from which production will be marketed. Transportation costs and their impacts on regional comparative advantage for the different products will become increasingly more important as fuel costs rise. Gasoline which was $0.99 a gallon early in 1979 rose to $2.39 by mid-1980 and there is no end in sight for future price increases.

A fourth factor which must be considered before undertaking a national level land base assessment is that of computerization of the SIEDRA data base. Almost all of the data refinement and analysis computations carried out in the study were done on hand calculators. For the regional study, which was limited to 29 GDSSs and three land uses, the use of hand calculators was both feasible and desirable from the training standpoint. The calculators forced the SIEDRA staff to pay continuous attention to every number processed and required more staff members to become involved in the computations than would have been necessary with the use of a computer. On the other hand, errors in data entry and in the copying of numbers between calculators were a continual nightmare that consumed enormous amounts of previous staff time. A national study, which would involve at least 100 GDSSs and up to 25 alternative land uses, could not be carried out efficiently without computerization of the data base.

A final primary consideration in going to a national study and to additional regional studies is that of increased sophistication of economic analysis techniques. Increased analytical sophistication would require more highly trained analysts than those on the current SIEDRA staff. Because of the organizational structure of the SEA, in which there are separate sub-ministries for economic analysis and for land use analysis, SIEDRA has been quite successful in obtaining highly qualified personnel from the non-economic disciplines but has had very limited success in obtaining good economic analysts. This institutional obstacle to improved economic analysis by the SIEDRA staff will have to be overcome if SIEDRA is to progress over time into such analytical techniques as linear and non-linear programming, various econometric techniques, as components of more general systems simulation models of the agricultural sector.

The Need for Additional Information

The final comment in this discussion of the study results is a repetition of a statement made in the first chapter: Policymakers need to obtain information in addition to this land base assessment before making policy decisions related to land use changes. There are many critical factors vearing on land use alternatives which were not studied in this land assessment. For instance, a major rice area expansion into former cultivates pasturelands would, according to the study results, significantly increase labor use in the area. Labor availability was not analyzed in the study but is obviously a critical consideration in a land use change requiring labor intensification. Also, a significant migration of laborers into an area implies that the government will have to invest in certain social overhead capital, such as schools, medical facilities, and roads if the laborers are to become permanently settled in the area. Investment in social overhead capital was not analyzed in the study but is a factor which policymakers must take into consideration if a major land use change is to be successfully made. History is strewn with examples of costly, unsuccessful attempts at land use changes (e.g., colonization in several Latin American countries) in areas where the principal selection criterion was that they "had good soils."

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

The Dominican Republic has been importing increasing quantities of rice since 1972. In 1978 the government began a program to increase domestic rice production in order to reduce foreign exchange expenditures and to increase employment. As a sub-component of that program, this study was undertaken to assess the agronomic and physical ("agrophysical") and economic ("agroeconomic") feasibility of rice production expansion in each land unit ("GDSS") in the Central Region of the country (see Figure 2-1). The regional study was to serve as a prototype for a national rice land use assessment and for studies of other agricultural land uses.

The Central Region was selected for study because of data availability and because of the region's proximity to the Santo Domingo office of the technical staff ("SIEDRA") conducting the study. This proximity permitted relatively inexpensive field training of the SIEDRA staff and verification of questionable data.

The analysis was to two types. First, an agrophysical analysis of the land base was carried out in order to identify areas with potential for increased rice production. Rice plant tolerance limits for potentially limiting soil and water characteristics were estimated and crosstabulated with the corresponding GDSS characteristics. For each of the GDSSs selected through that process estimates were made of the area potentially available for rice expansion, current normal (expected) rice yields and production, and possibilities for multiple rice production cycles.

Second, an economic analysis was made of the GDSSs selected in the agrophysical analysis. Benefits and costs of the production of rice and of its two principal competitors for land in the Central Region (sugarcane and cultivated pasture used for milk production) were analyzed from the producer cash expense ("monetary") and the national opportunity ("unsubsidized") points of view. A typical current set of rice production techniques and an alternative set requiring increased labor and/or decreased foreign exchange use were analyzed. The benefit-cost results were used in partial budgeting of a hypothetical 25,000 ta expansion of rice production area using 11 alternative strategies. The strategies consisted of various assumptions on expansion decision rules (maximization of rice production, maximization of rice monetary and unsubsidized returns to land and management, maximization of rice production labor use, and minimization of rice production foreign exchange use) and policy variables (rice production techniques, number of rice production cycles per year, and expansion in current or potentially available GDSSs).

Results of the agrophysical analysis indicated that rice production was adaptable to rainfed GDSSs 07A, 07B, 20A and 20B, irrigated GDSSs 06A, 07A, 16A, 16B, 21A and 21B, and to subirrigated inclusions 07As and 11Bi (see Tables 4-2 and 4-3). Total physical area potentially available for rice expansion was estimated at 310,000 ta (1 ta - 1/15.9 ha) for rainfed and 75,000 ta for irrigated production (see Table 5-2). Multiple rice production cycles were determined to be feasible in eight of the twelve GDSSs and inclusions.

Economic analysis results indicated that irrigated GDSSs 06A and 07A and rainfed GDSS 20B should be given priority attention for rice expansion projects in the Central Region. Expansion in those areas would be profitable both to producers (monetary returns) and to the nation (unsubsidized returns) using a combination of typical and alternative rice production techniques. Labor use would increase substantially and foreign exchange use per unit of rice produced would decrease if rice were substituted for cultivated pasture used in milk production. Rice substitution for sugarcane would not be economically rational under the assumptions of the study.

Conclusions

Conclusions drawn from the study can be divided into policy and methodological conclusions. There are two major policy conclusions. First, there are land areas in which rice could be produced profitably from both the producer's and the nation's standpoints and at the same time provide increased employment opportunities and decreased use of foreign exchange per unit of rice produced. Irrigated GDSSs 06A and 07A and rainfed 20B are the best prospects. A 25,000 ta expansion of rice production in those GDSSs under strategy E (maximization of rice monetary returns with free choice of production technique and GDSS) would increase annual labor use by 2.4 million hr and increase brown rice production by 4.4 million qq. The unsubsidized cost of domestic production would be \$3.2 million of which \$0.3 million would be used for foreign exchange. An equivalent quantity of imported rice would cost \$5.8 million. Thus, domestic production of the 4.4 million qq of rice which would otherwise be imported could save the country $2.6 million total and $5.5 million in foreign exchange. The $2.6 million in savings could be interpreted as the economic value of this rice study.

Second, there are profitable alternative rice production techniques which could increase labor use and decrease foreign exchange use. Adoption in current rice production areas of the alternative techniques analyzed in this study would both increase labor use and decrease foreign exchange use by about 50 percent. Such techniques must be introduced to producers through the Dominican research and extension institutions if they are to bring about the desired impacts in the field.

There are three major methodological conclusions. First, the study methods seem to be appropriate to the current Dominican planning environment. However, the secondary and judgmental data sources used in the study should be supplemented by land use surveys at the farm level, preferably as components of more comprehensive agricultural sector surveys. This integration of surveys would help to assure data compatibility and completeness for overall sector analysis.

Second, several of the critical assumptions made in this paper should be given more detailed study prior to use in project planning. The order of priority should be: (a) number of rice multiple production cycles possible in each GDSS; (b) relative product prices; (c) irrigation infrastructure costs; and (d) unsubsidized prices. Third, other intra- and inter-sectoral production and consumption information in addition to this land use assessment should be incorporated in the rice expansion policymaking process in order to increase the probability that a feasible and desirable expansion policy and resulting projects can be planned and implemented. More detailed land base analysis in the field is required to locate, within the selected GDSS, specific areas suitable for project development.

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