# IMPACTS OF AGGREGATION ERROR
# ON AN AGRICULTURAL
# INFORMATION SYSTEM

By

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ABSTRACT

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Developing countries often rely on agriculture to provide savings, labor, food supplies, and/or foreign exchange for economic development. Yet the sector generally has severe problems that limit its ability to be this engine for growth.

To understand sector problems and suggest solutions a variety of agricultural information systems have been developed over the past several decades. A frequent criticism of the systems is that they do not incorporate enough detail and are not sufficiently complex. At the same time, others argue that because it is so costly and difficult either to correctly specify model structures or to avoid data measurement errors, models should be small and simple in structure.

This dissertation investigates how varying the amount of data detail affects the output of information from one information system -- the Comprehensive Resource Inventory and Evaluation System (CRIES). The purpose of CRIES is to provide national planners with information useful to analyzing agricultural production potential.

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Three soil inventories utilizing the phases of the soil great group, subgroup, and family, respectively, and three map scales -1:1,000,000; 1:250,000; and 1:100,000, respectively were constructed of the Cibao Valley in the Dominican Republic. The map units and principal soil components of these inventories, crop yield interpretations, and resource use data provided the data for a cost-minimizing linear programming (L.P.) model. Without changing specification of the L.P., the model was run for three policy questions at three different levels of soil aggregation: Detailed, Intermediate Weighted, and Aggregate Weighted. In addition, the model was run at these three levels but with different and "independent" crop yield estimates for each level. These latter three L.P.'s, the Detailed, Intermediate, and Aggregate differ both in the degree of soil aggregation and yield estimates.

Specification error in this simply structured L.P. does not vary with aggregation since only one L.P. is used. Measurement error occurs at each level of aggregation. Aggregation error is measured by comparing the solution values of the two area-weighted L.P.'s and of the two L.P.'s with "independent" yield estimates to solutions of the Detailed L.P.

The Aggregate soils inventory appears adequate for the user's needs. The map is legible, the number of map units is the same as the number of regions of interest to the user, and the inventory is least costly in time and funds. Data are less reliable than those of the more detailed inventories but sufficiently so given economic data to be associated with the principal components of each map unit.

The Intermediate Weighted L.P. may be preferable to the Aggregate Weighted L.P. since its Regional solution values more closely correspond to the Detailed solution, the base model for comparison. Optimal objective function values between the weighted L.P.'s do not differ significantly.

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Positively biased yield estimates (with respect Detailed yields) were used in the Intermediate and Aggregate L.P.'s. The Aggregate L.P. may be preferable to the Intermediate L.P. since its Regional solution values correspond best to the Detailed solution and since it is the least costly to construct. However, its yield estimates are subject to greater measurement error.

The relative utility of any one information system can only be determined by the user. The issue is one of setting priority between relatively low cost and time requirements but high specification and possibly measurement errors (which occurs with more aggregated, simpler systems) and high cost and time but lower specification and measurement errors (which occurs with more complex, large systems). Although theoretically possible, specification, measurement, and hence aggregation errors in information systems cannot be avoided. It is recommended that system builders be objective, that they faithfully interact with users to determine users' perceptions of the issues and their needs for analysis, and the appropriate type and size of information system to be built. Relatively less research attention should be given to exploring ways to reduce aggregation error and relatively more to identifying the values and needs of user groups.

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# CHAPTER I

# INTRODUCTION

## Statement of the Problem

In many developing countries, one-half or more of the population lives in rural areas and gains its livelihood from agriculture. The agricultural sector is frequently burdened with a major responsibility to promote national economic development. Ways of promoting such development include increasing food supplies for domestic consumption, releasing labor for non-farm employment, enlarging the size of the domestic market for manufactured goods, increasing the supply of domestic savings and exchange (Myint, 1975). At the same time, these countries commonly face human problems such as low per capita food consumption, poor nutrition, high unemployment and low incomes; and natural resource problems such as subutilization of potentially highly productive soils, overutilization of relatively low productive soils, declining soil fertility, erosion, eutrophication of water supplies, high rates of slash and burn agriculture and deforestation, and others, all in the face of severely limited financial and skilled human resources needed to resolve them.

Governments of developing countries recognize that they must understand the nature and extent of sector problems if they are going to be able to obtain the expected contributions to development. Ignorance about agricultural production potential can be overcome only by systematically gathering data relevant to clearly specified problems, analyzing those data, and providing information useful to those responsible for formulating agricultural policies.

National and international agencies have financed innumerable efforts to produce data and useful information on sector problems. These efforts, some of which may be labeled agricultural information systems, have had the potential to help resolve such problems by improving the decision making process of national planning bodies. Unfortunately, literature of the natural resources disciplines suggests that the proliferation of data and analyses has not produced this desired result. Typical criticisms of marginally useful information systems--of well-intentioned but irrelevant studies -- include:

- users are not clearly specified;
- problems are not clearly described;
- relationships modeled are too simple to be useful in such a heterogeneous sector; or, models are too complex for users to understand chains of causality;
- models are too normative;
- the simplifying assumptions of theory and the resultant implications are never explained to the users;
- models have too much or too little detail. Errors of specification, measurement, and aggregation seriously limit usefulness.

## Study Objectives

This dissertation is an inquiry into the information production function of one agricultural information system--generally represented by the Comprehensive Resource Inventory and Evaluation System (CRIES)[1] project in the Dominican Republic (D.R.). CRIES provides subject matter research to assist participating countries develop an agricultural resource inventory and analytical system that

[1]CRIES is funded by the Office of International Cooperation and Development in the U.S. Department of Agriculture through a Participating Service Agreement between the U.S. Agency for International Development and the USDA. Participation of Michigan State University is covered under a Research Agreement between the Economics and Statistics Service of the USDA and MSU.

will help national planners explore the extent, quality, and use options of natural resources. The CRIES D.R. system is based on the CRIES' conceptualization of agricultural production potential: maximum crop production given limits set by the distribution and quality of natural and human resources, production techniques, and societal institutions. Within this broad subject matter area, data are made available for resource planners and users with concerns about solving specific resource problems.

The general objective of this dissertation is to investigate how varying the amount of spatial data detail affects system output: information useful to national planners and policymakers about how the land resources of the Cibao Valley might be most efficiently used to increase crop production. The general procedure is to a) construct three soil inventories of the Cibao Valley and specify one linear programming (L.P.) model aggregated to three different levels, and b) compare the information produced by each soil inventory-L.P. information system.

This dissertation is only a partial investigation into the information production function. For example, the question of whether any system's analyses become useful to policymakers is largely a function of the latter's relationship to the subject matter area and the analyses undertaken. Hence, a more complete investigation of usefulness would involve user interviews as one way of establishing both monetary and non-monetary values for inputs and outputs.

Intended users of the results of this study are information system builders, such as CRIES personnel. These persons must interact with potential system users to establish the relevant data detail for soils, land use, production methods, etc., that are necessary for useful subject matter research.

## Research Approach

The specific procedure to be followed includes these major steps:

1. Review the literature for criticisms of national/regional agricultural planning efforts.
2. Establish the need for an information system approach to the subject matter area of agricultural production potential. Define data, information, and information system and criteria for developing systems that are credible to intended users.
3. Build five information systems for the Cibao Valley.
   a) Describe a problem within the subject matter area to which the information systems will be applied: making the least costly use of Cibao Valley land resources to meet crop production requirements.
   b) Prepare and describe the three soil inventories of the Valley.
   c) Build five interregional L.P. models. Three of the L.P.'s will differ only in the degree of soil aggregation. Otherwise, they have identical data inputs. Two will differ both in degree of soil aggregation and in crop yield estimates.
4. Compare inputs and outputs of the five information systems:
   a) Develop performance indicators of changes in the data inputs (the soil maps and the L.P.'s) and information outputs (from the soil maps and the L.P.'s).
   b) Examine the information content of each soil map and the impact of land aggregation on the solution values of each L.P. Discuss the differences in policy prescriptions of each system for resource use in the Cibao Valley.
5. Formulate conclusions regarding the importance of errors of specification, measurement, and aggregation to developing information systems for national policymakers concerned with agricultural production potential.

The organization of this dissertation is as follows: Chapter II is a literature review of criticisms of earlier agricultural information systems including a section on aggregation error. In Chapter III, a generalized information system is presented and the differences between data and information are discussed. In Chapter IV, a method is developed to evaluate information content from soil maps and linear programming models, the two analytical tools under study. The information output of the Detailed, Intermediate, and Aggregate soil maps and five L.P. models are presented and evaluated in Chapter V using the performance indicators of the previous chapter. In Chapter VI, conclusions relative to the effects of specification, measurement, and aggregation errors on the production of useful information are made and recommendations for further research are suggested.

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# CHAPTER II

## CRITICISMS OF PREVIOUS AGRICULTURAL STUDIES

### Growth and Use of Formal Analytical Systems

During the past two decades, support for policy research and analysis has grown impressively. In a recent five-year period, 1969-1974, expenditures on nondefense program evaluations alone rose to $146 million, a 500 percent increase (Rein and White, 1977). In spite of the growth in formal planning-policy systems, documentation of direct use is rarely found. An exception is found in the National Water Commission which sponsored a linear programming (L.P.) analysis of optional water-resource policies to the year 2000. Based upon model projections, the Commission concluded that "no additional irrigated agriculture was needed to meet domestic and export needs, and that Federal subsidies for development or additional irrigation in the United States should be discontinued (Holcomb Research Institute, 1976).

During the past decade, most major national agricultural and related resource commissions have used large-scale L.P. models to assess the

> impacts of different policy alternatives at both national and regional levels; to evaluate the productivity potentials of the agricultural sector and the nation's land and water resources; to indicate generally 'the what and where' as variables at the national level and in international trade have impacts which thread back to individual producing and resource areas; and to reflect interdependencies among regions, technologies, resources, commodities and policies (Heady, 1975, p.4).

L.P., the mathematical tool under study in this dissertation, has the ability to recognize interregional relationships, which are important because producers and resources are spatially distributed. Interregional L.P. serves well as a tool to generate information at both national and regional levels. National-level information is needed so that supplies can be equated with demand and interdependence can be established among regions. Regional detail is needed so that the flexibilities of, or restraints on, production and resource use can be measured, and impacts can be expressed at the regional level.

Accompanying the growth in support for analytical systems has been a chronic sense of frustration about their usefulness both on the part of those who have conducted the work and those who have sponsored it. For example, despite the large number of soil surveys--one kind of information-generating effort--undertaken in this period, it is felt by many soil scientists that "these have not influenced agricultural development...or...increased productivity as ought to be expected" (Stobbs, 1970, p. 41).

In spite of the feelings that policy research and evaluations have been largely ineffective, there has been very little systematic investigation into the extent to which research enters the policy process. One of the few studies of this kind found that "rarely is policy formulation determined by a concrete point-by-point reliance on empirically grounded data" (Caplan, 1975, p. 47). Attempting to determine why some studies were used while others were not used for public policy, Caplan concluded that lack of contact between researchers and policymakers and lack of trust were the major factors for variations in utilization.

Mathematical models, which are often a major part of informational efforts, have also been repeatedly criticized. In 1966, a participant at a conference devoted to agricultural sector analysis commented that, "there is nothing like the array of formal planning models presented at this conference to give one particularly interested in the agricultural sector even more neuroses than he might already have" (Heady, 1966, p. 381). Eleven years later, the U.S. General Accounting Office reported that while there had been a proliferation of quantitative models in response to the growth in concern about the workings of an increasingly complex and interdependent agricultural sector, the number of models had raised doubts about which models would be useful.

## Two Categories of Criticisms

For discussion purposes, criticisms of previous agricultural studies may be grouped roughly into two broad categories. The first deals with questions of who is the user, what are his needs, and how congruent are the analytical tools to these needs. The second deals with questions of the structure and detail of mathematical models, particularly L.P. Obviously, the two categories are closely related.

### Poor Identification of Users

Eisgruber points out that the major limitation to the usefulness of many information efforts is poor definition of user groups. In most agricultural information systems, "the modeler rarely interacts with the policymaker but instead with a technical staff" (Eisgruber, 1967, p. 1548). It should not be assumed that the users of information-generating systems are the policymakers themselves since technically competent policy analysts may act as important intermediaries between the policymaker and the system builder. Without considerable interaction between the analyst and the system builder and also between the policymaker and his analytical staff, differences in values and objectives cannot be sufficiently recognized and considered.[1]

Identifying the users as "policymakers" does not resolve the problem of definition since this term can have a variety of meanings. Policymakers vary in professional background: they may have technical skills, or they may have policy

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[1] This criticism is not restricted to the public sector. A recent article in Fortune Magazine describes part of the problem and some means to deal with it. The article contends that data processing managers invent solutions without identifying the problems. The last thing considered would be impacts on the user. Currently, the successful data processing shops have good relations with top management, not because top management understands computers, but because the data processing manager understands the business. Data processing managers are moving higher up in the management structure (Bylinsky, 1978).

skills. They are sensitive to different issues and to different inputs. In addition, because policy issues are typically highly complex and uncertain in most agencies, there may be a large number of influential decision-makers having conflicting views.

Needs and objectives of users are often not clearly identified by system builders. In the context of developing nations, Vernon discusses the extent to which large-scale model-building supports the needs of national planners. Among the international agencies, three basic criteria seem to have evolved for a country to be said to have a national plan: first, the plan must be comprehensive, i.e., it must explicitly state a set of output and income targets and relate these targets to other performance variables both within and among sectors of the economy. Second, it must be consistent, i.e., the composition of goods produced must be consistent with the composition of goods demanded. Third, it must make optimal use of a country's scarce resources (Vernon, 1966).

Vernon questions the extent to which information-generating efforts that are comprehensive, consistent, and optimal meet the needs of policymakers. Aside from these perhaps secondary characteristics of national plans is the overriding need for a plan to justify a claim for foreign aid. Top echelon decision makers are acutely aware of the scarcity of national resources for development. They may be quite willing to sacrifice consistency, for example, in order to meet this primary purpose. The national plan also can serve as a document to generate local hopes, describe the policymaker's interest in local problems, and strengthen the incumbent's hold on his office.

Incompatibility between national plans and national planners often rests on different assumptions regarding the nature of information itself. The planning process in western developed economies depends for its validity upon certain critical capacities. These include the capacity to gather information and to create common planning assumptions among sectoral planning agents.

Information should not flow in a single direction but be part of a dynamic process. This is not the case in Latin American nations where communication channels are more nearly monologue than dialogue, more vertical than horizontal. This situation stems from an acute shortage of administrative and technical skills in the public sector; from fears of proposals that recommend significant change; from a society that has long been based on personal relations that run from a "patron" to those protected; and from a deep-seated suspicion between the private and public sectors.

Another problem of developing models for policymakers is the professional requirement to satisfy not only the needs of the policymaker but also the demands of the professional community. Policymakers may change with elections, but the modeler's peer group remains. This dual audience can create problems. For example, a goal of merely collecting statistically reliable data useful at some uncertain later date for policy analyses may be preferred by some disciplinary specialists. This long-term approach may not satisfy the most urgent needs of the policymaker who must also consider changing political forces in his decision making (Cummings, 1977).

Models

The second general category of criticisms deals with confusion over the appropriate type of model to be constructed, appropriate use of values, and appropriate levels of data detail. Where desirable, discussion will be related to linear programming models.

Too often, individuals have approached problem identification and solution from only the narrow perspective of their own disciplines. For example, having identified a problem of chronic low incomes in a rural area, an agronomist may recommend introduction of a new high-yielding crop. Unless other aspects of the problem such as local and distant markets for the crop and peasants' attitudes toward the uncertainty involved in changing their habits are also studied, the proposal may be ill-conceived.

At the heart of this issue is confusion over the type of research that ought to be undertaken for a specific purpose. Three broad types may be cited: disciplinary, subject matter, and problem-solving (Rossmiller, 1978). The purpose of disciplinary research is to develop or refine disciplinary theoretical knowledge and/or methodology. Although disciplinary specialists may regard this research as problem-solving, it may not be so due to inadequate treatment of facets of the problem which lie outside of the discipline. Subject matter research develops information about an area of concern that contains many specific interrelated problems. Being multi-disciplinary, it brings together relevant bodies of knowledge. Additional data, analytical tools, and information must be provided to solve specific problems. The agricultural information system considered in this dissertation reflects subject matter research. It can make a contribution to knowledge about agricultural production potential but cannot solve specific problems. Credibility gaps between economists and policymaking users are created when the latter wanted problem-solving efforts but received subject matter efforts. The third type of research is problem-solving. Information that is derived from this research is also multidisciplinary, but it is problem-specific as well. Output from a problem-solving analysis is a prescription for action.

A further criticism is that models are normative, i.e., evaluative and value-laden, and therefore of limited operational value in analyzing development problems and prescribing solutions (Singh, 1976). As noted above, policymakers may not have the same values as model-builders. Thus, a credibility gap could arise if the former did not fully accept the modeler's single goal of maximizing efficiency.

Use of the normative is not undesireable _per se_ but not recognizing what constitutes use of the normative may be confusing. For example, resource economists who assume that technology, institutions, and people are fixed are not avoiding the normative. Their acceptance of the existing distribution of opportunity sets and of power between persons as a valid starting point for trade; their definitions of which outputs are products and which are waste; their use of market valued inputs and outputs; and their assumption that the rational actor is either a profit or utility maximizer; are all normative decisions.

In information-generating efforts that use maximizing techniques such as L.P., the frequent failure to recognize the four normative preconditions for maximization described below damages credibility (Johnson, 1971). Furthermore, these preconditions must be established before credible and acceptable decisions can be made using L.P. alone. The inability to satisfy them is a major reason L.P. can provide only limited information that may be useful to making decisions.

The first precondition is the existence of a common denominator which reduces the "goods" being sought and the "bads" being avoided to a single dimension. Monetary values may or may not be usable for reducing the health objective of one policy, environmental objectives of another, and income objectives of another policy to comparable levels. Second, such a common denominator should be interpersonally valid since some policies may confer "goods" on some people and "bads" on others. Third, the maximum to be found must exist. When programs and policies involve technological, institutional, and social changes, there is no automatic ordering of programs and policies that will meet the mathematical conditions necessary for locating an optimum. Until such an order is established or found to be unnecessary, it is impossible to maximize the difference between good and bad, even if a common denominator is available. Fourth, a decision-rule is needed to prescribe the right action to take. In a static economy when the first preconditions are met, the rule is simply to maximize the difference between good and bad. In real world situations, however, when positive and normative knowledge is imperfect, when actors may not always be ma

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maximizers, when optimizing order of programs and policies is unknown, and when an interpersonally valid common denominator may not have been found, the definition of an acceptable rule by anyone other than the user of the information system may be impossible.

Aggregation Error.[1] Much concern is focused upon the significance of different amounts of data detail in an information system. This concern will be discussed in terms of aggregation error and its components specification error and measurement error. The aggregation problem surfaces whenever the economist, who wishes to study aggregate supply or demand relationships, must choose between macro or microanalytical techniques. Macro techniques would provide for direct statistical estimation of the aggregate functions without requiring analysis of the individual decisionmaking units. Micro techniques, by more manageably focusing on the individual unit, would much better represent the social, economic, and cultural forces that condition behavior. On the other hand, the huge number of micro models needed to represent the behavior of all firms in the market precludes full and complete application of microanalytic methods.

One approach for proceeding beyond micro to macro analysis involves identifying an hypothetical farm whose supply function is "representative" for farms in a given region. Aggregation of farm supply functions based upon this Marshallian concept of typical farms involves

a) sorting farms in a region into homogeneous categories and deriving supply functions for "representative" farms in each category;
b) aggregating these functions to provide a regional estimate of supply response; and
c) adjusting results on the basis of experience to make predictions (Barker, 1965, pp. 705-6).

[1]The term "aggregation bias" is frequently used. "Bias" denotes a systematic error rather than a random error. Since errors in aggregation may be biased or unbiased, depending on the method of aggregation, the term "aggregation error" will be used instead of "aggregation bias".

A conventional presentation of the aggregation problem is as follows: Assume farm A has 100 units of capital and 50 units of labor; B has 100 units and 150 units, respectively. It requires 10 units of labor and capital to produce one unit of product Y. Programmed separately, A and B will produce a total of 15 units of Y. However, if their resources are averaged, the representative farm would have 100 units of capital and 100 units of labor. Programming this farm and multiplying by two (to represent the two farms in the aggregated farm) allows production of 20 units of Y. The supply function for this representative farm will thus be shifted to the right.

When the representative farm aggregate is represented by a single linear programming (L.P.) model, the question to be asked is, to what extent must the component farms be alike in order for the single L.P. to represent their supply functions without distortion. Day has shown that aggregation error can be avoided only if farms are classified into groups which are defined according to rigid theoretical requirements for homogeneity (Day, 1963):

a) technological homogeneity: each farm has identical production possibilities, resources and constraints, levels of technology, and managerial ability;

b) pecunious proportionality: individual farmers hold net revenue expectations that are proportional to average expectations; and

c) institutional proportionality: the constraint vector of the model for each farm must be proportional to the aggregate constraint vector (Buckwell, 1972, pp. 122-123).

These may be algebraically stated as:

1) $B_1 = B_2 = \dots B_n = B$ where

$B_i$ is the input-output matrix for each farm 1, ... n.

2) $Z_i = a_i Z$ where

$Z_i$ is the net return expectation of the $i^{th}$ farm.

3) $C_i = b_i C$ where

$C_i$ is the resource constraint vector of the $i^{th}$ farm.

"$a_i$" and "$b_i$" are scalars $\geq 0$.

A consequence of these requirements is that each farm should be pecuniously and institutionally proportional to the arithmetic mean farm for its group. Others concluded that it is "not possible to find empirical cases to fit Day's conditions" (Paris and Rausser, 1973, p. 660).

Attempts to develop less demanding conditions include those which suggest that farms be classified on the basis of the most limiting resource for each product (Sheehy and McAlexander, 1965). Aggregation error would be less than under the conventional grouping used as an example above. Miller would include in one group all those farms that have a common range of resource ratios; the result of such a grouping is individual farm solution vectors all containing the same activities although not necessarily at the same levels (Miller, 1973). Unfortunately, as Buckwell pointed out, the application of both Sheehy and Miller's conditions requires full previous knowledge of the technology matrices of the individual farms. Hence, not even these methods are easy to apply.

In contrast to defining the "representative farm" and then aggregating to regional totals is the "aggregate resource" situation in which the L.P. considers a region as an entity with aggregate relations estimated for it. The L.P. uses the geographic map unit directly as the unit of optimization or relevant resource restraint. In concept, the restraining resources of individual farms are summed to a regional (map unit) total. Specification of the areas is simply a special problem in aggregation over inputs. Some of the assumptions underlying this aggregation should be noted. First, a single value is used for technical coefficients in the resource area even though these may be very different within the components of that area. Second, a single farm model is assumed although farmers' characteristics across the resource area may vary a great deal. Third, except for land, the supplies of other production inputs are assumed to be perfectly elastic.

The "aggregate resource" approach is under study in this dissertation. The authors cited on the previous two pages dealt with errors in L.P. "supply functions" resulting from different methods of aggregating the representative farm. This dissertation explicitly considers the question of the effect of aggregating soils of different qualities and to a lesser extent the resources attached to the soils.

Specification Error. Some economists criticize information systems for being too aggregative *per se*. For example, Singh believes that for agricultural models to be useful in so heterogeneous a sector, they must incorporate a great deal of detail. "Until farm-level behavior is first understood and modeled, normative national models for the spatial allocation of agricultural resources provide few operational clues to the development of the sector in LDCs" (ibid., p. 771). Much more detail would be needed to adequately represent the institutional structure and its constraints. This view is echoed by Falcon who states that unless mathematical programming models are founded on detailed farm-level models of specific agricultural regions, they are "likely to give misleading implications for policy in developing countries" and should be used with "extreme caution" (Heady, 1966, p. 382).

The validity of this "disaggregated-first" approach rests on the ability a) to specify perfectly conditions actually facing the farm firm for a given length of run; b) to specify perfectly interrelationships among farms; and c) to meet Day's conditions for aggregation without error. It was concluded above that Day's conditions (or those even less demanding) could not be met. It is also argued that it is impossible to avoid specification error since it is impossible to construct complete structural or behavioral systems for representative farms. Aggregation of misspecified relationships increases the amount of misspecification and hence aggregation error. Further, as Fromm notes, it is highly doubtful that economic theory is so encompassing that it is possible to faithfully relate microtheory to macrophenomena. Even when microtheory provides behavioral propositions, normally they refer to static or dynamic equilibrium states and not to the disequilibrium situations of the real world. Functional specifications are always underlain by the strict, simplifying assumptions of the theory (Fromm, 1973).

Finally, the "disaggregated-first" approach seems to be based on the questionable assumption that national policy decisions are made on the same basis as are firm-level decisions. This is not the case inasmuch as the national decision-maker may be more concerned with the values of several interest groups as well as with his own and also with the long run.

Measurement Error. Measurement errors both for micro and for macro variables include errors in technical coefficients, the resource restrictions, input cost, etc. Data may be drawn from a number of sources. Thus, some data may really be modal, or average, or drawn from a very small and unrepresentative sample. Yet all inputs represent the total number of farms or resource areas. If sampling techniques are used, errors arise if the distribution of the model's parameters over all farms was not known but estimated. Without an historical record, it may be difficult to establish the relevant range for any variable. If each of several variables is felt to have wide ranges, the utility of model solutions may be seriously questioned. If the distribution of a variable's values is expected to have a large variance and/or if the distribution is expected to be badly skewed, the use of some representative value has less meaning. Citing the nearly full utilization of some forms of capital, human, and natural resources in developing countries, Vernon feels such skewed distributions may be characteristic of certain sectors. Accordingly, and in contrast to Singh and Falcon, he concludes that the proper amount of data detail may be quite low, for "the best of models cannot be expected to yield a great deal more than the simpler varieties" (Vernon, p. 65).

Since measurement error will normally occur before aggregation, its magnitude influences aggregation error. It is not obvious that aggregation of measurement errors will produce greater error, however. If measurement errors at the disaggregated level were not biased, their aggregation might result in a net reduction of error as overestimates cancelled out underestimates.

Two additional issues surface in the discussion of small, simple vs. large, complex models: cost and time required to build, run, and interpret them. Because the costs of obtaining sufficient data and estimating microrelationships are very high, some favor more aggregated or simpler models. Because the time required to build complex models is greater than for simpler models, the latter may be favored also. There are at least two aspects. First, for political reasons, timeliness of analytical results may be highly important to the user. Second, and related to cost, large and complex models may require greater amounts of scarce supplies of skilled technicians and analysts than smaller models.

In summary, over the past several decades the number of quantitative models constructed to address agricultural issues has increased dramatically. Lack of documentation on their actual use is consistent with the variety and severity of criticisms levied upon them. A repeated issue is that of the proper amount of data detail to be incorporated into model structure. This is the issue of large, complex vs. small, simple models. Inability to perfectly specify functional relationships and to avoid measurement errors and hence aggregation errors either in complex or aggregated models is apparent. The question of the correct degree of aggregation may be one of setting priorities between control of specification, measurement, and aggregation error on the one hand and the cost and time required to build alternative systems on the other hand. In this dissertation, one L.P. model structure (see p. 51-2) is specified. It is quite simple and aggregated. Without changing the L.P. specification, the model is run at three increasingly aggregated levels of detail. Hence, trade-offs of different amounts of measure ment errors, a given high level of specification error, and costs of the three different levels of detail will become apparent in the following chapters.

# CHAPTER III

# INFORMATION SYSTEMS

In order to begin to resolve criticisms of information-generating efforts such as those discussed in the previous chapter, it is important to understand how useful information may be produced. This chapter first presents a generalized information system and then the specific case of the CRIES information system developed for the Cibao Valley.

## A Generalized Information System

Figure 3-1 depicts the major components of a generalized information system. Given the infinite variety of the real-world, the researcher must simplify reality in order to be able to deal with it. If data produced are to be internally consistent and correspond to reality in important ways, classification must itself be based on concepts that are meaningfully related to one another and to the real world. Thus, to produce accurate data, conceptualization of some aspect of reality must first occur. These steps of conceptualizing an area of concern, determining which data to gather, and deciding which methods to use, gather, store, and retrieve them, comprise the data subsystem of the information system in Figure 3-1.

An information system includes not only data production but also analysis and interpretation in the context of some problem or set of problems. Decision-makers rarely use raw data. Rather, the data gathered may be interpreted or revised, or new data may be gathered and interpreted.[1] Analytical tools that provide the informational inputs needed to solve the sets of decision rules established by the decision-maker are critical to the successful operation of the system.

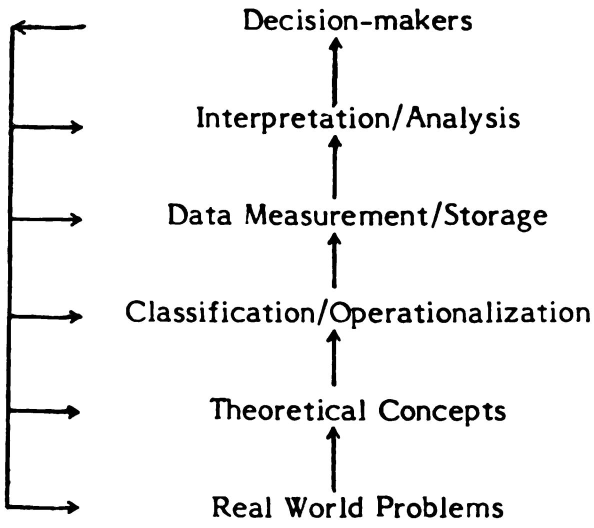


Figure 3-1.-- A Generalized Information System

Source: Adapted from Bonnen, 1975, p. 758.

<u>Criteria For Information System Credibility</u>

The fundamental purpose of our information system is to increase the user's knowledge about the set of problems in his area of concern. In order that this be possible, there should be interaction between the researcher and system users. Such communication may have several consequences. First, it allows a better understanding on the part of users of the conceptual, operational, and analytical structure of the system. Second, the system builder can better determine whether the system represents reality as the users perceive it. Third, the builder

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[1] Data are not equivalent to information although the terms are often used interchangeably. Data become information by being associated with and interpreted with respect to an issue which is of concern to a decision-maker. It is in practice difficult to distinguish between data and information within the context of an information system since unprocessed, unformatted, raw data are rarely used by either the final user or his staff. Instead, at a minimum, data are presented in some particular format that carries with it some degree of interpretation.

can become better aware of the roles played by his values and by those of his client(s).

Production of useful information requires that both positive and value-laden normative knowledge be utilized. Positive knowledge refers to concepts that describe conditions, situations, and things without assigning degrees of "good" or "bad." Positive knowledge is nonevaluative. Normative, on the other hand, means evaluative. Hence, normative knowledge includes standards for judging conditions, situations, and things in terms of (not as) good and bad.

Inasmuch as the use of the normative is inevitable, system builders must be objective if their work is to be accepted by the user. Normative knowledge is considered objectively true if it meets four tests. They are a) logical consistency, b) correspondence with reality, c) clarity, and d) workability (Johnson, 1971).

The important question in determining logical consistency (or validation) is whether the underlying assumptions and theories and the interactions among the parts of the system are compatible with the general set of problems to be analyzed. If, as sometimes happens, the system builder omits this test, or any of the other three tests, and tries to function as the policy analyst without the latter's much greater breadth of knowledge, the usefulness of the system is apt to be seriously jeopardized. Although logical consistency implies some sort of a comparison between model and reality, there may be little quantitative information about the real system that can be used as a basis for comparison. In such a case, the subjective judgments of the system builder and user are heavily relied upon.

Correspondence with reality, also called model verification, is closely related to logical consistency. It involves testing concepts with respect to their ability to reflect real world phenomena accurately. Since the researcher's perspectives and experiences are necessarily limited while reality is infinite, it is at this point that one is faced with deciding when singular statements (summaries of observations) can lead to the universal ones (generalizations) of economic theory. While final proof is never possible, the test of verification can be met if empirical theories are intersubjectively testable (Shapiro, 1973).

The third test is clarity. The system's conceptualization of reality and the underlying theory and assumptions must be explainable and understandable to the user.

Finally, the decision-maker tests the system for workability. This is a test of the system's prescriptive ability and is undertaken by the user. The system must provide information usable to the decision-maker in the process of solving the variety of problems found in the area of concern.

## Comprehensive Resource Inventory and Evaluation System (CRIES)

The real-world set of problems (refer to Figure 3-1) about which the CRIES information system attempts to provide information relate to a country's agricultural production potential. The objectives of CRIES are to

1. develop a natural resources classification and analytical framework adaptable to many countries and capable of accumulating and transferring reliable information among countries.
2. help national planning agencies strengthen their capacity to determine the extent, quality, and use of their resources, and to evaluate partial impacts of alternative uses.

Intended users of the information are public officials with agricultural policymaking responsibilities at the national level and their immediate technical staff. Development of this resource information system is not intended to provide solutions to specific problems falling within the subject matter area of agricultural production potential, nor is it intended to provide comprehensive recommendations about needed sources of action. It is designed to provide a specific, limited amount of information that together with other sources of information will permit setting policies to attack problems in effective ways.

Conceptualization of Production Potential.

Conceptualization of production potential is based on host country documents that contain statements of agricultural problems and public policies and interpretation of these problems and policies by U.S. and host country specialists in agricultural production economics, soil science, botany, and agronomy.

A development plan for the northwest area of the Dominican Republic discusses agricultural production potential of the Cibao Valley:

> ....a disequilibrium exists that will be accentuated if adequate measures are not enacted immediately. This disequilibrium is determined by....rapid population growth; migration, principally to Santo Domingo and Santiago; low real incomes of the rural people; scarce educational and health opportunities; the lack of remunerative employment and of adequate communications; inadequate food supplies; and poor nutrition.
>
> From the viewpoint of production, only limited supply is observable, as well as underemployed labor, land held idle for lack of water, credit, and other factors. Among others, the following actions are needed: identify possibilities for increasing yields and production of currently cultivated crops; identify new crop possibilities; identify new activities such as livestock, forestry, mining, and tourism; adopt natural resources conservation practices (Organizacion de Estados Americanos, 1977, p. xxx).

Another Cibao area study found that soil resources considered suitable for food production are quite limited in the Dominican Republic because of the naturally steeply sloping and broken relief of much of the island. Due to increasing demands of a growing population, and to national needs such as more employment, higher incomes, and more foreign exchange, "it is necessary to use natural resources to their natural productivity" (FAO, 1974, p. 1).

In subject matter research such as this dissertation, each specialist is expected to contribute with scientific objectivity to the conceptualization of the area of concern.

Contributions from Production Economics. The production economist is concerned with the efficient allocation of resources to produce desired outputs. His theory may be static in that there are a given number of exact and unchanging relationships among a number of economic variables. The static system is timeless; it does not deal with the path to equilibrium.

Assumptions of static production economics fall into three broad sets. The first set consists of assumptions that fix:

a. production functions by assuming a constant state of technology and input-output relationships;

b. utility functions by assuming unchanging tastes, habits, and customs, the ownership pattern for resources (and hence the distribution of private real incomes and power relationships; there is no assumption of perfect competition), and population levels;

c. the institutional mix of the economy by assuming unchanging public-private sector relationships and the existence of markets where goods and services are produced and exchanged without coercion.

The second set of assumptions eliminates random elements by assuming perfect knowledge and rational behavior. The third set concerns the behavioral forces that drive the system. Consumers are assumed to act to maximize their utility, and producers, their profits. Not only does such behavior work to solve individual producer/consumer problems, but it is assumed to promote resolution of national/regional problems.

A consequence of these assumptions is that purely static analyses may tend to create credibility gaps between the analyst and decision-maker. While the assumptions make possible a theory that is manageable conceptually, the decision-maker may want to go beyond the market to non-market changes in technology, institutions, and people and into situations where knowledge is imperfect. Because of his concern for societal welfare, he may go beyond market pricing to value the net changes in utility. Most real-world problems and solutions involve going beyond free exchange to include the use of power and coercion to redistribute the ownership of rights and property. Static theory lacks the ability to resolve dynamic problems in which changes occur that confer benefits on some and damages upon others. All adjustments are "better" because of the perfect knowledge assumption: ex ante = ex post. Nobody will enter into any transaction unless that person is made better off.

In spite of these limitations, the theory is highly useful in that, by simplifying the complexities of reality, it becomes possible to gain at least a partial understanding of how resources are allocated. It is critical to credibility, however, that the decision-maker understand the limitations of the analysis. The decision-maker with his concern for increasing the welfare of society, needs to be aware of both an analysis that accepts the status quo distribution of opportunity sets and power and other types of analyses that provide information essential to his other decision rules.

Two concepts of production economics have been drawn upon in particular, to help conceptualize the subject matter area, i.e., the agricultural production potential of the Cibao Valley. These two concepts are comparative advantage and marginal productivity analysis. With respect to the former, it has been demonstrated that while the possession of a substantial quantity of natural resources of a relatively high quality is conducive to a region's economic development, it is not obvious that any particular type or amount is absolutely essential to such growth. What is required is access to natural resources via trade with other regions as well as the availability of substantial quantities of capital and labor (Herfindahl, 1969). This principle of comparative advantage underlies the production economist's conceptualization of agricultural production potential. It was first stated by the classical economist David Ricardo in 1817. Refining Adam Smith's conception of absolute advantage, Ricardo showed, in the context of international trade, that trade might take place to the advantage of both trading partners even if one had an absolute advantage in both of the commodities exchanged. Trade, and hence resource allocation, would thus occur because of comparative advantage, a situation depending only on productivity ratios of its resources (Lekachman, 1959). In this study, the trading partners are regions within the Dominican Republic.

Marginal productivity analysis is based on the concept that, given a set of fixed inputs, as the amount of a variable resource used in the production of some good is increased in successive equal increments, output will at first increase at an increasing rate, then at a decreasing rate, reach a maximum, and then decrease absolutely. This is the familiar law of variable proportions or law of diminishing returns. Given the assumptions of a static economy, producers will produce up to the point where marginal value product equals marginal factor cost. At that point profits are maximized. This optimal or high profit point thus depends upon the relationship of the prices of the product and the resource inputs as well as upon the physical production function.

Contributions from Soil Science. The soil scientist views soils as independent natural bodies. Each is composed of a unique combination of four soil forming groups and time: climates, living organisms, topography, parent materials, and age of land surface (Johnson, 1978). According to this concept, the kind, thickness, and arrangement of soil layers in the profile are the result of interaction of temperature and moisture and their seasonal distribution; and of vegetation, animals, humans, and micro-organisms on the parent materials in particular topographic situations over time. Since soil is one of the fundamental components of terrestrial ecosystems, it must be studied to determine how it interacts within these ecosystems in the production of food and fiber products.

Soil resource inventories provide data for the study of this part of the ecosystem. At best, these inventories are incomplete records of soil conditions within an area. They are documents that record the geographic distribution of unique kinds of natural soil bodies on maps and identify the properties that characterize them (Cline, 1978).

The three major elements of a soil inventory may be noted: characterization involves the field and laboratory study of soils. It is based on grouping individual pedons (observed elements) into taxons to define the ranges in their characteristics or properties, and to understand the evolution of landscape relationships of the soils present.

The second element, classification, is done in such a way that one soil varies from another in one or more properties to such a degree that the combinations of all the properties result in different responses to management for growing crops and facilitate the evaluation of production potential (USDA, Soil Taxonomy, 1975). When consistently and reliably done, soil classification makes possible soil surveys that are consistent between different places and that include accurate interpretations of soils for specific uses.

The Taxonomy, with its hierarchical classification, provides the flexibility needed. There are six categories in the classification. In order of decreasing rank and increasing number of differentiae and classes, the categories are order (10 in the U.S.), suborder (47), great group (185), subgroup (970), family (4500), and series (10,500). The most heterogeneous category is the order; the most homogeneous is the series. Further, phases may be used as subdivisions of any category; and even phases of series may vary in their productive potential.

This dissertation deals with the great group, subgroup, and family taxa since they have frequently been utilized in national/regional resource analysis. At the great group level, the soil scientist is able to consider the whole soil, the assemblage of horizons, and the most significant properties of the soil. Subgroups are subdivisions of great groups. In addition to the processes that have dominated soil development, the soil scientist also considers subordinate properties that are marks of important processes. At the still more detailed family level, the intent is to group soils within a subgroup that have similar physical and chemical properties which affect their responses to management. The agronomic responses of comparable phases of all soils in a family are nearly enough the same to meet most needs for practical interpretations of such responses. The purpose of the family (and also series) category is primarily pragmatic in contrast to the conceptual natures of the higher categories. Phases add to the pragmatic value of all categories.

The third element, mapping, is done in order to be able to make more precise statements about the mapped subdivisions of the area than about the area as a whole (Beckett, 1968). Descriptions of the soils including statements about their morphology and their important qualities and the proportions and patterns of the soils in each map unit are described in the text accompanying the map.

Soil inventories are made for many different purposes. Some purposes, such as farm planning, require refined distinctions among kinds of soil that occupy small homogeneous soil areas (usually phases of soil series). Others, such as national planning, require a broad perspective of the soils of large and commonly heterogeneous but distinctive areas (usually phases of the highest categories). The attributes of the maps and the intensity of application of the methods by which they are made vary greatly within this range. Theoretically, basic input elements of a soil inventory can be adjusted to provide the most useful product for the principal intended purposes. Different intensities of field study, different degrees of mapping detail, different phases or levels of abstraction for defining units, and different map unit designs produce soil surveys of widely ranging applicability (USDA, Soil Survey Manual, 1975, with parenthetical amplifications).

The desirability of different levels of detail in a soils inventory is a function of the amount of information that is needed and can be utilized for the specified purpose as well as on the availability of base maps. If topographic maps, for example, are unavailable, other sources such as aerial photos, radar imagery, satellite imagery, mosaics of such photos and/or imagery, planimetric maps, orthophotos, tabular information, or other information, would have to be used. To a much lesser extent, the availability of other land resource information (weather records, geologic maps, vegetation maps, weather station data, land use maps, etc.) influences the degree and/or feasibility of soil resource inventories of differing levels of detail.

Collaboration with Other Disciplines. Climatology and botany are important to conceptualizing the stated area of concern. Soil productivity is a synthesis of conditions of soil fertility, water control, plant species and varieties, pest control, and physical environment. Plant growth depends on the environmental conditions in the immediate vicinity of the plant. Plants, as integrators of a variety of environmental variables, are potentially better indicators of climate than many instru ments are because they are continuously receiving climatic inputs. Due to a scarcity of meteorological time series data, field verification of vegetative assemblages is frequently necessary in order to understand the climate. Environmental conditions (temperature and precipitation) that the botanist can help identify are a required datum to specify certain soils taxa. Consideration of both soils and climatic data make possible the identification of areas that demonstrate similar production potential.

Resource interpretation for more than broad suitability ratings for general crop groups requires the added input of agronomy. Soil productivity is that quality of a soil that summarizes its potential for producing plants under defined sets of management practices. Comparison of soil and climatic requirements of plant cultivars found in a region, with the characteristics of the agro-ecological areas, is the basis for a suitability assessment. The agronomist describes and defines regional cropping practices and systems, both current and possible, and estimates expected crop yields for each agro-ecological area under a specific management method.

Operationalization of These Conceptual Inputs

Operationalization of this conceptualization of production potential requires establishment of data categories and gathering of those data. The CRIES information system does these things by means of the following components:

a. A resource classification that defines land units in a way consistent with established taxonomy of soils.

b. Land units that are sufficiently homogeneous with respect to plant productivity and adaptability to be reliably depicted by agronomic parameters for national agricultural resource analysis. This land unit, the Production Potential Area (PPA), is conceptually mappable, but this has been considered unnecessary given the area of concern and level of planning. The definition of a PPA follows:

> A PPA is an aggregate area of individual soil bodies and associated climates within a Resource Planning Unit (defined below) which is sufficiently homogeneous with respect to plant adaptability, potential management requirements, and productivity to be reliably depicted by unique estimates of those parameters for national analysis and planning (USDA and MSU, 1980, p. 3).

c. Land units that are spatially identified to permit the association of representative social and economic data to the agronomic areas. These landscape units are composed of discernable patterns of PPAs. They are homogeneous only in their repeating heterogeneity of soils and climate.[1]

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[1] In the CRIES system, these are called Resource Planning Units. They are defined as a geographically delineated unit of land that is relatively uniform with respect to land forms, kinds, and patterns of soils, climate, and vegetation (ibid., p. 3).

d. Representative sets of agricultural production practices and costs and the spatial identification of these representative sets to map units and then to PPAs.

Interpretation and Analysis.

The next component of an information system is interpretation and analysis.[1] The analytical tools of interest to this dissertation are soil maps and cost-minimizing linear programming (L.P.).

Map information content involves relationships found in the number, size, shape, frequency, and pattern of the various soil delineations of each map unit. Map units are rarely considered pure--composed of only one kind of soil body--but are variable to differing degrees.

Another map characteristic is scale. As map scale decreases, ground area represented by one square centimeter of map area increases. In order that map delineations be legible, increasingly aggregative and increasingly heterogeneous soil area are required at increasingly smaller map scales.

Although map scale is frequently expected to indicate the possible uses of a map, the level of detail incorporated in it, and the kinds of interpretations that could be made, these are often erroneous expectations because of the differences in inventory methods upon which a given map is based. Eswaran notes that the proper decision on map scale requires one to determine the following: first, the purpose of the survey; second, the degree of precision desired for the location of map unit boundaries, and the maximum percentage of error acceptable; third, the size of the smallest map unit which will not exceed this maximum error; and, lastly, the map scale at which the user's minimum area of interest is the same as this smallest acceptable map unit (Eswaran, 1978).

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[1] Data measurement is discussed in detail in Chapter IV.

Soil inventories with excessive detail may provide more information than can be used effectively and efficiently for a particular purpose. Excess information is manifest in too many map units, too many map unit components, or maps too large or in too many sheets to be used conveniently. The size of the study area or country then, is roughly correlated with the number of resource units at any given level of intensity (Knox, May 1979).

Linear programming (L.P.), the second tool of interest, has been in use by agricultural economists since the early 1950s "to specify the 'optimum' organization of resources and enterprises on farms, ... , profit maximizing mixes of commodities produced ... , cost minimizing methods of processing products ... , spatial equilibrium patterns in the flow of agricultural products, 'optimum' interregional patterns of resource use ... , and to solve related problems" (Heady, 1971, p. 1).

L.P. is a budgeting procedure that breaks the production process into a series of linear relationships or activities. The ratios between any two inputs and between any input and the output are fixed and hence independent of the level of production. By comparing the single input-output ratio of one method of doing an operation to the ratio of another method and then comparing the two methods with the factor price ratio, the most advantageous method can be determined. The linearity assumption for any method of production does not imply that only constant returns to scale may be handled by an L.P. "Diminishing returns" can be incorporated by specifying additional methods of performing an operation.

In Figure 3-2, a series of independent input-output points, each a defined method of production, are connected to suggest an iso-product "curve" for a product Y as well as a production function. However, in order to produce Y in a specific way, inputs $X_1$, $X_2$, and $X_3$ must be combined in a definite proportion, i.e., the inputs are perfect complements. Inasmuch as $dy/dx_i$ cannot be defined for perfect complements, the function is not defined.

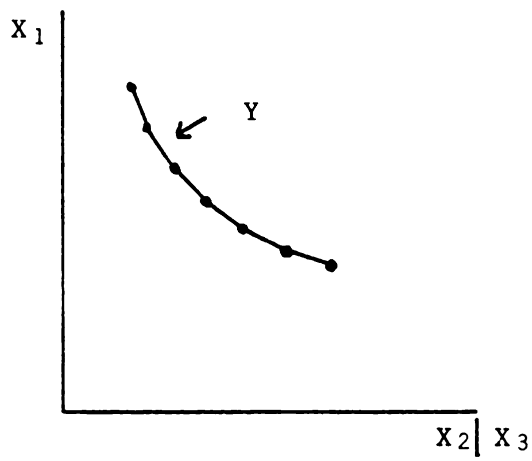


Figure 3.2 -- An Iso-Product "Curve"

Any L.P. problem has three quantitative components; they are:

a. An objective function that is to be either maximized or minimized. Often profits are maximized or costs are minimized.

b. The existence of alternative processes by which the objective may be reached. A process is a method of converting resources into a product. Two processes are the same if they use the same resources or restrictions in the same proportions. A process may be represented by one point of the production function concept used in marginal analysis. Where a production function is linear, it is defined as different levels of the same process. A nonlinear function is a collection of different processes.

c. A restricted or limited availability of resources. Basically, some combination of processes, each of which has resource requirements, is found that maximizes or minimizes the objective function subject to two restraints:

(1) the total amount of resources used must be equal to or less than the supply; and

(2) the level of any process must be equal to or greater than zero.

In addition to the linearity assumption and those stated earlier for static economics, L.P. has several additional assumptions:

a. Additivity. Processes must be additive in the sense that when two or more are used, their total product must equal the sum of the individual products. No interaction between certain inputs can occur. If there is interaction, the entire combination must be treated as a single process. The additivity assumption also implies that the sum of the resources used in each process equals the total resource use of all processes.

b. Divisibility. All non-negative levels of input use and output are production possibilities. Resources and products are assumed infinitely divisible; the lumpiness of inputs and outputs is ignored. Inputs are perfect complements; outputs are perfect substitutes with respect to contribution to the maximand.

c. Finiteness. It is assumed that the number of alternatives and resource restrictions is finite.

CHAPTER IV

# A METHOD TO EVALUATE IMPACTS OF ALTERNATIVE LEVELS OF DATA DETAIL

A major criticism of information systems has been that the data detail employed is not appropriate for either the identified problem, the analytical tools used, or the needs of the user. The purpose of this chapter is to present a method to understand more clearly the process of producing information. The method will involve first, varying the degree of detail in one data input, soils, and studying the change in information produced (output) by the analytical tools employed--soil maps and a least cost linear programming (L.P.) model; and second, varying both the degree of detail and crop yield estimates and making a similar study of change in information produced. The other steps in the generalized information system presented in Figure 3-1--the real world subject matter area and conceptualization of it, data classification, storage, and retrieval, analytical tools, and the user--are not varied.

First, the user group, study area, and the problem to be analyzed will be described. Next, three soil inventories, each of a different level of aggregation, will be presented. Data from the inventories will provide inputs to a) three L.P. models that differ from one another not in specification but in the number of activities and constraints stemming from the number of principal soil components (PPA's), and to b) two L.P. models that also differ in crop yield estimates. Performance indicators will be developed that will suggest, by showing differences in the data inputs and information outputs, the nature of the information production function. It must be emphasized that this analysis is only a partial one. Interaction with users regarding clarity, validation, verification, and workability of alternative levels of detail and hence their usefulness is a step not in the scope of this thesis. This step would be required for a complete analysis.

## User Group, Problem Identification, and Study Area

Policy analysts and planners concerned with the capability of the Cibao Valley and major regions within it to produce food and fiber for both its own and for non-Valley requirements are the users of the information systems being constructed. In this regard, the Cibao is treated as if it was a country. The professional interests of this group of planners would be diverse, as they in fact are in the Subsecretary of Natural Resources. This diversity might include remote sensing, agrometeorology, forestry, soils science, agronomy, range science, and agricultural economics.

Within agricultural production potential, the general area of concern, the problem to be analyzed is how to use the land resources of the Cibao Valley in the least costly way to meet current and future crop requirements, both internal and external. In order that the analysis not lose credibility among hypothetical users due to lack of clarity about the analyst's value assumptions, the following limitations are identified:

1. Only a partial, noncomprehensive, analysis is to be made. The focus is primarily on one aspect of production potential--the physical resource possibilities. The region's ability to realize these possibilities or even the desire to try will depend on societal institutions, e.g., land tenure, educational levels of farmers, pricing policies, and customs, that are exogeneous to this analysis. The impacts of resource use changes on other sectors of the economy, such as transportation, and even on aspects of the agricultural sector itself, such as input prices, are not considered.

2. Linear programming solutions are not assumed to be sufficient per se for making "real world" decisions since the four normative preconditions for maximization (of minimization) discussed earlier cannot be substantiated.
3. The analysis must be interpreted with recognition given that information on the reliability of the parameters included in the analysis is largely absent.
4. For these reasons, the information provided by this particular information system cannot be used alone for decision-making. However, it can serve as a needed input to the users' decision-making process. Methods used to develop each of the data inputs are professionally acceptable. The data themselves are considered internally consistent, and their behavior corresponds with reality as previously experienced by the professionals involved.

The Study Area is the Cibao Valley. There are two major reasons for choosing this area: first, it is a very important agricultural area in a developing country; second, a sufficient amount of data on soils and general land cover is available from previous work.

In its 1968-1985 Development Plan, the National Planning Office delineated four national planning regions. The most important, with an estimated 39 percent of the nation's land area and 51 percent of the 1971 population, was the greater Cibao Valley. The highly productive flatlands of this Valley were studied by the FAO between 1969 and 1974. Somewhat more than 70 percent of this 6,299 square kilometer flatlands area was estimated to be in farms. Of the total land in farms, 44 percent was estimated to be either in cultivation or idle; 27 percent was in cultivated pasture, 18 percent in natural pasture, and 11 percent in other uses. The agricultural sector of the Study Area contributed 24 percent of the national agricultural product in 1971. It was also the principal source of area employment.

With respect to national exports, the Cibao accounted for 80 percent of those from tobacco, 42 percent from coffee, and 27 percent from cocoa. In terms of production, the Cibao produced 90 percent of the nation's tobacco, 33 percent of its coffee, 25 percent of its cocoa, 29 percent of its rice, 53 percent of its plantain, 46 percent of its yucca, and 32 percent of its sweet potatoes.

As part of the FAO study program, a semi-detailed soil inventory of 222,000 hectares was done for the flatlands between Monte Cristi on the west and Pimentel-Cotui in the east (FAO, Informe Tecnico 6, 1974). It is this area that is being studied in this dissertation. Two major river systems drain this inventoried area: the Yaque del Norte flows westward from just east of Santiago to the Caribbean Sea at Monte Cristi; the Licey, Cenavi, and Camu Rivers in the eastern end of the Study Area are major tributaries of the Yuna which is just east of the Study Area.

The Study Area is quite homogeneous in many respects. The soils are almost all nearly level, very deep, and formed in water-deposited sediments. Most are medium, moderately fine, or fine textured. Much of the area is cultivated and irrigated. On the other hand, there is a great range in precipitation. The climate is humid in the east and arid or semi-arid in the west. Soil moisture regime is probably the most important variable characteristic.

Three major regions were identified by the CRIES-assisted SIEDRA[1] staff generally taking into account population, climate, type of agriculture and economic activity, and the resource base. The Western Region extends from Monte Cristi to Esperanza. Except for a small area east of Esperanza, the region is dry, with average annual rainfall of 400-800 mm., and hot, with an average annual temperature of 27°C. The region has slopes of 0-3%. No cropping is possible without irrigation, but with irrigation, the soils are quite productive.

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[1]SIEDRA is the Spanish acronym for Inventory and Evaluation System of Agricultural Resources. SIEDRA is located within the D.R. Subsecretariate of Natural Resources.

Flooding is generally not a problem; salt and sodium accumulation is found where irrigation and drainage practices are unsuitable. The major crop is rice, with some plantain, sugarcane, and natural pastures. To the south and east of Esperanza, where precipitation is higher (probably 1,200-1,400 mm.), more plantain and some tobacco are found. One major east-west highway and numerous hard-surfaced feeder roads are located in the region. Only three notable centers of population exist: Monte Cristi with 15,800 persons (1971), Esperanza with 22,700 persons, and Valverde (Mao) with 46,600 persons.

The Central Region extends from just east of Santiago to Esperanza. Physiography changes to include some rolling plains with slopes of 3-15 percent and scattered others of up to 30 percent. Along the Yaque del Norte River are the flood plains noted above. Average annual rainfall is 800-1,400 mm. in the rolling plains areas and 1,200-1,800 mm. along the Yaque. Supplemental irrigation is generally needed although not always available. Major crops are tobacco in the rolling hills and rice and plantain on the lower terraces. The transportation network is similar to that in the West except that it is quite extensive around Santiago, a city of 268,400 persons in 1971.

The East Region extends from Licey, east of Santiago, to Pimentel-Cotui, just outside the eastern rim of the Study Area. Physiography returns to the 0-3 percent slopes of the West. Terraces of stream, lacustrine, or marine origin and alluvial foot slopes occur in this area. This is the wettest of the three regions with average annual rainfall ranging from 900-1,500 mm. in most of the region to 1,600-2,000 mm. on the easternmost side. Irrigation is required only for rice. Land use includes much interplanting of food crops (corn, beans, yucca, plantain, sweet potatoes, and tobacco) in the west and central parts to extensive and highly productive rice and pastures in the southeast; cocoa is found in the hillier areas. Except for those used in some of the rice fields, production methods here, as in other regions, are quite simple. A number of hard-surfaced roads transect the region. Population centers are found all along the edges of the region: Moca - 96,200; Salcedo - 40,500; San Francisco de Macoris - 133,800; La Vega - 165,500; and Fantino - 16,000.

## Three Cibao Valley Soil Inventories

Three soil inventories were constructed: Detailed, Intermediate, and Aggregate. Ideally, the three inventories would have been developed completely independent of one another, perhaps by different soils scientists using the same technical guidelines. Inasmuch as this was not possible, a soils scientist[1] prepared the three inventories for the purpose of permitting analysis of the Valley's agricultural potential. Each was developed according to the following criteria:

Detailed Inventory:
1) Map units are properly described as phases of soil family taxa;
2) Map unit delineations are legible at a 1:100,000 map scale.

Intermediate Inventory:
1) Map units are properly described as phases of soil subgroup taxa;
2) Map unit delineations are legible at a 1:250,000 map scale.

Aggregate Inventory:
1) Map units are properly described as phases of soil great group taxa;
2) Map unit delineations are legible at a 1:1,000,000 map scale.

The FAO map was published at a scale of 1:50,000. Its map units are mostly consociations or associations of phases of "series." The FAO "series" (Knox, 1978) are not taxonomic subdivisions of soil families so do not fully qualify as series. They are more broadly and loosely defined than required by current U.S standards. They are classified to the subgroup level of the soil taxonomy; however, some of the classifications are contrary to other information about the soils, and some of the series seem to be broader than the subgroup to which they are assigned. Some

[1] Ellis Knox, Salut Incorporated, Columbia, Maryland.

FAO map units, particularly those in flood plain areas, are very vaguely defined, loose associations or undifferentiated groups of suborders and great groups. The number of "series" and map units is excessive compared to the amount of information given for each unit. In the Study Area, 55 distinct "series" and 9 associations of "series" are identified. As a result, the FAO map shows a number of boundaries of which the significance is not at all clear.

The FAO report was augmented by information from the 1967 OAS study of the natural resources of the D.R., by the previously prepared CRIES national-level soils inventory, and by brief field observations. The OAS soil map was published at a scale of 1:250,000. Map units are loosely defined associations of very broadly conceived series. They are "broadly conceived" in that The OAS report does not attempt classification of the soils, and the descriptive material provides a skimpy basis for classification.

The third data source, the national CRIES soil map, was previously drawn at a scale of 1:250,000. Map units are associations of phases of subgroups.

The Detailed soil map was drafted on the FAO map at 1:50,000 scale, but its delineations were drawn for presentation at 1:100,000 scale. See Figure 4-1 in the packet. The 31 map units are associations of phases of families. Ninety-five delineations and 45 unmapped principal components, PPAs, of the map units were also defined. The soil classification of the FAO report was used in most cases, but Salorthids were changed to Camborthids, and the aridic moisture regime was expanded at the expense of ustic moisture regime. The classification of soils as Mollisols or Alfisols was accepted in large part. (In the national CRIES map, Argiustolls and Haplustolls were reclassified as Ustropepts, Argiaquolls as Pellusterts or Fluvaquents, and Tropaqualfs as Tropaquepts.) Figure 4-2 is a sample Map Unit-PPA form used for all three soil inventories.

The Intermediate soil map, Figure 4-3, closely follows the national-level CRIES map. It was also drawn on the FAO soil map base at 1:50,000. The

| Characteristic | Unit | Map Unit 01<br>PPA 011 | PPA 012 |
|---|---|---|---|
| General | | | |
| Corresponding Map Symbol from FAO Soil Map | | Ang 2<br>Fo 2 | Mt<br>-- |
| Position in Landscape | | Terrace | Terrace |
| Ave. Annual Rainfall | mm. | 1600-2000 | 1600-2000 |
| Ave. Annual Temperature | °C. | 25-27 | 25-27 |
| Soils | | | |
| Principal Soil Component | | Abruptic Tropoquolf | Abruptic Tropoquolf |
| Slope | % | 0-3 | 0-3 |
| Depth to Bedrock | cm. | 150+ | 150+ |
| Surface Texture | | Medium | Medium |
| Stoniness | | Not Stony | Not Stony |
| Permeability | | Very Slow | Very Slow |
| Drainage | | Imperfect | Imperfect |
| Flooding | | None | None |
| Reaction | | Slight/Moderate Acid. | Strong Acidity |
| Base Saturation | % | 50+ | 50- |
| Salinity | | Nonsaline | Nonsaline |

Figure 4.2-- Cibao Valley Map Unit-PPA Sample Form

Figure 4.3 -- Intermediate Soil Map of the Cibao Valley, Scale 1:250,000

(in packet)

criterion for legibility is specified at 1:250,000 scale. Seven map units, described as associations of phases of subgroups, 11 delineations, and 14 PPAs are defined. The dominant textural phases of the subgroups are specified so that interpretations can be made as though the components were families. Contrasting soils of minor extent and more extensive intergradational or intermediate soils that are identified on the family-level map are ignored at the subgroup level.

The Aggregate map, Figure 4-4, was also drawn on the FAO soil map at 1:50,000. Only three map units, each with one delineation, are shown. They separate the udic, ustic, and aridic moisture regimes. They are associations of phases of great groups, but because the total range in soil characteristics in the Study Area is very limited, the nine PPAs are described and interpreted more or less at the family level.

Following common soil survey practice, at all three levels the Soil Taxonomy is used to organize information, guide the design of map units, and name PPA components of map units. Almost never does a component cover the whole range of the class used to name it. Within the restricted universe of the Cibao Valley, relatively narrow ranges are presented by Taxonomy classes even at the great group level. By emphasis on the dominant and representative segments of the soils, use and management interpretations can be considered more or less at the family level with all three maps.

Taxonomically, each Aggregate map unit could be a perfect composite of Intermediate map units which in turn could be perfect composites of Detailed map units. However, because of the intermingling of soil bodies, difference in map scales at which the three maps were drawn and need for legibility, the cartographic correspondence is not so exact. Table 4-1 presents the taxonomic relationships as modified for cartographic needs between the three levels of map units. In several instances, a Detailed PPA, 051 for example, belongs to more

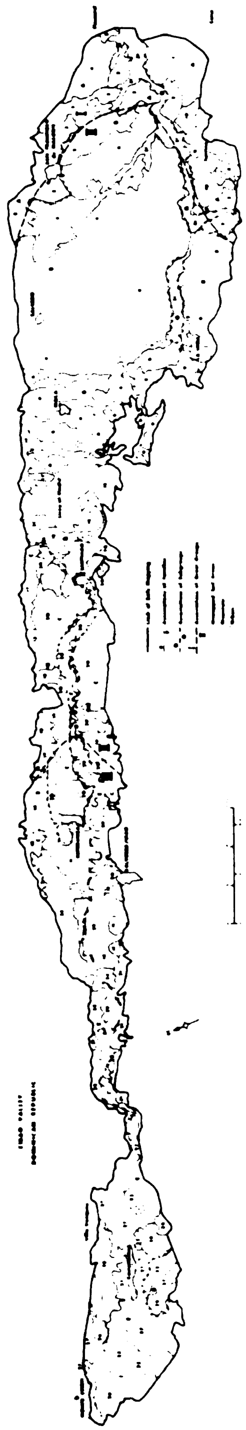

**Figure 4-4 -- Aggregate Soil Map of the Cibao Valley**

Table 4-1.-- Relationships of Map Units and Their Component PPAs

Aggregate Map Unit I

| Aggregate PPAs | Intermediate PPAs | Detailed PPAs by Intermediate Map Unit A | G | Dominant, Similar, and Included Soil Subgroups |
|---|---|---|---|---|
| I1 | A1 | 011, 012, 013, 042 | | Abruptic Tropaqualfs |
| | A1 | 021 | | Aeric Tropaqualfs |
| | A1 | 031 | | Aquic Haplustalfs |
| I2 | A2 | 041, 051 | | Udic Chromusterts |
| | A2 | 081 | | Aquic Chromuderts |
| I3 | A3 | 101 | | Fluvaquentic Eutropepts |
| | G1 | | 311 | Aquic Ustifluvents |
| | G3 | | 313 | Typic Ustifluvents |
| | G2 | | 312 | Aeric Tropic Fluvaquents |

Aggregate Map Unit II

| Aggregate PPAs | Intermediate PPAs | Detailed PPAs by Intermediate Map Unit B | C | F | G | Dominant, Similar, and Included Soil Subgroups |
|---|---|---|---|---|---|---|
| II1 | B1 | 061,071 | | | | Udic Pellusterts |
| | B1 | 051,091 | | | | Udic Chromusterts |
| | B1 | 081 | | | | Aquic Chromuderts |
| II2 | C1, F2 | | 191,201 | 302 | | Fluventic Haplustolls |
| | C1 | | 171 | | | Cumulic Haplustolls |
| | C1 | | 181 | | | Typic Haplustolls |
| | B1, C1 | 151 | 161 | | | Typic Argiustolls |
| | C1 | | 131 | | | Cumulic Haplaquolls |
| | B2 | 092 | | | | Typic Haplaquolls |
| | B1 | 121 | | | | Typic Argiaquolls |
| II3 | F1, G3 | | | 301 | 313 | Typic Ustifluvents |
| | B1 | 072 | | | | Aquic Ustifluvents |
| | G1 | | | | 311 | Aquic Ustifluvents |
| | G2 | | | | 312 | Aeric Tropic Fluvaquents |

Table 4-

Aggreg

Map U

Aggreg
PPA

III1

III2

III3

Table 4-1.-- (continued)

Aggregate
Map Unit III

| Aggregate PPAs | Intermediate PPAs | Detailed PPAs by Intermediate Map Unit D | E | Dominant, Similar, and Included Soil Subgroups |
|---|---|---|---|---|
| III1 | E1 | | 271, 291 | Ustic Torrifluvents |
| | E1 | | 262 | Ustic Torrifluvents (Saline) |
| | E1 | | 272 | Aquic Ustifluvents |
| | E1 | | 281 | Aeric Tropic Fluvaquents |
| | E1 | | 282 | Aeric Tropic Fluvaquents (Saline) |
| III2 | E2 | | 141 | Typic Haplaquolls |
| III3 | E3 | | 241, 292 | Fluventic Camborthids |
| | E3 | | 251, 261 | Fluventic Camborthids (Saline) |
| | E3 | | 242 | Fluventic Camborthids (Alkaline) |
| | D1 | 221 | | Pachic Haplustolls |
| | E3 | | 211 | Aridic Haplustolls |
| | E3 | | 232 | Fluventic Haplustolls |
| | E3 | | 231 | Fluvaquentic Haplustolls |
| | E3 | | 111 | Aquic Ustropepts |

than one Intermediate and/or Aggregate map unit. Appendix Table A-20 presents the relationships between PPAs at the three levels of aggregation.

## Soil Map Comparison Factors

Soil map evaluation suggests an assessment of the accuracy with which different soil areas are indicated and of how useful the map is to users. While most users do not have the opportunity to "ground truth" soil maps, an investigation of the methods to prepare the inventories can indicate which of several maps may more closely correspond to actual resource distribution. Secondly, estimates of relative costs, a factor important to the workability of any proposed survey, can also be made by studying the methods to be used. Finally, the map itself can be inspected for its information content, that is, the relationships found in the number, size, shape, frequency, and pattern of soil areas on a map; soil variability; and map legend characteristics.

Various comparison factors have been suggested by the soil science profession to compare soil maps of different intensities. The factors may be placed into two groups: those based directly on each soil map and those based on assumptions as to how the inventories would have appeared had they been constructed independently. See Figure 4-5. A description/definition of each factor and a comparison for each soil map will be made in the next chapter.

## Five Linear Programming Models

Five cost-minimizing L.P. models were built to analyze how to use the soil resources of the Cibao Valley in the least costly way to increase crop production. The models have identical structures. Three models (Detailed, Intermediate Weighted, Aggregate Weighted) differ only in the disaggregation of the Valley's land base as provided by their respective soil inventories. Two others (Intermediate and Aggregate) differ from the Detailed both in disaggregation and in crop yield estimates. The models are

| | Based on Soil Map | Inventory Assumptions |
|---|---|---|
| I. Methods of Preparation | | |
| A. Base data collection | | x |
| B. Base maps adequacy | | x |
| C. Observations/$Km^2$ | | x |
| II. Map Characteristics | | |
| A. Scale | x | |
| B. Observations/$cm^2$ | | x |
| C. Map delineations | | |
| 1. Average size (ha.) | x | |
| 2. Least size (ha.) | x | |
| 3. Number | x | |
| 4. Area covered by lines (ha.) | x | |
| D. Map units | | |
| 1. Taxonomic level | x | |
| 2. Phases | x | |
| 3. Soil variation | x | |
| 4. Purity | x | |
| 5. Agronomic interpretations | x | |
| III. Map Analysis | | |
| A. Map legibility | x | |
| 1. Map texture intensity | x | x |
| 2. Index of maximum reduction | x | x |
| 3. Minimum scale of reduction | x | x |
| B. Reliability of boundaries | | x |
| C. Measured vs. summed areas of map delineations | x | |
| D. Map unit descriptions | x | |
| IV. Estimated Inventory Cost | | x |

Figure 4-5.-- Soil Map Comparison Factors

1. Detailed (crop yields vary by PPA); 45 PPAs.
2. Intermediate Weighted (crop yields are area weighted averages of the Detailed PPAs comprising each Intermediate PPA); 14 PPAs.
3. Aggregate Weighted (yields are weighted averages of the component Detailed PPAs); 9 PPAs.
4. Intermediate (crop yields vary by PPA); 14 PPAs.
5. Aggregate (crop yields vary by PPA); 9 PPAs.

Current use of the Intermediate-level map units and PPAs, by crop and production technique, was established and mechanically allocated to the Detailed and Aggregate PPAs through the use of percentage ratios discussed below. Thus, only one set of production methods and of production costs was used for all three sets of land areas. Two sets of crop yield estimates were made. In the first set, Aggregate Weighted and Intermediate Weighted PPA yields were simply weighted averages of the yields estimated for the component Detailed PPA's. In the second set, differences in land quality of the Detailed, Intermediate, and Aggregate PPAs were recognized by separately making yield estimates for the Detailed PPAs, then for the Intermediate PPAs, and then for the Aggregate PPAs. Hence, costs per unit of production vary. Neither the level nor the mix of variable factor proportions vary from one PPA to another.

Algebraic Structure of the Basic Model.

The structure of the model is as follows:

Objective Function:

$$\text{MIN } Z = \sum_{hijk} (c_{ijk} \cdot x_{hijk}) + \sum_{hh'k} (c'_{hh'k} \cdot t_{hh'k})$$

Land Constraints:

$$\sum_{jk} x_{hijk} = X_{hi} \qquad \text{for each } h, \text{ for each } i$$

$$k=1,\cdots,13$$

$\sum_{jk} x_{hijk} \leq 1.2 X_{hijk_{cn}}$ , $k=1\text{-}3, 6\text{-}9, 11$ — for each i, for each h

$\sum_{jk} x_{hijk} \geq 0.7\ X_{hijk_{cn}}$ , $k=1\text{-}3, 6\text{-}9, 11$ — for each i, for each h

$\sum_{jk} x_{hijk} \leq X'_{hijk_{cn}}$ , $k=1\text{-}3, 6\text{-}9, 11$ — for each i, for each h

$x_{hik} = X_{hi_{cn}}$ , $k=12$ — for each i, for each h

$x_{hijk} = X_{hijk_{cn}}$ , $k=4, 5, 10$ — for each i, for each h

Transportation Constraint:

$\sum_{h} t_{hh'k} \geq R_{h'k}$ — for each k = 1,···,10 (11 is interplanted package of crops) for each h'

Production is Transported:

$\sum_{ij} (x_{hijk} \cdot y_{ijk}) - \sum_{h} t_{hh'k} = 0$ — for each k = 1,···,11 for each h

Where:

i = production potential area (PPA). In the Detailed model, i = 1 ... 45; in the Intermediate models, i = 1 ... 14; in the Aggregate models, i = 1 ... 9.

j = crop production method, j = 1, 2, 3.

k = crop, k = 1, ..., 13.
1-10 are individual crops in which areas of 4, 5, 10 are fixed; 11 is interplanted group of crops 2, 3, 6-9; 12 is pasture; 13 is idle.

h = production region, h = 1, 2, 3.

h' = requirements region, h' = 1, 2, 3, 4.

$c_{ijk}$ = cost of producing crop k by production method j on PPA i; (pesos/hectare).

$x_{hijk}$ = area of crop k under production method j on PPA i in region h; (hectares).

$c'_{hh'k}$ = cost of transporting crop k from producing region h to requirements region h'; (pesos/unit of production).

$t_{hh'k}$ = units of crop k transported from producing region h to requirements region h'; (units of production).

$X_h$ = area available for crop production and pasture in producing region h; (hectares).

$X'_{hi}$ = one-half of area of PPA i in Region h not used for any type of production in Current Normal.

$y_{ijk}$ = estimated yield of $PPA_i$ for crop k under production method j; (units of production/hectare).

$R_{h'k}$ = requirement for crop k in requirements region h'; (units of production).

Z = total cost of crop production and transportation; (pesos).

cn = Current Normal conditions

In obtaining the optimal solution subject to the constraints noted, land in pasture, and several small area crops (banana, cocoa, and sugarcane) were fixed at their present Current Normal levels.[1] In order to respect implicitly the socioeconomic factors that have determined current PPA use, L.P. solution values of PPA areas in each crop-production technique combination were restricted to 70-120 percent of their Current Normal levels in the Benchmark run and to 70-130 percent in the Growth and Growth/Shift runs (more fully defined below). In those instances where some crop-production technique is not found on a PPA, 50 percent of the total area of the PPA is available for use by the L.P. For example, suppose the area of PPA 01 is 4000 ha. and only 500 ha. is in use (corn-low technique). The relevant constraints on use of PPA 01 would be:

a) corn/low area could range from 350 to 600 ha., 70-120 percent of 500 ha.

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[1] The L.P.'s were run on an IBM 370-138 using the Magen L.P. system. The Haverly optimizer takes as input an L.P. matrix and converts it to the form required to produce an optimal solution. Because the optimizer does not have the ability to bound columns, the 70-120% bounds had to be done with rows. As a result, the sizes of the matrices were increased considerably. The optimizer is most efficient when the number of rows is less than 1800. Removing cocoa, sugar cane, and banana from the matrix was necessary to reduce matrix size. The size of the three matrices was:

| | Rows | Vectors | Elements |
|---|---|---|---|
| Detailed | 2044 | 3076 | 7531 |
| Intermediate | 795 | 1256 | 3066 |
| Aggregate | 600 | 955 | 2308 |

b) beans/low (a crop-technique combination not currently found on PPA 01) could enter the L.P. solution on up to 2000 ha. on PPA 01, 50 percent of 4000 ha.

Linear Programming Solution Comparisons

Without changing specification of the L.P., the model was run for three policy questions at three levels of soil aggregation: Detailed, Intermediate Weighted, and Aggregate Weighted. In addition, the L.P. was run at these three levels but with different and "independent" crop yield estimates (see section below on "Crop Yield Estimates") for each level. These latter three L.P.'s, the Detailed, Intermediate, and Aggregate differ both in the degree of soil aggregation and yield estimates.

The three policy questions are: given the Current Normal pattern of cropland use,

1. What would be the most "efficient" (least costly) means of meeting regional crop requirements? This the the Benchmark run.
2. What would be the most "efficient" means of meeting regional requirements that are 20 percent greater than those of the Current Normal? This is the Growth run.
3. What would be the most efficient means of meeting regional crop requirements that, in addition to experiencing an overall 20 percent growth, also reflect shifts in population from rural regions to the Santo Domingo region by increasing the requirements of this latter region for non-export crops relative to the other regions. This is the Growth/Shift run.

The following comparisons will be made between the Detailed L.P. and each one of the four aggregated L.P.'s:

1. Absolute solution values for regional and Valley crop area, production, production cost, transportation flows, and value of the objective function.

2. A summary comparison statistic, Theil's Inequality Coefficient, U, will be used to compare Regional and Valley changes, from Current Normal values, of cultivated area and production as calculated by each of the models. The formula for U is:

$$U = \frac{\sqrt{\Sigma (0_{2i}-0_{1i})^2}}{\sqrt{\Sigma \; 0_{1i}^{\;2}}}$$

where $0_{1i}$ are the differences between the Detailed L.P. solution and the Current Normal value of some parameter i; $0_{2i}$ are the differences between the Intermediate Weighted L.P., for example, and the Current Normal. When there is perfect correspondence between all of the changes predicted by the Detailed and another model, U is zero. Non-negative, it has no upper limit.

This paper does not attempt to determine the significance of any particular U value. This can only be done by the user of the information produced by the L.P.'s.

3. Results will also be evaluated by computing bias (average signed error) in the more aggregated models with respect to the Detailed model by determining if their solution values are either larger or smaller than the Detailed values on the average. If the weighted sum of the overestimates equals the weighted sum of the underestimates, the bias is zero. The formula for computing bias is

$$\text{Bias} = [\Sigma_i (W_i \cdot \frac{0_{2i}-0_{1i}}{0_{1i}})] \times 100$$

where $0_{2i}$ is, for example, the Aggregate Weighted solution value and $0_{1i}$ is the Detailed value for the specific variables noted above, and $W_i = \frac{0_{1i}}{\Sigma_i 0_{1i}}$ This formula can be simplified to

$$\text{Bias} = \frac{\Sigma_i (0_{2i}-0_{1i})}{\Sigma \; 0_{1i}} \times 100$$

No estimates were made of economic data gathering and assembly costs since only one land use inventory was undertaken. Relevant records would require developing data independently for each model.

In addition to the above and in order to suggest further the loss of information from land aggregation, the variance of Detailed PPA yields around the Intermediate Weighted (Aggregated Weighted) yield of each respective Intermediate (Aggregate) PPA and the coefficient of variation will be calculated by crop. The formula for variance is

$$\text{Variance} = \sigma^2 = \frac{\Sigma (y_i - \bar{y})^2}{n-1}$$

where $\bar{y}$ is the weighted average yield of the crop on the Intermediate (Aggregate) PPA and $y_i$ is the yield on the Detailed PPA. The formula for coefficient of variation is: $\frac{\sigma}{\bar{y}}$ where $\bar{y}$ is the mean yield and $\sigma$ is standard deviation.

Percentage bias among the Detailed, Intermediate, and Aggregate sets of yield estimates will be calculated to suggest in a general way the significance of additional measurement error incurred due to making "independent" crop yield estimates for PPA's at each level of aggregation.

$$\text{Bias} = \left[ \sum_{k=1}^{m} \left( W_k \cdot \frac{O_{ji} - O_{ki}}{O_{ki}} \right) \right] \times 100$$

where $O_{ji}$ is the weighted yield of crop i on Intermediate PPA j; $O_{ki}$ is the yield of crop i on the $k^{th}$ Detailed PPA composing that Intermediate PPA; $W_k = \frac{A_k}{A_j}$ where $A_k$ is the area of the Detailed PPA and $A_j$ is the area of the Intermediate PPA.

Methods to Estimate L.P. Coefficients

Map Unit Areas. Area measurements of each map delineation on each of the 14 sheets of the 1:50,000 FAO base map were made by planimetering the boundaries as drawn on the base map. The summation of delineations composed of the same soil type resulted in area measurements of each map unit. Table A-1 contains these data. The total measured area of the Cibao Valley varies from one map to another due to operator errors in using the planimeter. The Detailed measurement was 2179.5 $km^2$; the Intermediate measurement was 2221.3 $km^2$; and the Aggregate measurement was 2286.3 $km^2$.

PPA Areas. Since PPAs are unmapped, indirect means had to be used to estimate areas. Two different methods were used. The Intermediate soil inventory records an approximate percentage composition of each Intermediate map unit by its PPA components and for "undescribed inclusions." This percentage was allocated to the PPAs in the map unit on the basis of their area. See Table A-2.

The Aggregate soils inventory also records the PPA composition of Aggregate map units. As was done with Intermediate PPAs, Aggregate PPA area was adjusted to include the undescribed inclusions. See Table A-3.

This procedure could not be used for Detailed PPAs since the Detailed inventory did not include this quite specific area information about the unmapped PPAs. Instead, the original 1:50,000 FAO base maps on which Detailed map units were drawn were studied to determine the FAO soil "series" within each. These "series" were then correlated with the PPA definitions of the Detailed inventory in which predominate "series" had been denoted. The FAO estimated area of each "series" in each map unit was recorded. Realizing that map units often have dissimilar inclusions because of cartographic construction, a gross estimate of the percentage of each map unit's area occupied by each "series" was made. With no FAO "series" information in map units 29-31, an arbitrary allocation was made.

An example of the procedure used for Detailed PPAs follows:

1) Detailed map unit 9 has 2 PPA - 091 and 092.

2) The major FAO soil "series" by map symbol in each PPA are:

091 - Ar

092 - PC

3) FAO estimated Ar area at 500 ha. and PC area at 900 ha.

4) Using 1,400 ha. as equivalent to the size of map unit 9, 091 is considered to be 35% and 092 to be 65% of this Detailed map unit.

Percentages such as these were applied to the planimetered Detailed map units to estimate measured PPA area. See Table A-4.

In order to test the effects of land aggregation, it is important that the area of an Aggregate PPA be equal to the sum of the Intermediate PPAs that comprise it and that the area of an Intermediate PPA equal the sum of its component Detailed PPAs. Since PPAs are not mapped, the method of determining PPA measured area is only an approximation. Separately measuring the Aggregate, Intermediate, and Detailed map units and then allocating to PPAs did not permit these equalities. Detailed and Aggregate PPA areas are "normalized" to the Intermediate PPA areas to provide these equalities. The Intermediate map unit measurements and PPA percentage composition are used as control totals. Since they do not correspond to measured area of their respective Intermediate PPA, Measured Detailed map units and calculated PPA areas are used only to establish relative percentage occupancy of the Intermediate PPA area (the control total). The same method was used to allocate Intermediate PPA area to each Aggregate PPA. The example below demonstrates the normalization method and calculation of Detailed PPA areas. The percentages, 19.8%, 14.7%, and 35.5% are used to allocate A2 area to Detailed PPAs 041, 051, and 081. See Tables A-5 and A-6.

| Intermediate PPA | | Detailed PPA in A2 | | Int. Area | Normalized | Allocators |
|---|---|---|---|---|---|---|
| Name | Measured Area | Name | Measured | Det. Area | Det. PPA Area | of A2 |
| A2 | 6210 ha. | 041 | 2430 ha. | 0.5056 | 1228.6 ha. | 19.8% |
| | | 051 | 5493 ha. | | 2777.5 ha. | 44.7% |
| | | 081 | 4359 ha. | | 2203.9 ha. | 35.5% |
| | | | 12282 ha. | | 6210.0 ha. | 100.0% |

Regions. Three production Regions--East, Central, and West--were identified by the SIEDRA staff. Briefly the sparsely populated, dry West requires irrigation for crop production; irrigated rice is the major crop. The moister Central region has a more rolling terrain. Tobacco is the major crop in the uplands; rice and plantain are on the flood plains. Santiago, the second largest city in the country, is located here. The East is the wettest; irrigation is practical only to obtain a second rice crop. Interplanting of annual food crops is widespread. The East is composed of 90 percent of Aggregate map unit I and 69 percent of II; the Central is 12 percent of II; and the West is all of map unit III and small portions of I and II. See Tables A-7 and A-8.

Cropland Use. Due to time and budget limitations, the land use and agronomic data that were developed to describe the Cibao Valley's resource base are not considered sufficiently accurate to be actually used by planners who wish to analyze the area's agricultural production potential. The data were developed in order to illustrate the nature of impacts on information generated by a particular CRIES system, and in this respect, they demonstrate internal consistency and correspondence to reality. The data could be used to illustrate (in an ordinal way) how Cibao Valley production potential may be affected by alternative uses of its land resources.

The methods used to determine land use were influenced by the total absence of secondary data for the Study Area. This absence occurs largely because existing secondary sources present data by administrative boundaries, such as provinces, rather than by the physiographic boundaries used to identify map units and PPAs.

Given the lack of reliable secondary data sources, the non-coincidence of Study Area boundaries with administrative divisions, and the methodological purposes of this study, the author decided to rely on the informed judgment of persons familiar with the Cibao Valley and trained in soils, agronomy, and agricultural economics to develop Current Normal estimates of land use by each crop-production method combination for the Intermediate Map Units and PPAs only.

The first step to determine PPA use was done in collaboration with agronomist Francisco Rodriguez of the SIEDRA program in Santo Domingo. Drawing upon Rodriguez' previous field work and supervisory experience in cost of production surveys in the central and eastern parts of the Valley, upon national production cost budgets of the Agriculture Bank, regional cost of production budgets of the field offices (Northwest, North, and Northeast) of the Secretary of Agriculture, and upon the CRIES national soil map, a first approximation of the production regions just discussed, of the major crops and production methods found in each region, and production costs was made. Total area cultivated was the criterion for selection of major crops and production methods.[1]

This first approximation provided a framework for a three-day "windshield survey" directed by Ingeniero Jose Santiago, a SIEDRA soils scientist who had been the principal Dominican counterpart in the FAO soil survey of the Cibao. An agronomist with extensive experience in tropical cropping systems (including previous experience in the Cibao) was also a major participant.[2] Utilizing the FAO 1:50,000 topographic map showing land uses[3] as of 1965, and major land use interpretations of December 1973 and July 1978 LANDSAT imagery,[4] current

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[1]Given other purposes of the study, other criteria such as the proportion of farms using a particular production practice or using a certain set (or specified range) of inputs, the proportion of production, the amount of labor inputs or of other specified inputs, foreign exchange earnings, etc., could have been used. Selection of what is major may vary yearly as markets, price, and climatic conditions change. "Normal" conditions with respect to such conditions were assumed.

[2]Dr. Trevor Arscott, Department of Agronomy, Ohio State University, Columbus, Ohio.

[3]Categories included plantain, cocoa, coffee, rice areas, sugarcane areas, and pasture.

[4]Categories included sugarcane, forest, and intensive mixed agriculture. Scattered cloud cover limited interpretations east of Santiago. Interpretations were done by the Remote Sensing Project, MSU.

cropland use was visually identified in each Intermediate map unit. The FAO soil inventory included only the generally flat and rolling lands of the Cibao which were in agricultural use. Extensive areas in urban or forest use or regarded as unsuitable for agriculture were designated as "not mapped." These non-agricultural uses are thus not in the Intermediate land use.

This identification served as the basis for revising Rodriguez' estimates of crop area and production practices. For each Intermediate map unit, percent estimates of land use by crop were made. These estimates were in turn modified and estimates were made for the map unit PPAs in discussion with agronomist Ramon Jimenez, the sub-director of the FAO-sponsored Centro de Desarrollo Agropecuario (CENDA) in Santiago, and his staff. The crop categories considered in the field reconnaissance were rice, tobacco, sugarcane, plantain, bananas, yucca, corn, beans, cocoa, sweet potatoes, a general "annuals" category, pasture and idle. See Table A-9. CENDA staff felt 30 percent of this general "annuals" area was interplanted. Interplanting is found only on those Intermediate map units largely in the East, that is, A, B, and a minor part of C. The remaining 70 percent of the "annuals" is planted to single crops. The interplanted hectare is defined to include corn, beans, yucca, sweet potatoes, tobacco, and plantain. Except for rice, which is double-cropped in all three regions, only very limited double-cropping is practiced.

Table A-10 shows the allocation of crop use, idle, and pasture to the Intermediate PPAs. Idle is assumed to occupy 20 percent of each PPA. For map units C, D, E, and F and the unmapped PPAs within them, the crop distribution percentages estimated in the field reconnaissance were multiplied by the total active cropland in the particular PPA to obtain crop area estimates by PPA.

In order to consider interplanting, the allocation of cropland use on Intermediate map units A, B, and C differs from the other regions in treatment of the general "annuals" category. An example illustrates the assumptions and method:

Assumption: - 30% of the "annuals" area is interplanted and 70% is planted alone. The relative distribution of crops in the 70% area is: yucca - 30%, corn - 25%, plantain, sweet potatoes, and beans -15% each.

Assumption: - of the interplanted area, 30% is in corn and beans during the first planting and yucca and corn during the second planting;

- 30% is in plantain and beans; no second planting;
- 10% is in tobacco and yucca; no second planting;
- 30% is in plantain, sweet potatoes, and beans; no second planting.

Assumption: - whenever plantain is interplanted, it occupies one-third of the cultivated area.

Calculations for the yearly use of 100 hectares of interplanted "annuals":

- 30 hectares in corn/beans and yucca/corn (equivalent to 15.0 ha. in corn, 7.5 ha. in yucca, 7.5 ha. in beans--two plantings);
- 30 hectares in plantain/beans (equivalent to 10.0 ha. in plantain and 20.0 ha. in beans--one planting);
- 10 hectares in tobacco/yucca (equivalent to 5.0 ha. in tobacco and 5.0 ha. in yucca--one planting);
- 30 hectares in plantain/sweet potatoes/beans (equivalent to 10.0 ha. in plantain, 10.0 ha. in sweet potatoes, 10.0 ha. in beans--one planting).

In summary, the yearly use of 100 interplanted hectares is 37.5 hectares in beans, 20.0 hectares in plantain, 15.0 hectares in corn, 12.5 hectares in yucca, 10.0 hectares in sweet potatoes, and 5.0 hectares in tobacco. These crop totals converted into percentages are used to determine Intermediate PPA use in the East. See Table A-10.

Crop Production Methods and Costs. One to three "representative" production methods with an associated yield and variable on-farm production costs (pesos/hectare) were defined for each crop by the consulting agronomist, and the SIEDRA agronomist and soils scientist mentioned earlier. The specific methods, yields, and costs are in Table A-11. Production costs would be expected to vary from PPA to PPA as fertilizer application rates, the amounts of labor for fertilizer application, etc., would also vary. For example, use of the same method for corn may yield 30 qq. on one PPA and 40 qq. on one of greater inherent productivity. Thus, harvesting costs on the second PPA should be one-fourth greater. Absence of reliable data on such relationships led the analyst to vary costs only by yields. Thus, a "representative" method with a cost of $60.00/ha. is applied to every PPA. Cost per quintal varies with yield: on the first PPA, cost is $2.00/qq.; on the second, $1.50/qq. The current distribution of these methods by Intermediate map unit and PPA was calculated using percentage allocators developed by the scientists cited above.

Crop Distribution to Detailed and Aggregate PPAs. The only land use inventory done was for the Intermediate map unit and PPA level. Allocation of crops and production methods to Detailed PPAs was done on the basis of the percentage compositions of Intermediate PPAs by Detailed PPA. Allocation to an Aggregate PPA was done on the basis of its composition by Intermediate PPAs. See Table A-12.

Crop Yield Estimates. In the absence of any crop yield data by soil, estimates of yield potential for each crop were made by ordinally ranking the productivity of each Detailed, each Intermediate, and each Aggregate PPA, on an index of 0 to 100 under one of the "representative" production methods. Each index was converted to an estimated yield by multiplying the index by the yield associated with the "representative" method. See Table A-11 for the base yields. The resulting yield estimates by PPA are consistent relative to one another. They are not valid in an absolute sense for lack of more information on PPA physical and chemical characteristics. These yield estimates are inputs to the Detailed, Intermediate, and Aggregate models. As discussed earlier, weighted averages of the Detailed yields were inputs to the Intermediate Weighted and Aggregate Weighted models.

Conceptually, the amount of descriptive information was least for the soil great group (the Aggregate PPA) and greatest for the soil family (the Detailed PPA). As stated earlier, however, due to the restricted universe of the Cibao, the difference in information between soil subgroups was not as great as would occur worldwide or even in a much larger country.

Limited information on soil properties such as salinity, reaction, base saturation (properties that directly affect various crop responses) was also used to estimate the yield indices; however, one soil property and dominant crop requirement often tended to predominate in estimating an index. In the case of paddy rice, poor drainage is desirable for good water control and management, but such a condition is detrimental for good banana production. An example of a crop's ability to attain the "normal yield" value on a particular PPA can be demonstrated by cacao. This tree possesses a deep tap root system which requires a relatively deep permeable soil. A soil with an impervious texture and structure such as an Aquic Chromudert would, therefore, be undesirable for good cacao production (Arscott, 1979). Factors such as slope and erosion potential were also considered. A given crop may do quite well for one cropping season on a PPA with a high erosion risk under the respective cropping practice. However, yields in following years may fall significantly due to the severe erosion produced by the first crop. Table A-13 presents the descriptions of Aggregate PPA I1, Intermediate PPA A1, and Detailed PPA 011.

Transportation Costs. Tariffs established by the Dominican government to transport one quintal of produce from designated sites to Santo Domingo were used to estimate transport costs for the L.P. All map units and their PPAs that are in a production region have the common transport cost of the region. Trade may occur between any of the three production regions (East, Central or West) and any of the requirement regions (East, Central, West or Santo Domingo). These costs are presented in Table A-14.

Production Requirements. Relative crop production requirements in the four requirements regions were estimated in different ways. Rice marketing is based on the quantity and distribution of rice storage facilities. Tobacco is assumed to be required only in the Central Region since its production is totally controlled by the nation's major export houses all of which are located in this Region. Sugarcane is assumed to be evenly required between the West, the location of the Valley's only sugarcane mill, and the non-Cibao area south of the East Region. This non-Cibao area is part of the Santo Domingo Region. Corn is largely utilized in the poultry industry which is concentrated in the Santo Domingo Region. Cocoa is primarily an export crop. An estimated 90 percent is marketed through Santo Domingo for export. Current requirements for plantain, bananas, beans, yucca, and sweet potatoes are assumed to be based on the relative populations of the four regions. For these crops, as for those above, production from non-Cibao areas of the country is ignored. No differentiation is assumed between population parameters on diets between the regions. No production is derived from pasture. Tables A-15 and A-16 present percentage distribution and of crop requirements, and percentage distribution of crop requirements assuming a shift in population toward Santo Domingo.

In the absence of independently derived production levels by crop and region, the product (crop-production method area per PPA) x (crop-production method yield on each PPA) is used to estimate current production of each crop.

These sums for each crop, one based on the detailed yields, one based on intermediate yields, and one based on aggregate yields, were calculated. The least restrictive sums for each crop were chosen as right-hand side constraint on production. Multiplication of these output levels by the distribution percentages results in current production requirements by crop and requirements region. See Table A-17.

Aggregation Rules. Cropping patterns and costs generated by the three L.P. models will be compared at the Region level. The rules to allocate solution values to the Regions are found in Tables A-18 and A-19.

# CHAPTER V

## A COMPARISON OF THE INPUTS AND OUTPUTS OF FIVE INFORMATION SYSTEMS

The purpose of this chapter is to discuss each of the three inventories in terms of the soil map comparison factors presented in Figure 4-5, and to discuss the differences in solution values of the L.P. models. Inasmuch as it was not possible to undertake three completely independent soil inventories, the discussion of soil inventory methods and costs was based on assumptions of SIEDRA soil scientists for conditions in the Cibao Valley.

### Comparative Evaluation of Three Soil Inventories

The assumed conditions are as follows:

> The size of the Study Area would be 250,000 hectares; the purpose of the study would be to assist Study Area planners to analyze the area's agricultural potential; the smallest map delineation would be consonant with that purpose; map scales and soil mapping units would be: --1:100,000 and associations of phases of soil families, 1:250,000 and associations of phases of soil sub-groups, and 1:1,000,000 and associations of phases of soil great groups; topographic and climatic maps would exist; aerial photos at 1:20,000 and smaller scales would exist; sufficient laboratory equipment, staff, materials, and budget would exist to finish any one of the inventories in one year. Insofar as the

latter conditions seemed unrealistic, a conservative bias was given to the costs of the more intensive surveys.[1]

Preparation Methods

The preparation of each inventory would generally require that 10-15% of the allotted work time be spent compiling existing tabular data, imagery, and maps and doing preliminary photographic interpretation to establish map units. One-half to three-quarters of the time would be spent in the field making observations, boundary checks, analysis of soil samples, and map unit revisions. Finally, 10-25% would be devoted to classification, laboratory analysis, and report writing.

For each, map units would be initially established through interpretation of existing photography. A sample area (not necessarily contiguous) representing 10% of the 250,000 ha. Cibao would be established.

For the Detailed inventory, aerial photos of 1:20,000 scale and a topographic map 1:50,000 scale would be used. Also for the Detailed inventory, 10 observations/$km^2$ in the sample area would be made. A detailed field analysis would be made of three of these observations. Tentative typical profiles would be described. Outside of the sample area, five observations/$km^2$ would be made. A detailed laboratory analysis in a central laboratory would be made of two of the five observations/$km^2$. Map unit boundaries would be based on the photo interpretations and field and laboratory analysis. Publication scale would be 1:100,000. Map units would be phases of families and associations of phases of families (Jose Ogando, 1979).

For the Intermediate inventory, aerial photos of 1:60,000 scale and a topographic map of 1:250,000 scale would be utilized to establish map boundaries. Only five observations/$km^2$ would be made in the sample area. A detailed field analysis would be made of one of these observations/$km^2$. In the rest of the

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[1] A revision of these cost assumptions is suggested in Chapter VI.

non-sample Cibao area, 2-3 observations/$km^2$ would be made, with a detailed laboratory analysis of 1 observation/$km^2$ made in the central laboratory. Extrapolation would be less precise than in the Detailed inventory. Publication scale would be 1:250,000. Map units would be phases of subgroup level.

For the Aggregate inventory, aerial photos of 1:80,000-100,000 scale and a topographic map of 1:250,000 scale would be utilized to establish map unit boundaries. Three observations/$km^2$ in the sample area would be made and a detailed field analysis of 0.5/observations/$km^2$ in the sample area. There would be no central laboratory analysis. Outside of the sample area, one observation/$km^2$ would be made. Publication scale would be 1:1,000,000. Soil map units would be phases of great group level.

This description of methodology suggests greatest reliability (and cost) would be found at the Detailed level and least, at the Aggregate level. A relative scale proposed by Cline (Cline, 1978) is also used to rank the three inventories on the reliability of preparation methods. Means to collect base data would range from 1 (most reliable) to 5 (least reliable). His scale is defined as follows:

1 - detailed field work with remote sensing support;

2 - detailed field work without remote sensing support;

3 - reconnaissance field work with remote sensing support;

4 - reconnaissance field work without remote sensing support or only remote sensing with field checking;

5 - exploratory field work without remote sensing or only remote sensing;

6 - schematic compilation only.

"Detailed", "reconnaissance", and "exploratory" are defined as follows in the Soil Survey Manual (USDA, 1951):

> Detailed - boundaries are sketched from observations of their entire occurrence on the ground.

Reconnaissance - only part of the boundaries are seen. First, a schematic map is made from available evidence on relief, geology, climate, and vegetation. Choose sample areas for detailed work and extrapolate results.

Exploratory - boundaries are usually obtained from compilation of existing sources; identify soil associations through limited field checking.

Based on this scale, the means to collect data in the Detailed inventory are the most reliable (3), while those of the Aggregate are least reliable (5). While the same type of base map would probably be used in each inventory, the information content of the large scale 1:50,000 topographic map would probably be greater than that of the 1:250,000 map. Therefore, the map used in the Detailed inventory would be more informative than that used in the other inventories.

Map Analysis

The characteristics of the three soil maps are presented in Table 5-2. They provide the basis for map analysis.[1]

Map Legibility. Map legibility is largely subjective. Factors that influence it include the number of delineations per unit of map area, colors or patterns used to represent them, ground features shown on the map, and quality of map presentation. Only the first factor, the number of delineations per unit of map area, is varied between the three maps, and it is discussed here.

[1]Before turning to map analysis, mention is made of the relationship between scale, field observations/cm.$^2$ of map and field observations/km$^2$ of land. At a scale of 1:100,000, 1 cm.$^2$ on the map represents 1 km.$^2$; at 1:250,000, 1 cm.$^2$ represents 6.25 km.$^2$; and at 1:1,000,000, 1 cm.$^2$ represents 100 km.$^2$. Thus, although the number of observations/cm.$^2$ increases as scale decreases, the number of field observations per unit of land area and, therefore, information content decreases.

Table 5-1. Comparison of Soil Inventory Preparation Methods

| Preparation Methods | Soil Inventory | | |
|---|---|---|---|
| | Detailed | Intermediate | Aggregate |
| Adequacy of base map | | | |
| Type | topographic | topographic | topographic |
| Scale | 1:50,000 | 1:250,000 | 1:250,000 |
| Photos Scale | 1:20,000 | 1:60,000 | 1:80-100,000 |
| Field observations/km$^2$ | 5.5 | 2.7 | 1.2 |
| Observations w/lab. analysis/km$^2$ | 2 | 1 | 0 |
| Collection of base data (rank) | 3 | 4 | 5 |

Table 5-2.-- Characteristics of Cibao Valley Soil Maps

| Characteristics | Map | | |
|---|---|---|---|
| | Detailed | Intermediate | Aggregate |
| Scale | 1:100,000 | 1:250,000 | 1:1,000,000 |
| Field observations/km.$^2$ | 5.5 | 2.7 | 1.2 |
| Field observations/cm.$^2$ | 5.5 | 17.2 | 120.0 |
| Map delineations | | | |
| Number | 95 | 11 | 3 |
| Minimum size (cm$^2$) | 2.04 | 2.04 | 2.04 |
| Minimum size (ha.) | 204 | 1275 | 20,400 |
| Least size (no.) | 3 | 1 | 0 |
| Average size (cm.$^2$) | 21.9 | 32.3 | 7.6 |
| Average size (ha.) | 2,190 | 20,190 | 76,200 |
| Smallest size (cm.$^2$) | 0.3 | 1.2 | 3.0 |
| Area covered by 1 cm. length of line (ha.)[1] | 8 | 50 | 800 |
| Map units[2] | | | |
| Number | 31 | 7 | 3 |
| Taxonomic level | family | subgroup | great group |
| Phases | yes | yes | yes |
| Agronomic interpretation | crop yields | crop yields | crop yields |

[1]Boundary lines are 0.8 mm wide.

[2]A map unit may be composed of 1 or more delineations.

Legibility decreases greatly if a large number of map symbols must be placed outside of the delineations and keyed to them by arrows. In this regard, a "minimum-size" delineation is one in which a simple map unit symbol (2-3 digits) can be printed legibly. Alternatively, it is the smallest area that can be easily discerned by the user. Its size is, of course, affected by its shape. Detailed map unit 31, for example, is long and narrow and so would have to be larger, for legibility than if it were round. While the concept is a parameter for the determination of a suitable published map scale, it is a highly subjective concept. Sizes of 0.4 $cm^2$ to 1.5 $cm^2$ (¼ $in.^2$ = 1.61 $cm^2$) have been suggested where 2-3 digit map symbols are used (Eswaran, 1978). Inasmuch as the Intermediate map units would be designated by symbols with 8-15 digits,[1] a slightly larger "minimum size" delineation, one of 2.04 $cm^2$ (3/4 in. X 3/4 in.), is used here. The actual land area represented is 204 ha. at a scale of 1:100,000, 1275 ha. at 1:250,000, and 20,400 ha. at 1:1,000,000.

On many soil maps, there may be a few delineations smaller than the theoretical minimum called "least-size" delineations. Obviously, a relatively large number of these areas, so small that map symbols would have to be keyed outside of them, would decrease legibility. These "least-size" delineations are particularly significant for large-scale (1:20,000 and larger) maps since the delineations may imply highly contrasting small areas that are not just incidental observations. Given the small scale of the three maps, "least-size" may not be of great significance except possibly for some areas in the Detailed map. On the Detailed 1:100,000 map there are only three, and on the Intermediate Map just one "least-size" delineation.

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[1] Map unit symbols have not been prepared. However, the symbols used in the CRIES soil mapping for the Dominican Republic were 8-15 digits. This mapping is closely equivalent to the Intermediate soil inventory.

The "average-size" delineation for each map is presented in Table 5-2. Their ground representation ranges from 2,200 ha. at 1:100,000 scale, to 20,200 ha. at 1:250,000 scale, to 76,200 at 1:1,000,000 scale.

The relative complexity or simplicity of a map can be indicated by relating the number of delineations per unit of map area to the maximum number allowable while maintaining legibility. If the minimum-size delineation is 2.04 $cm.^2$, then the reciprocal, 0.49, is the maximum number of delineations/$cm.^2$. If n = the number of delineations/$cm.^2$ of map area then n also

$$= \frac{1}{\text{average-size delineation}}$$

and map texture intensity (MTI)

$$= \frac{n}{0.49}$$

$$= \frac{1}{\text{average-size}} + \frac{1}{\text{minimum size}}$$

$$= \frac{\text{minimum-size } (cm.^2)}{\text{average-size } (cm.^2)}$$

The larger the MTI, the more complex the map. The MTI for the maps are: Detailed - 0.093, Intermediate - 0.063, and Aggregate - 0.268. Relative to one another, the Aggregate map is the most complex, the Intermediate map the simplest; all are below the maximum number of delineations/$cm^2$.

A map becomes illegible if a large proportion of the delineations are "least-size". Map intensity can also be understood by determining the degree to which map scale can be reduced before the average-size delineations become "least-size", i.e., smaller than the theoretical minimum-size delineations. The map index of maximum reduction is thus defined as the square root of the ratio between the average-size and minimum-size delineations of the actual map. The minimum scale of reduction, then, is the smallest scale to which a map can be reduced before the average-size delineations become smaller than the minimum-size delineation.

Minimum scale of reduction = actual scale + (actual scale) (index of maximum reduction)

The index of maximum reduction and the minimum scale of reduction for the three maps are:

| | | | |
|---|---|---|---|
| Detailed | 3.28 | and | 1:428,000 |
| Intermediate | 3.98 | and | 1:1,245,000 |
| Aggregate | 1.93 | and | 1:1,930,000 |

The minimum scale of reduction certainly does not indicate a useful scale for, if average-size delineations were reduced to the minimum-size, a large proportion of the delineations would be "least-size". A much smaller scale than that of the published map suggests that the surveyor might have worked with a smaller scale from the standpoint of legibility. A high (e.g., 10-20) index of maximum reduction may indicate relatively homogeneous soil bodies, improper scale definition, or an inadequate survey. A low (e.g., 1-2) index suggests intensive mappings (Eswaran, 1978). Only the Aggregate map approaches the intensive mapping range of the index of maximum reduction.

The values for the three Cibao maps suggest that smaller survey scales (and hence lower costs) may have been desirable from a legibility perspective for the Detailed and Intermediate maps. At the same time, the previously noted homogeneity of the soil resource would also seem to support smaller scales.

In addition to the above considerations about map complexity, the total number of delineations is important: given a purpose for a study, the fewer the number the easier and less costly the tasks of gathering soils data and complementary socioeconomic data, correcting errors in existing data, analysis and interpretation, and presentation of analytical results to decision-makers. The number of delineations for the three maps are: Detailed - 95; Intermediate -11; Aggregate - 3.

The adequacy of map scale must also be related to the user's area of planning interest. The largest map scale, then, is defined by the size of the smallest area of interest the user would want to identify on the map. Given the national orientation of intended users, the three Cibao regions could serve the users initially as minimum areas of interest. Broad plans could indicate general use patterns that would make most efficient use of Valley natural resources. Later, the same planners could be expected to focus on subregions within a particular region or regions for more intensive investigation and data collection. From a natural resources aspect only, these subregions would be relatively more homogeneous and could correspond to individual or small groups of map units. From a natural resources standpoint only, individual map delineations would define the minimum area of interest for the Valley's regional planners. In this regard, then, the Aggregate inventory with three map delineations and nine unmapped PPAs may provide the users with sufficient geographic information. The detail of the Detailed (95 delineations and 45 unmapped PPAs) and Intermediate inventory (11 and 14) may not be any more useful than the Aggregate inventory.[1]

The smallest map delineation in each inventory is: Detailed - 30 ha., Intermediate - 750 ha., and Aggregate - 30,300 ha. Given the minimum-size delineations (defined for legibility at 2.04 $cm.^2$), only the Aggregate map appears to be adequate since only its minimum-size delineation (204 ha., 1,275 ha., and 20,400 ha., respectively) is smaller than its smallest map unit.

Reliability of Delineation Boundaries. The intensity of the soil inventory and map scale determines the reliability of delineation boundaries. Theoretically,

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[1]Only limited planning would be possible if only resources were considered. Planners would need to address social and economic factors, the relationships between these factors and with natural resources, and hence the relevant minimum areas of interest. Given the scarcity of reliable socio-economic data the additional usefulness of an inventory as disaggregated as the Detailed is particularly questionable.

the larger the scale, the larger is the number of observations required for boundary placement and the more accurate is the placement. Given the discussion on inventory methods, the Detailed inventory ought to have the most reliable boundary placement, the Aggregate the least reliable.

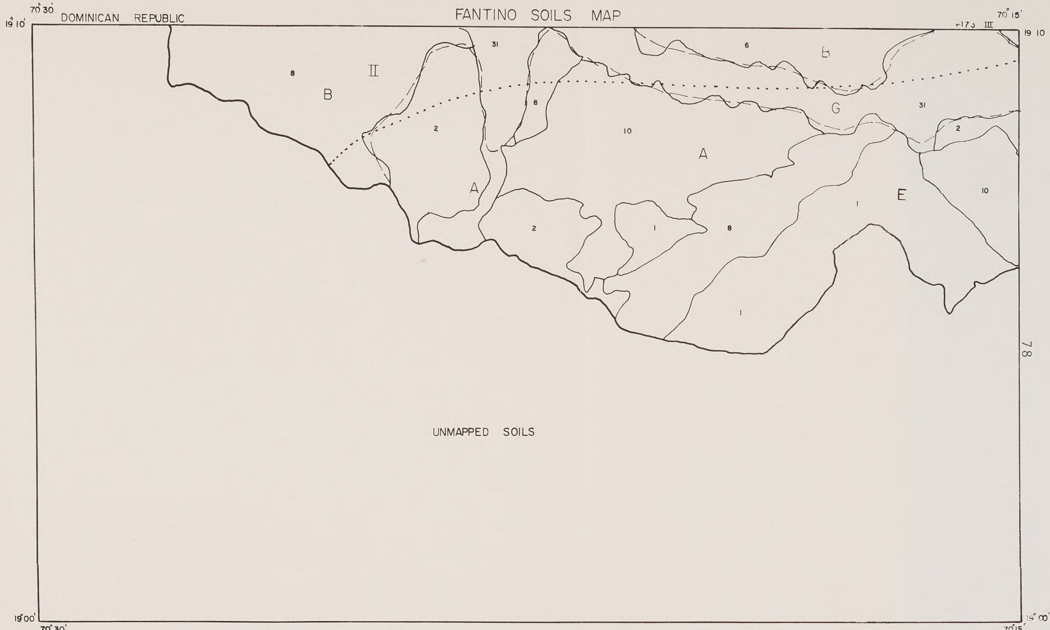
The accuracy of boundaries may also be a function of line width: the smaller the size of individual delineations, the greater the effect of width. Should a boundary line be misplaced, the percentage error in the area of the delineation is greater the smaller the delineations. Ten measurements were made of the width of the delineation lines on the 1:100,000 map and averaged. The land area covered by a 1.0 cm. length of this thickness (0.8 mm.) of line would be 8 ha. at 1:100,000, 50 ha. at 1:250,000, and 800 ha. at 1:1,000,000. Assuming circular average size map unit areas, the areas of their boundary lines would be 6, 5, and 10 percent, of the circular areas in the Detailed, Intermediate, and Aggregate inventories. Thus, effect of line width on Intermediate delineations is relatively smaller, 5 percent, since average size (32.3 $cm.^2$) is greater than in the other inventories. With respect to the Detailed inventory (6 percent error), however, this Intermediate advantage may be cancelled out by the less reliable means used to collect Intermediate data and hence locate boundary lines. Given the less reliable means used in the Aggregate inventory to collect base data as well as smaller average delineation size (7.6 $cm.^2$), errors in placement, 10 percent, are more sizable than in the other inventories. The area of a boundary line of a minimum size area on the Detailed, Intermediate or Aggregate inventory maps represents 20 percent of its area.

Comparison of Measured and Summed Detailed Areas of Map Delineations. The area of each map delineation, at all three levels of detail, was planimetered as drawn on the 1:50,000 scale FAO base maps. Theoretically, area measurements would sum exactly across the three levels of soil detail. That is, Aggregate map delineations (associations of phases of great groups) would be perfect sums of the Intermediate map delineations (associations of phases of subgroups) which in turn would be perfect sums of the Detailed map delineations (associations of phases of families). For several reasons this boundary coincidence does not occur.

Cartographic error may occur when delineation boundaries from maps of three different scales (1:1,000,000; 1:250,000; and 1:100,000) are drawn on the same 1:50,000 base map. The lines from a small 1:1,000,000 scale map do not exhibit as much precision as the lines from a 1:100,000 map. Conversely, if a 1:100,000 map is reduced in scale to 1:1,000,000, its delineation boundaries lose their twists and turns and become smoother.

Intermediate delineation A in the southeastern part (Fantino) of the Cibao illustrates such cartographic errors. Intermediate map unit A is defined to include only Detailed map units 1, 2, 3, 4, 5, 8 and 10 (see Table A-18); yet it has been drawn to include minor parts of 31 (and one major part of 31). See Figure 5-1. Intermediate G defined to include only Detailed 31 has been drawn to include parts of 6 (of Intermediate B), 10 (of Intermediate A), and 2 (also of A). Aggregate map unit I defined to include Intermediates A and G, see Table A-6, has been drawn here to include parts of G (also of Aggregate II) and of B (only of Aggregate II). Aggregate II defined to include Intermediate B, C, F and G here also includes part of A (of Aggregate I).

Another aspect of cartographic error relates to the minimum size needed for legibility on the published map. Map delineation may retain inclusions of non-similar soils simply because to split the delineation unit into two or more parts and maintain purity would mean illegible map units when published. For example, south of Castanuelas in the western Cibao, Intermediate delineation D has been drawn to include Detailed 27 even though 27 properly belongs to Intermediate E. See Figure 5-2.




: map boundary
: associations of families
: associations of subgroups
: associations of great groups
: unmapped area

approximate scale

0 1 2 3 4 5 Km

1:100,000

Figure 5-1 -- Southeastern Cibao Valley

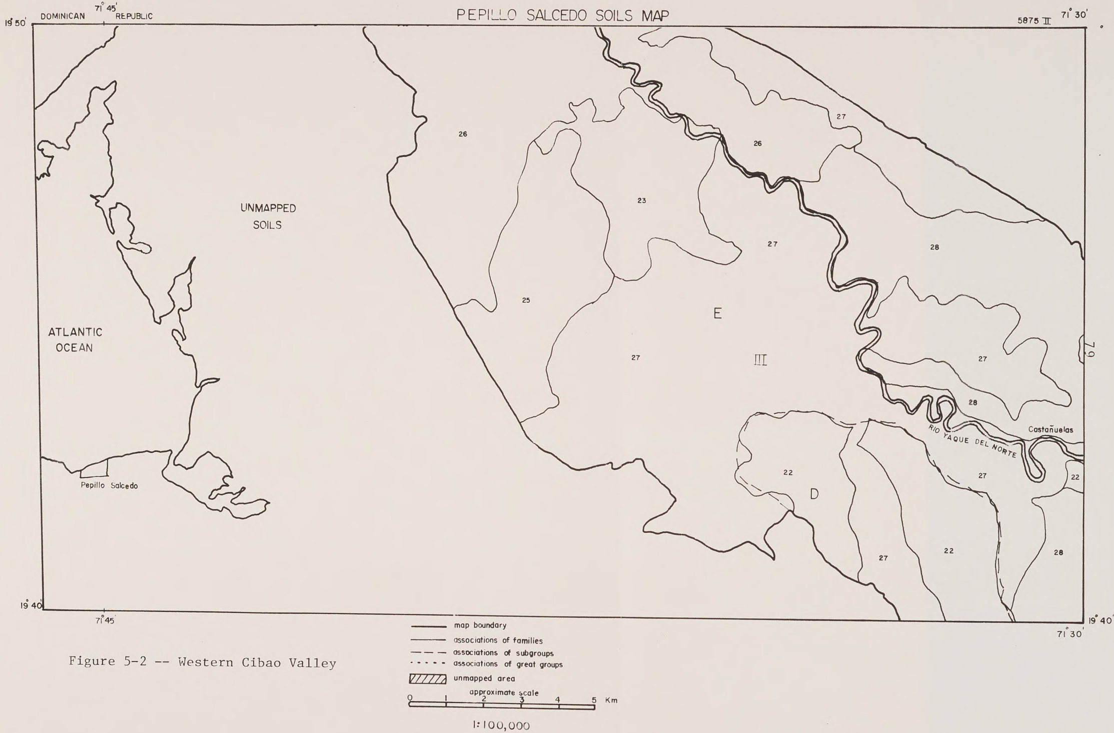



Figure 5-2 -- Western Cibao Valley

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Other possible sources of error arise from neglecting to include small areas of Detailed delineations which are on the borders of the fourteen 1:50,000 base map sheets in an Intermediate or Aggregate delineation, improperly locating soil boundaries, mislabeling, using line markers of varying widths, and inexact use of the planimeter. The planimeter, for example, approximates curves with linear segments. Area measurement of those map delineations with a higher proportion of curved boundaries (Detailed would generally have more than Intermediate which would have more than Aggregate delineations) would therefore be subject to greater error.

Tables A-20 and A-21 present the cartographic relationship between the Detailed, Intermediate and Aggregate units and the measured areas of each map unit. The area measurements at the three levels are 2179.53 $km^2$, 2221.32 $km^2$, and 2286.34 $km^2$, respectively. The Intermediate measured area is 1.9 percent greater and the Aggregate measured area is 4.7 percent greater than the sums of the measured Detailed map units.

Measurement error appears when comparisons are made between the planimetered Intermediate (Aggregate) map delineations and the sums of those Detailed delineations of which the Intermediate (Aggregate) delineations are composed. At the Intermediate level, the difference between measured and summed areas is least for the larger map units (5.3% for B, 0.3% for E, and 4.5% for C) and largest for the smaller map units (17.6% for D, 22.5% for F, and 72.9% for G). A, a relatively large unit, has a relatively high difference of 15.4%. This pattern seems explainable largely by noting that small areas of dissimilar soils often would be included within a map unit for legibility purposes. G, for example, is typically a long, narrow shape immediately paralleling rivers.

Measurement of map delineations is another minor source of error. An indication of the relative size of this error was made by remeasuring every $10^{th}$

Detailed delineation (16 of 153), based on the original order of measuring on the individual map sheets, every 5$^{th}$ Intermediate delineation (7 of 36), and every 4$^{th}$ Aggregate delineation (7 of 22). Table A-22 compares the initial and follow-up measurements of the chosen map delineations. The average absolute difference between the first and second measurements was 0.8% among Detailed delineations, 0.9% among Intermediate delineations, and 1.0% among Aggregate delineations. Even the errors of individual areas never exceeded 4.0%, less than the percentage the boundary line represents of the average size map unit even in the Intermediate inventory.

No defensible conclusion regarding the relative error encountered in measuring the three sets of map units is drawn. Detailed lines with their twists seem more subject to mechanical planimeter error yet those twists which have soils informational significance are smoothed out in the more generalized, smaller scale maps.

Map Unit Descriptions

The soil taxonomic classification of the map units in the three inventories are family, subgroup, and great group. Because of the restricted extent of the Study Area, map units almost never cover the whole range of the class used to name it. The total range in soil characteristics for Cibao Valley great groups and subgroups is quite limited. Thus, great group descriptions are "more or less" (Knox, July 1979) done at a family level of significance. Soil phases, for example, are the same as those at the other levels. Similarly, the dominant textured characteristics of the subgroups were able to be specified and so descriptions could be made "more or less" at the family level. The family-level map is most closely based on the FAO "series-level" map. With some assumptions about clay mineralogy, the "series" were placed into families based on the information given in the report on particle size distribution. There is considerably more doubt about placement at the higher subgroup and great group levels than at the family level. Although the FAO information leaves questions about the degree of flood hazard, the nature of soils on the flood plains, and the drainage restrictions, the family map could present "reasonable analysis for interpretation of management requirements and use potentials" (Knox, July 1979).

At each of the three levels, both consociations and associations of soils are utilized. By definition a consociation is purer than an association. It is a mapping unit in which only one identified soil component (plus allowable inclusions) occurs. An association is a geographic mixture of areas of two or more distinctive kinds of soil, or of a soil and a kind of miscellaneous area. Principal components of soil associations are generally not delineated at scales smaller than 1:20,000. In the Detailed inventory, 19 map units are consociations and 12 are associations. The Intermediate and Aggregate inventories have 3 and 0 consociations and 4 and 3 associations, respectively. This suggests a highest level of purity, given the taxonomic level, for the Detailed inventory and least for the Aggregate inventory.

Soil Inventory Costs

The costs of gathering and developing soils information depend on such a variety of factors that to date, no neat and tidy formula for their estimation has been proposed. These factors include climate; transportation difficulties; health problems of field personnel; levels of wages; imposition of completion deadlines; availability of secondary materials such as topographic maps, planimetric maps, geologic maps, meterological data and maps, recent aerial photography, photomosaics, satellite images, soil surveys at larger or smaller scale; type of equipment for field and laboratory work; and availability of trained personnel; number of cloud-free days; severity of rainy seasons; and complexity of the terrain. Most developing countries require that all work be done through their national soils agency; although the impact of this requirement on costs will vary by country, it may cause at least a doubling of costs over that demanded by foreign consultants (Bleisch, 1979).

A brief review of cost estimates suggests their great variability. The U.S.D.A. estimates the relative costs of detailed soils surveys for U.S. counties of 700 square miles of survey area as 1.0 for low intensity, 1.4 for medium, and 2.0 for high intensity land use (Herfindahl, 1969). In a low intensity area, 75 percent would be in extensive agriculture, such as range. In a medium intensity area, 50 percent would be in cropland with the remainder in range and forest. A high intensity area would have a mixture such as 33 percent cropland, 15 percent range and forest, 25 percent urban, and 25 percent other. Field work accounts for 80 percent or more of total costs in each type.

In 1964, the OAS estimated costs of various soil surveys in the Guayas River Basin in Ecuador (OAS, 1964). Direct costs (those associated with a particular type of survey activity) and overhead costs (such as facilities, topographic map work, mosaics, and drilling) were of approximately equal importance. The direct costs of different survey activities were as follows:

| Survey Activity | Cost/Acre - $ - | Relative Cost |
|---|---|---|
| Reconnaissance soils capability | 0.015 | 1.0 |
| Semi-detailed soils capability | 0.113 | 7.5 |
| Detailed soils capability | 0.358 | 23.9 |

Finally, Eswaran presents the following relative costs for three classes of surveys as defined by the Soil Conservation Service (Eswaran, 1978).

| Class of Survey | Objectives | Map Scale | Relative Cost |
|---|---|---|---|
| Order V | national planning | 1:1,000,000 | 0.2/ha. |
| Order IV | regional planning | 1:500,000 | 1/ha. |
| Order III | cultural systems | 1:100,000 | 2/ha. |

It is obvious that these four sets of estimates are not comparable. The lack of comparability may stem from differences in definitions as well as from the factors noted above.

The procedure to obtain cost estimates for the three Cibao inventories was to specify conditions relevant to soils inventory in the D.R. A SIEDRA soils scientist was asked to estimate the costs as if the three inventories were independently constructed. The assumptions about conditions, materials, facilities, and labor in the D.R. and in the Cibao Valley were stated above. Table 5-3 summarizes the costs of each inventory. Appendix A-23 presents the cost detail.

Table 5-3.-- Soil Inventory Costs

| Item | Detailed | Intermediate | Aggregate |
|---|---|---|---|
| | | ($1000) | |
| Personnel | 271.2 | 90.0 | 21.2 |
| Materials | 4.4 | 1.3 | 0.5 |
| Vehicles | 70.0 | 21.0 | 4.2 |
| Lab. Analyses | 150.0 | 33.8 | 20.3 |
| Publications | 74.3 | 29.2 | 9.2 |
| Total Cost | 569.9 | 175.3 | 55.4 |
| Cost/Ha. ($/ha.) | 2.28 | 0.70 | 0.22 |

The relative costs for the three inventories are 1.0 for the Aggregate, 3.2 for the Intermediate, and 10.3 for the Detailed inventory.

The purpose of this section has not been to draw precise conclusions regarding the information content and costs of the three soil inventories. Rather, it was to present a method which planners could use to make such an evaluation in their specific situation. In general though, it appears that much more soils information is generated in a "detailed" than in an "intermediate" or "aggregate" inventory. Not surprisingly, it is more costly. The issue is to present intended users with a comparative statement of the information produced by each. It is their responsibility to choose. Attention was paid to only one presentation tool-soil maps. Several measures of information content were discussed.

## Comparative Evaluation of Linear Programming Solutions

### The Detailed, Intermediate Weighted, and Aggregate Weighted Models

The three models - Detailed, Intermediate Weighted, and Aggregate Weighted - were run for three different policy questions. The questions are:

1. Given the Current Normal pattern of cropland use and Regional crop requirements, what would be the least costly means of meeting these requirements? This is called the "Benchmark" run.

2. Given the Current Normal pattern of cropland use, what would be the least costly means of meeting Regional crop requirements that are 20 percent greater than those of the Current Normal? This is called the "Growth" run.

3. Given the Current Normal pattern of cropland use and Regional crop requirements at 120 percent of Current Normal, what would be the least costly means of meeting requirements if, due to shifts in population away from rural Regions to Santo Domingo, the requirements of this Region for non-expost crop are increased relative to the other Regions? This is called the "Growth/Shift" run.

Except for corn and for idle area in the Detailed model, solution values of the three models, do not vary between the Growth and Growth/Shift runs. See Table 5-4. However, transportation flows between Regions are different in 28 of 90 (3 models x 3 Regions x 10 crops) possibilities. See Tables A-26 and A-27. This indicates the insignificance of transportation costs relative to production costs in the Objective Function. Total production cost of the Detailed Growth/Shift solution is only 0.6 percent greater than the Growth solution in the East, 0.1 percent less in the West, and less than 0.01 percent less for the entire Valley. The Objective Function value is 0.3 percent greater in the Growth/Shift run.

Table 5-4. -- Differences in Crop Area Between Detailed, Intermediate Weighted, and Aggregate Weighted Solutions, Growth and Growth/Shift Runs[a]

(% of Growth Solutions)

| | Detailed | | | | Intermediate | | | |
|---|---|---|---|---|---|---|---|---|
| Crop | East | Central | West | Valley | East | Central | West | Valley |
| Rice | - | - | - | - | - | - | - | - |
| Tobacco | - | - | - | - | - | 0.1 | - | 0.0 |
| Plantain | - | - | - | - | - | 2.4 | - | 0.3 |
| Banana | - | - | - | - | - | - | - | - |
| Sugar Cane | - | - | - | - | - | - | - | - |
| Corn | -1.0 | - | 59.1 | 0.4 | -4.6 | 41.8 | - | 0.3 |
| Beans | - | - | - | - | -0.4 | 10.9 | - | 0.6 |
| Yucca | - | - | - | - | - | 1.0 | 5.5 | 0.6 |
| Sweet Potatoes | - | - | - | - | 3.8 | -6.0 | -19.7 | 0.2 |
| Cocoa | - | - | - | - | - | - | - | - |
| Interplanted | - | - | - | - | -1.8 | - | - | -1.6 |
| Idle | -0.3 | - | - | -0.2 | 0.1 | 1.3 | 0.2 | 0.2 |

[a]No differences occur in the Intermediate Weighted, Aggregate Weighted, or Aggregate solutions.

Due to the trivial differences between Growth and Growth/Shift Solutions, comparisons between Detailed, Intermediate Weighted, and Aggregate Weighted solutions in the Benchmark and Growth runs are now made. Although not always true, the difference in solution values between the Intermediate Weighted and Aggregate Weighted models are less than the difference from the Detailed solution.

The differences between the cropping pattern of the Detailed model and those of the two aggregated models are presented in Tables 5-5, 5-6, and 5-7. Each table is progressively more in summary form. For both aggregated models, the difference is much less at the Valley than at the Regional level. See Table 5-6. Also, for both models, the total (unsigned) difference at the Valley and Regional levels is less for the Growth than for the Benchmark run.

Regional differences from the Detailed solutions are much larger for the Aggregate Weighted than for the Intermediate Weighted model. For example, in the Benchmark and Growth runs, respectively, the sum of unsigned differences for 11 crop and idle areas is 516 percent and 643 percent, respectively, for the Intermediate Weighted model and 1506 percent and 2033 percent, respectively, for the Aggregate Weighted model. For the two runs, the Intermediate Weighted model shows a smaller amount of Regional variation around the Detailed solution in 4 of 6 instances. See Table 5-6.

The areas of three crops that were relatively small in the Current Normal were not allowed in the linear programming algorithm. The crops and their areas are banana -4005 ha., sugarcane - 8237 ha., and cocoa - 9313 ha. Difference in their areas from the Detailed solution occurs outside of the models. Aggregating Detailed map units did lead to some noticeable differences at the Regional level for each of the three crops.

*Table 5-5.* -- *Area, Production, and Cost Differences Between the Detailed, Intermediate Weighted, and Aggregated Weighted Solutions, Benchmark Run*

Table 5-5. -- Area, Production, and Cost Differences Between the Detailed, Intermediate Weighted, and Aggregated Weighted Solutions, Benchmark Run

| Crop/Region | Area | | | Production | | | Production Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Detailed | Intermediate Weighted | Aggregate Weighted | Detailed | Intermediate Weighted | Aggregate Weighted | Detailed | Intermediate Weighted | Aggregate Weighted |
| | (1000 hectares) | | | (1000 units) | | | (million pesos) | | |
| Rice | | | | | | | | | |
| East | 10.5 | 10.7 | 11.1 | 1,310 | 1,330 | 1,390 | 12.4 | 12.6 | 13.2 |
| Central | 1.2 | 1.3 | 1.4 | 100 | 100 | 110 | 1.4 | 1.5 | 1.5 |
| West | 13.1 | 13.1 | 12.6 | 1,290 | 1,270 | 1,200 | 13.4 | 13.4 | 12.9 |
| Valley | 24.8 | 25.1 | 25.2 | 2,700 | 2,700 | 2,700 | 27.1 | 27.5 | 27.7 |
| Tobacco | | | | | | | | | |
| East | 0.6 | 0.6 | 0.5 | 20 | 40 | 30 | 0.3 | 0.3 | 0.3 |
| Central | 12.7 | 13.2 | 15.1 | 360 | 350 | 380 | 6.7 | 7.0 | 8.0 |
| West | 3.6 | 3.4 | 2.8 | 90 | 80 | 60 | 1.9 | 1.8 | 1.5 |
| Valley | 17.0 | 17.2 | 18.4 | 470 | 470 | 470 | 8.9 | 9.1 | 9.7 |
| Plantain | | | | | | | | | |
| East | 7.6 | 6.3 | 8.9 | 170 | 120 | 210 | 4.5 | 3.9 | 5.3 |
| Central | 1.9 | 2.4 | 2.1 | 50 | 50 | 40 | 1.1 | 1.4 | 1.2 |
| West | 12.1 | 16.4 | 10.8 | 180 | 230 | 150 | 7.2 | 9.6 | 6.4 |
| Valley | 21.6 | 25.0 | 21.8 | 400 | 400 | 400 | 12.9 | 14.9 | 13.0 |
| Banana | | | | | | | | | |
| East | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Central | * | * | * | * | * | * | * | * | * |
| West | 4.0 | 4.0 | 4.0 | 4,320 | 4,320 | 4,330 | 2.6 | 2.6 | 2.6 |
| Valley | 4.0 | 4.0 | 4.0 | 4,320 | 4,320 | 4,340 | 2.6 | 2.6 | 2.6 |
| Sugar Cane | | | | | | | | | |
| East | * | * | * | * | * | * | * | * | * |
| Central | 0.2 | 0.2 | 0.2 | 10 | 10 | 10 | 0.1 | 0.1 | 0.1 |
| West | 8.0 | 8.0 | 8.0 | 350 | 390 | 350 | 4.4 | 4.4 | 4.4 |
| Valley | 8.2 | 8.2 | 8.2 | 370 | 400 | 370 | 4.5 | 4.5 | 4.5 |

(continued)

*Table 5-5. (cont'd.)*

Table 5-5. (cont'd.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Corn | | | | | | | | | |
| East | 10.3 | 9.9 | 11.3 | 340 | 360 | 400 | 1.7 | 1.7 | 1.9 |
| Central | 3.1 | 2.7 | 1.4 | 100 | 80 | 40 | 0.5 | 0.4 | 0.2 |
| West | 0.8 | 0.6 | 0.4 | 20 | 10 | 10 | 0.1 | 0.1 | 0.1 |
| Valley | 14.1 | 13.2 | 13.1 | 460 | 460 | 460 | 2.2 | 2.2 | 2.3 |
| Beans | | | | | | | | | |
| East | 6.9 | 5.9 | 6.8 | 210 | 220 | 230 | 1.7 | 1.5 | 1.7 |
| Central | 1.1 | 1.0 | 0.6 | 40 | 30 | 10 | 0.3 | 0.2 | 0.1 |
| West | 0.1 | 0.1 | 1.6 | * | * | * | * | * | 0.1 |
| Valley | 8.1 | 7.0 | 7.5 | 250 | 250 | 250 | 2.0 | 1.7 | 1.9 |
| Yucca | | | | | | | | | |
| East | 13.0 | 13.2 | 13.6 | 1,440 | 1,510 | 1,520 | 2.7 | 2.7 | 2.8 |
| Central | 2.2 | 2.1 | 1.6 | 320 | 240 | 200 | 0.5 | 0.4 | 0.3 |
| West | 0.1 | 0.2 | 0.5 | 10 | 20 | 60 | * | * | 0.1 |
| Valley | 15.3 | 15.5 | 15.7 | 1,780 | 1,780 | 1,780 | 3.2 | 3.2 | 3.2 |
| Sweet Potatoes | | | | | | | | | |
| East | 5.7 | 5.6 | 6.5 | 820 | 860 | 970 | 1.3 | 1.3 | 1.5 |
| Central | 1.1 | 1.0 | 0.8 | 200 | 150 | 120 | 0.3 | 0.2 | 0.2 |
| West | 0.8 | 0.8 | 0.2 | 110 | 110 | 40 | 0.2 | 0.2 | 0.1 |
| Valley | 7.6 | 7.4 | 7.6 | 1,130 | 1,130 | 1,130 | 1.8 | 1.7 | 1.8 |
| Cocoa | | | | | | | | | |
| East | 8.4 | 8.4 | 8.5 | 40 | 40 | 40 | 1.9 | 1.9 | 1.9 |
| Central | 0.9 | 0.8 | 0.7 | 10 | * | * | 0.2 | 0.2 | 0.2 |
| West | 0.1 | 0.1 | 0.2 | * | * | * | * | * | * |
| Valley | 9.3 | 9.3 | 9.3 | 40 | 40 | 40 | 2.1 | 2.1 | 2.1 |
| Interplanted | | | | | | | | | |
| East | 14.6 | 23.7 | 23.7 | Reported in production of tobacco, plantain, corn beans, yucca, sweet potatoes | | | 2.8 | 4.6 | 4.6 |
| Central | 2.2 | 2.7 | 1.1 | | | | 0.4 | 0.5 | 0.2 |
| West | 0.1 | 0.2 | 0.7 | | | | * | * | 0.1 |
| Valley | 17.0 | 26.6 | 25.5 | | | | 3.3 | 5.1 | 4.9 |

(continued)

Table 5-5. (cont'd.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pasture | | | | | | | | | |
| East | 4.5 | 6.8 | 6.2 | - | - | - | - | - | - |
| Central | 0.4 | 0.4 | 0.3 | - | - | - | - | - | - |
| West | 6.6 | 6.6 | 7.3 | - | - | - | - | - | - |
| Valley | 11.5 | 13.8 | 13.8 | - | - | - | - | - | - |
| Idle | | | | | | | | | |
| East | 36.6 | 28.2 | 22.4 | - | - | - | - | - | - |
| Central | 6.1 | 4.8 | 7.3 | - | - | - | - | - | - |
| West | 20.9 | 16.8 | 22.6 | - | - | - | - | - | - |
| Valley | 63.5 | 49.9 | 52.1 | - | - | - | - | - | - |
| Cropland Total | | | | | | | | | |
| East | 118.8 | 119.4 | 119.4 | - | - | - | 29.4 | 30.4 | 32.2 |
| Central | 33.0 | 32.5 | 32.5 | - | - | - | 11.4 | 12.0 | 12.2 |
| West | 70.3 | 70.2 | 70.2 | - | - | - | 29.9 | 32.2 | 28.3 |
| Valley | 222.1 | 222.1 | 222.1 | - | - | - | 70.8 | 74.6 | 73.6 |

*Less than 50 hectares (area), less than 5 units (production), less than 50,000 pesos (cost)

Table 5-6. -- Area Differences Between the Detailed, Intermediate Weighted, and Aggregate Weighted Solutions, Benchmark and Growth Runs

(% of Detailed Solution)

| | Benchmark Run | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Intermediate Weighted | | | | Aggregate Weighted | | | |
| Crop | East | Central | West | Valley | East | Central | West | Valley |
| Rice | 2.0 | 4.1 | 0.0 | 1.1 | 6.2 | 10.1 | -3.3 | 1.4 |
| Tobacco | 0.5 | 3.7 | -7.4 | 1.2 | -24.7 | 18.8 | -23.7 | 8.1 |
| Plantain | -17.5 | 27.4 | 35.3 | 16.0 | 16.9 | 12.5 | -11.1 | 0.9 |
| Corn | -3.6 | -12.8 | -22.1 | -6.6 | 9.7 | -54.8 | -43.4 | -7.4 |
| Beans | -14.1 | -14.2 | 32.6 | -13.7 | -2.3 | -45.0 | 100.5 | -7.1 |
| Yucca | 1.0 | -3.4 | 38.9 | 0.7 | 4.2 | -25.0 | 240.1 | 2.5 |
| Sweet Potatoes | -2.7 | -8.2 | -2.9 | -3.5 | 13.9 | -26.0 | -69.1 | -0.7 |
| Interplanted | 62.0 | 22.0 | 58.1 | 56.8 | 62.0 | -51.7 | 435.1 | 50.2 |
| Idle | -23.0 | -20.6 | -19.3 | -21.6 | -38.9 | 19.6 | 7.7 | -18.0 |
| Banana[a] | 0.0 | -50.0 | -0.0 | -0.2 | 0.0 | -50.0 | -0.0 | -0.2 |
| Sugar Cane[a] | 0.0 | 0.0 | 0.0 | 0.0 | -24.8 | 8.3 | -0.2 | 0.0 |
| Cocoa[a] | 0.5 | -5.3 | -0.6 | -0.0 | 0.8 | -22.4 | 23.3 | 0.0 |
| Unsigned Differences | | | | | | | | |
| Regions | | | | 515.8 | | | | 1506.1 |
| Rice | | | | 6.1 | | | | 19.6 |
| Tobacco | | | | 11.6 | | | | 67.2 |
| Plantain | | | | 80.2 | | | | 40.5 |
| Corn | | | | 38.5 | | | | 107.9 |
| Beans | | | | 60.9 | | | | 147.8 |
| Yucca | | | | 43.3 | | | | 269.3 |
| Sweet Potatoes | | | | 13.8 | | | | 109.0 |
| Interplanted | | | | 142.1 | | | | 548.8 |
| Idle | | | | 62.9 | | | | 66.2 |
| Valley | | | | 121.4 | | | | 96.5 |

(continued)

Table 5-6 -- (cont'd.)

| | Growth Run | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Intermediate Weighted | | | | Aggregate Weighted | | | |
| Crop | East | Central | West | Valley | East | Central | West | Valley |
| Rice | 8.0 | -5.4 | 0.7 | 3.7 | 8.7 | 12.5 | -0.2 | 4.4 |
| Tobacco | 60.8 | 0.2 | -1.0 | 1.9 | 20.6 | 17.5 | -13.6 | 10.6 |
| Plantain | -20.2 | 4.3 | 47.6 | 20.4 | 15.9 | 9.5 | 5.6 | 9.5 |
| Corn | 2.5 | -7.7 | -45.0 | -0.4 | 11.6 | -48.9 | 46.1 | 1.0 |
| Beans | 3.6 | -12.1 | 39.0 | 1.8 | 20.4 | -46.2 | 100.0 | 12.3 |
| Yucca | 7.4 | -3.3 | 46.1 | 6.4 | 11.0 | -24.6 | 256.9 | 8.4 |
| Sweet Potatoes | 16.6 | -3.5 | -86.9 | 2.5 | 19.8 | -9.8 | -70.6 | 5.9 |
| Interplanted | 9.6 | -4.1 | 69.5 | 8.4 | 8.3 | -64.6 | 435.9 | 2.4 |
| Idle | -34.8 | 3.8 | -34.6 | -32.5 | -60.8 | 65.2 | -9.1 | -30.1 |
| Banana[a] | 0.0 | -50.0 | 0.0 | -0.2 | 0.0 | -50.0 | 0.0 | -0.2 |
| Sugar Cane[a] | 0.0 | 0.0 | 0.0 | 0.0 | -24.8 | 8.3 | -0.2 | 0.0 |
| Cocoa[a] | 0.5 | -5.3 | 0.0 | 0.0 | 0.7 | -22.4 | 230.3 | 0.0 |
| Unsigned Differences | | | | | | | | |
| Regions | | | | 643.0 | | | | 2032.5 |
| Rice | | | | 14.1 | | | | 21.4 |
| Tobacco | | | | 71.0 | | | | 51.7 |
| Plantain | | | | 72.1 | | | | 31.0 |
| Corn | | | | 55.2 | | | | 101.6 |
| Beans | | | | 54.7 | | | | 166.6 |
| Yucca | | | | 56.8 | | | | 292.5 |
| Sweet Potatoes | | | | 107.0 | | | | 100.2 |
| Interplanted | | | | 83.2 | | | | 508.8 |
| Idle | | | | 73.2 | | | | 135.1 |
| Valley | | | | 78.2 | | | | 84.8 |

[a] These crops did not enter into the L.P. optimization; area differences occur outside of the L.P.'s.

Table 5-7. -- Intermediate Weighted and Aggregate Weighted Solutions as Percentages of Detailed Solutions, Benchmark and Growth Runs

| | Benchmark Run[a] | | | | Growth Run | | | |
|---|---|---|---|---|---|---|---|---|
| Model/Parameter | East | Central | West | Valley | East | Central | West | Valley |
| | (%) | | | | (%) | | | |
| Intermediate Wt'd. | | | | | | | | |
| Crop areas | 82-162 | 50-127 | 77-158 | 86-156 | 79-160 | 50-104 | 13-169 | 99-120 |
| Idle areas | 77 | 79 | 81 | 78 | 65 | 104 | 65 | 67 |
| Aggregate Wt'd. | | | | | | | | |
| Crop areas | 75-162 | 45-118 | 56-565 | 92-150 | 75-138 | 50-118 | 29-536 | 99-120 |
| Idle areas | 61 | 119 | 108 | 82 | 39 | 165 | 91 | 69 |
| Intermediate Wt'd. | | | | | | | | |
| Crop production | 0-161 | 67-110 | 86-300 | 98-109 | 0-165 | 70-121 | 14-300 | 98-100 |
| Aggregate Wt'd. | | | | | | | | |
| Crop production | 75-139 | 44-308 | 31-900 | 97-100 | 75-136 | 34-111 | 29-900 | 97-100 |
| Intermediate Wt'd. | | | | | | | | |
| Crop costs | 85-161 | 78-128 | 81-158 | 86-157 | 83-163 | 78-104 | 13-172 | 100-123 |
| Total prod. costs | 103 | 105 | 107 | 105 | 104 | 99 | 112 | 106 |
| Aggregate Wt'd. | | | | | | | | |
| Crop costs | 75-162 | 48-119 | 75-536 | 94-150 | 75-122 | 35-118 | 28-536 | 100-111 |
| Total prod. costs | 112 | 107 | 94 | 104 | 110 | 106 | 101 | 106 |

[a]Underlining shows which model solution shows the smallest variation around the Detailed solution value for the indicated parameter. For convenience, ranges exclude those areas smaller than 50 hectares, production levels below 5 units, and costs less than 50,000 pesos.

General relationships for area differences of individual crops are somewhat difficult to discern. In the Intermediate Weighted model, the unsigned sums of differences for specific crops show that rice, tobacco, and sweet potatoes are the closest to Detailed values in the Benchmark run. In the Growth run, this can be said only about rice. In contrast, the further degree of aggregation in the Aggregate Weighted model seems to have more clearly established area difference relationships. In both runs rice, tobacco, and plantain are in one group - that with the least difference.

Area idle in the East and West, and at the Valley level is less in both aggregated models than in the Detailed solution. This may be due to greater flexibility and efficiency of land use in the Detailed model.

Difference from the Detailed solution seems to be positively correlated with the coefficient of Detailed yield variation, see Table 5-8, particularly in the Aggregate Weighted model. The lowest coefficients of variation are for plantain, rice, and tobacco, the crops with the least difference from the Detailed solution. Unexplainable is crop area interplanted. Whereas this activity has the lowest coefficient, it shows the greatest amounts of difference.

Absolute solution values for Regional production of individual crops also show considerable variation from the Detailed values. See Table 5-7. For both aggregated models, the Valley solutions are nearly the same as those of the Detailed model. The relatively smaller variation in production (versus that of area) is consistent with the L.P. structure. The L.P. attempts to minimize costs; reducing production down to the right-hand side crop requirements constraint, a greater than or equal to constraint, helps to do this.

Conversely, the relatively greater variation in area than in production stems from each model's ability to choose to use from 70 to 120 percent, in the Benchmark run and 70 to 130 percent in the Growth and Growth/Shift run, of the

Table 5-8. -- Relation Between Coefficient of Yields Variation and Unsigned Regional Crop Area Difference from Detailed Solution

Unsigned Differences From Detailed Crop Area Solutions

| Crop[a] | Coefficient of Detailed Yield Variation[c] | Benchmark Run | | | Growth Run | | |
|---|---|---|---|---|---|---|---|
| | | Difference | Intermediate Weighted | Aggregate Weighted | Difference | Intermediate Weighted | Aggregate Weighted |
| Interplanted | 0.318 | least | rice | rice | least | rice | rice |
| Plantain | 0.413 | ↓ | tobacco | plantain | ↓ | beans | plantain |
| Rice | 0.511 | ↓ | sweet potatoes | tobacco[d] | ↓ | corn | tobacco |
| Tobacco | 0.557 | ↓ | corn | sweet potatoes | ↓ | yuca | sweet potatoes |
| Sweet Potatoes[b] | 0.844 | ↓ | yuca | corn | ↓ | tobacco | corn |
| Corn[b] | 0.851 | ↓ | beans | beans | ↓ | plantain | beans[d] |
| Beans[b] | 0.876 | ↓ | plantain[d] | yuca | ↓ | interplanted[d] | yuca |
| Yuca | 1.016 | greatest | interplanted | interplanted | greatest | sweet potatoes | interplanted |

[a]Does not include banana, sugar cane, or cocoa since these crops did not enter the L.P. optimization.

[b]Yield estimate is zero on 17 PPAs, primarily in the West.

[c]Coefficient of variation = standard deviation divided by the mean.

[d]Absolute variation for idle area was less than that of this crop.

Current Normal area in each crop-production method combination, by PPA. In addition, in both runs the models can use up to 50 percent of the area of any PPA not in use in the Current Normal. The larger number of Intermediate PPAs, 14, than Aggregate PPAs, 9, implies more flexibility in the Intermediate Weighted model (most in the Detailed which has 45 PPAs) and hence relatively greater area variation with respect to the Detailed solution.

Regional values of both models for production cost of individual crops show considerable range, similar to that for area, about the Detailed values. Total production costs for all crops are greater than the Detailed solution in all areas except in the West where the Aggregate Weighted solution is 5.4 percent less. Regional production costs are never more than 12.9 percent greater (3.8 million pesos in the East Region - Aggregate Weighted solution) and Valley production costs never more than 5.4 percent, 3.8 million pesos, greater than the Detailed solution. Differences from the Regional Detailed solutions are usually but not always greater in the Growth run than in the Benchmark. The largest differences are in the Aggregate Weighted solution for the West, 18.6 percent greater, and for the Valley, 8.9 percent greater. Neither of the two aggregated models consistently show a greater (or lesser) difference from the Detailed solution production costs.

Regional crop requirements can be met either from production within the Region or by importing from another Region. In both models, crop transportation flows from one Region to another were nearly always (29 of 30 times) different from those of the Detailed model. Total flows, by crops, of course, were usually the same. See Table 5-9 and 5-10 for an example with rice. Transportation costs are insignificant relative to production costs. For example, when rice produced under the low production method is transported from East to Santo Domingo,

Table 5-9. -- Rice Production, Transportation Flows, and Production Cost Differences Between the Detailed, Intermediate Weighted and Aggregate Weighted Solutions, Benchmark Run

| Requirements Regions | Production | | | Total Transportation Flows[a] | | | Production Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Detailed | Intermediate Weighted | Aggregate Weighted | Detailed | Intermediate Weighted | Aggregate Weighted | Detailed | Intermediate Weighted | Aggregate Weighted |
| | | (1000 QQ) | | | (1000 QQ) | | | (1000 pesos) | |
| East | 1,317.4 | 1,328.5 | 1,391.9 | 540 | 540 | 540 | 12,324.8 | 12,608.6 | 13,173.1 |
| Central | 96.1 | 103.6 | 111.1 | 810 | 810 | 810 | 1,400.4 | 1,461.0 | 1,547.3 |
| West | 1,286.5 | 1,267.8 | 1,197.0 | 270 | 270 | 270 | 13,402.8 | 13,436.3 | 12,935.4 |
| Santo Domingo | 0 | 0 | 0 | 1,080 | 1,080 | 1,080 | 0 | 0 | 0 |
| Total | 2,700.0 | 2,700.0 | 2,700.0 | 2,700 | 2,700 | 2,700 | 27,128.0 | 27,505.9 | 27,655.8 |

[a]Includes amount produced within a region and transported to itself at zero cost. Reference to Appendix II shows that the flows from region to region differ between models.

Table 5-10. — Rice Transportation Flow Differences Between Detailed, Intermediate Weighted, and Aggregate Weighted Solutions -Benchmark Run

| Requirements Regions | Detailed Model Supply Regions | | | | Intermediate Weighted Model Supply Regions | | | | Aggregate Weighted Model Supply Regions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | Central | West | Total | East | Central | West | Total | East | Central | West | Total |
| | (1000 QQ) | | | | (1000 QQ) | | | | (1000 QQ) | | | |
| East | 237.4 | 96.1 | 206.5 | 540.0 | 540.0 | - | - | 540.0 | 540.0 | - | - | 540.0 |
| Central | - | - | 810.0 | 810.0 | - | 103.6 | 706.4 | 810.0 | - | 111.1 | 698.9 | 810.0 |
| West | - | - | 270.0 | 270.0 | - | - | 270.0 | 270.0 | - | - | 270.0 | 270.0 |
| Santo Domingo | 1,080.0 | - | - | 1,080.0 | 788.5 | - | 291.5 | 1,080.0 | 851.9 | - | 228.1 | 1,080.0 |
| Total | 1,317.4 | 96.1 | 1,286.5 | 2,700.0 | 1,328.5 | 103.6 | 1,267.8 | 2,700.0 | 1,391.9 | 111.1 | 1,197.0 | 2,700.0 |

transportation accounts for 5.6 percent of total costs; and from East to Central only 0.7 percent.

Objective function values for the three models and runs are shown in Table 5-11. In each instance, both aggregated models (the Aggregate somewhat less than the Intermediate) have a higher optimal solution than the Detailed model. The differences range from $2.9 to $5.4 million which is 3.9 to 6.4 percent greater than the Detailed solution.

Another method of comparison is done with the Theil Inequality Coefficient, U, discussed above. The coefficient compares L.P. changes predicted from the Current Normal level of some parameter. The U coefficients in Table 5-12 compare projected changes of each of the two models to the projected changes of the Detailed model for Regional and Valley cultivated area and for production. Since a Current Normal cost was not calculated, U is not available for costs. When there is perfect correspondence between the Detailed change and that of another L.P., U has a value of zero. Non-negative, it has no upper limit.[1] Coefficents are the same in the Growth and Growth/Shift runs for production and either the same or only slightly greater in the Growth/Shift run for area.

A markedly higher degree of correspondence with the change projected by the Detailed L.P. is noted for production than for cultivated area. Although even in production, in the East and Central Regions, the correspondence is not very close (with U ranges from 0.34 to 1.00). Correspondence in production with the Detailed solution is closer for the Valley than for the Regions. Coefficients for area do not indicate close correspondence to the Detailed solution in any cases, Region or Valley, nor do Regional area coefficients seem to be consistently larger or smaller than that of the Valley. Each of these points are consistent with the

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[1] Suppose a change in cultivated area of all crops from the Current Normal as solved in the Detailed and some model A is to be computed. If A predicts a change from 7 in the Current Normal to 14 and the Detailed predicts the same, 7 to 14, then U = 0; if A is 7 to 4, then U = 1.4; if A is 7 to 21, then U = 1; if A is 7 to 17, then U = 0.43; and so on.

Table 5-11. -- Differences Between Objective Function Solutions of All Models

| Model | Benchmark Run | Growth Run | Growth/Shift Run |
|---|---|---|---|
| | | ($1000) | |
| Objective Function Solutions | | | |
| Detailed | 73,910 | 85,170 | 85,440 |
| Intermediate Weighted | 77,770 | 90,610 | 90,880 |
| Aggregate Weighted | 76,790 | 89,830 | 90,100 |
| Intermediate | 70,650 | 79,680 | 79,940 |
| Aggregate | 69,370 | 77,750 | 78,000 |
| | | ($1000) | |
| Differences in Function Solutions | | | |
| Int. Wt'd. - Detailed | 3,860 | 5,440 | 5,440 |
| Agg. Wt'd. - Detailed | 2,880 | 4,660 | 4,660 |
| Int. - Detailed | -3,260 | -5,490 | -5,500 |
| Agg. - Detailed | -4,540 | -7,420 | -7,440 |
| Agg. - Intermediate | -1,280 | -1,930 | -1,940 |
| Agg. Wt'd. - Int. Weighted | -980 | -780 | -780 |
| | | (%) | |
| Differences as % of Detailed | | | |
| Int. Wt'd. - Detailed | 5.22 | 6.38 | 6.37 |
| Agg. Wt'd. - Detailed | 3.90 | 5.47 | 5.45 |
| Int. - Detailed | -4.41 | -6.44 | -6.44 |
| Agg. - Detailed | -6.14 | -8.71 | -8.71 |

Table 5-12. -- Correspondences Between Intermediate Weighted, Aggregate Weighted, and Detailed Solutions

| Solutions Compared to Detailed Solution | Area | | | | Production | | | |
|---|---|---|---|---|---|---|---|---|
| | East | Central | West | Valley | East | Central | West | Valley |
| | (U Coefficient[a]) | | | | (U Coefficient[a]) | | | |
| Benchmark Run | | | | | | | | |
| Intermediate Wt'd. | 1.495 | 0.491 | 0.854 | 1.161 | 0.337 | 0.442 | 0.061 | 0.035 |
| Aggregate Wt'd. | 0.667 | 1.937 | 1.634 | 0.510 | 0.659 | 0.721 | 0.133 | 0.017 |
| Growth Run | | | | | | | | |
| Intermediate Wt'd. | 0.872 | 1.141 | 2.445 | 1.012 | 0.994 | 0.428 | 0.150 | 0.028 |
| Aggregate Wt'd. | 0.663 | 1.143 | 1.537 | 1.063 | 1.001 | 0.649 | 0.125 | 0.013 |
| Growth/Shift Run | | | | | | | | |
| Intermediate Wt'd. | 0.874 | 0.141 | 2.451 | 1.009 | 0.994 | 0.428 | 0.150 | 0.028 |
| Aggregate Wt'd. | 0.665 | 1.143 | 1.537 | 1.065 | 1.001 | 0.649 | 0.125 | 0.013 |
| Solutions Compared to Intermediate Wt'd. | | | | | | | | |
| Benchmark Run | | | | | | | | |
| Aggregate Wt'd. | 0.667 | 1.937 | 1.634 | 0.510 | 0.483 | 0.574 | 0.141 | 0.041 |
| Growth Run | | | | | | | | |
| Aggregate Wt'd. | 0.565 | 1.542 | 1.207 | 0.607 | 0.280 | 0.489 | 0.107 | 0.040 |
| Growth/Shift Run | | | | | | | | |
| Aggregate Wt'd. | 0.565 | 1.542 | 1.207 | 0.607 | 0.280 | 0.489 | 0.107 | 0.404 |

[a]The formula for the Theil Coefficient $U = \frac{\sqrt{\Sigma (0_{2i} - 0_{1i})^2}}{\sqrt{\Sigma\ 0_{1i}^2}}$ where $A_i$ is the change in some parameter i from the Current Normal value to the Detailed solution; $P_i$ is the change from the Current Normal Value to the Int. Wt'd. or Agg. Wt'd. solution.

L.P. structure discussed above. Considering Regional area coefficients only, correspondence with the Detailed L.P. change from the Current Normal is greatest in the East except for the Benchmark run where the Central Region in the Intermediate Weighted model has the best correspondence.[1]

Area correspondence between changes projected by the Intermediate Weighted and Aggregate Weighted L.P.'s from the Current Normal are generally closer, as indicated by lower U values, than comparisons with the Detailed model. The least correspondence occurs at the Regional levels and appears to be quite low.

Bias, or average signed error, of L.P. solutions is a means of showing if the estimates of the more aggregated models are either larger or smaller than those of the Detailed on the average. If the weighted sum of the overestimates equals the weighted sum of the underestimates, the bias is zero. Percentage bias is presented in Table 5-13. More often than not both aggregated models showed a positive bias to Detailed solution values for cropland area. A negative bias of 1.9 to 6.5 percent appeared, however, in the Central Region. With respect to production, the aggregated models were as often positively as negatively biased. Except for the Central Region where a strong negative bias was always exhibited,

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[1]This performance is explainable if one considers the relative (to the total number of Detailed PPAs) number of PPAs that entered into solution in the Intermediate Weighted and Aggregate Weighted models: the larger the relative number that entered, the greater the degree of flexibility and the closer its flexibility to the Detailed L.P.

PPAs in Benchmark Solution

| L.P. | Number | | | Relative to Detailed L.P. | | |
|---|---|---|---|---|---|---|
| | East | Central | West | East | Central | West |
| Detailed | 16 | 18 | 24 | - | - | - |
| Int. Wt'd. | 5 | 8 | 6 | 0.31 | 0.44 | 0.25 |
| Agg. Wt'd. | 5 | 4 | 6 | 0.31 | 0.22 | 0.25 |

Table 5-13. -- Bias Between Detailed, Intermediate Weighted, and Aggregated Weighted Solutions

| Solutions | Cultivated Area | | | | Production | | | | Production Costs | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | Central | West | Valley | East | Central | West | Valley | East | Central | West | Valley |
| | (%) | | | | (%) | | | | (%) | | | |
| Benchmark Run | | | | | | | | | | | | |
| Int. Wt'd.: Det. | 7.6 | 2.2 | 8.0 | 8.6 | 2.7 | -12.6 | 1.0 | 0.3 | 3.4 | 5.2 | 7.4 | 5.4 |
| Agg. Wt'd.: Det. | 18.0 | -6.5 | -3.3 | 7.2 | 10.0 | -21.4 | -2.6 | 0.1 | 12.7 | 7.0 | -5.6 | 4.1 |
| Growth Run | | | | | | | | | | | | |
| Int. Wt'd.: Det. | 7.0 | -1.9 | 11.0 | 6.8 | 5.1 | -15.5 | -0.5 | 0.2 | 4.0 | -0.5 | 12.2 | 6.6 |
| Agg. Wt'd.: Det. | 12.2 | -6.2 | 2.9 | 6.4 | 7.9 | -20.6 | -2.0 | -0.1 | 10.3 | 6.2 | 0.6 | 5.7 |
| Growth/Shift Run | | | | | | | | | | | | |
| Int. Wt'd.: Det. | 7.2 | -1.9 | 11.0 | 6.8 | 4.7 | -15.5 | -0.2 | 0.2 | 4.0 | -0.5 | 12.3 | 6.6 |
| Agg. Wt'd.: Det. | 12.2 | -6.2 | 2.8 | 6.4 | 7.5 | -20.6 | -1.7 | 0.1 | 10.2 | 6.2 | 0.7 | 5.7 |
| Times Positive (no.) | 6 | 1 | 5 | 6 | 6 | 0 | 1 | 5 | 6 | 4 | 5 | 6 |
| Times Negative (no.) | 0 | 5 | 1 | 0 | 0 | 6 | 5 | 1 | 0 | 2 | 1 | 0 |
| | (%) | | | | (%) | | | | (%) | | | |
| Benchmark Run | | | | | | | | | | | | |
| Agg. Wt'd.: | | | | | | | | | | | | |
| Int. Wt'd. | 6.4 | -9.0 | -10.5 | -1.3 | 7.1 | -10.1 | -16.9 | -0.1 | 9.0 | 1.7 | -12.1 | -1.3 |
| Growth Run | | | | | | | | | | | | |
| Agg. Wt'd.: | | | | | | | | | | | | |
| Int. Wt'd. | 4.7 | -4.4 | -7.4 | -0.4 | 2.7 | -5.8 | -1.5 | -0.1 | 6.0 | 6.8 | -10.3 | -0.8 |
| Growth/Shift Run | | | | | | | | | | | | |
| Agg. Wt'd.: | | | | | | | | | | | | |
| Int. Wt'd. | 4.7 | -4.4 | -7.4 | -0.4 | 2.7 | -5.8 | -1.5 | -0.1 | 6.0 | 6.8 | -10.3 | -0.8 |
| Times Positive (no.) | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 3 | 0 | 0 |
| Times Negative (no.) | 0 | 3 | 3 | 3 | 0 | 3 | 3 | 3 | 0 | 0 | 3 | 3 |

the degree of bias is less than for area. At the Valley level, for example, production bias ranges from -0.1 percent to 0.3 percent while area bias ranges from 6.4 percent to 8.6 percent. With respect to production cost, the aggregated models were positively biased in 21 of 24 instances with a magnitude more similar to that of the area than to the production bias.

Table 5-13 also presents the average signed error of the Aggregate Weighted model with respect to the Intermediate Weighted model. Except for the East, the Aggregate L.P. is usually, 24 of 27 times, negatively biased. As with comparisons of other L.P.'s, the bias is least at the Valley level.

The variance and coefficient of variation for the Intermediate Weighted yield estimates and for the Aggregate Weighted estimates each of which are composed of Detailed yield estimates suggests part of the information loss that occurs with aggregation. Tables A-28 and A-29 present the range of variance and of the coefficient of variation for the 14 Intermediate and 9 Aggregate PPAs. The narrowest ranges for the coefficient of variation are found for corn (0.10-0.30), beans (0.12-0.33) and sweet potatoes (0.12-0.36); tobacco has the broadest range (0.16-1.74).

Detailed, Intermediate, and Aggregate Models

The two models - Intermediate and Aggregate - were also run for the three policy questions and compared to the Detailed solutions. Input to these models varies both in number of PPAs and crop yield estimates.

Table A-30 shows that the bias of the "independent"[1] Intermediate yield estimates with respect to the estimates made for the Detailed PPAs composing each Intermediate PPA is positive 79 times out of a 100. For only two crops, rice

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[1] The estimates are not truly independent from one another. Using the soil scientists' description of the PPAs, the agronomist ordinally ranked the production potential of each Detailed PPA on a 0-100 scale for each crop-low production method combination. He then ranked the Intermediate PPAs and then the Aggregate PPAs using the descriptions of these PPAs. Multiplication of the rank by the yield estimate for the combination produced the yield estimates used in each of the L.P.'s.

and corn, are the number of overestimates equal to the number of underestimates. Bias between yield estimates made for Aggregate PPAs and those for Detailed PPAs is positive 61 times out of 70. See Table A-31. The range in bias varies considerably among crops and is greatest for tobacco and rice and least for sweet potatoes.

With the two exceptions of differences in crop transportation flows, the Detailed and Aggregate model runs have nearly identical Valley solution values in both the Growth and Growth/Shift run. See Tables A-34 and A-35. Except for transportation flows, Aggregate L.P. values for the Regions are identical and the Detailed L.P. shows only a 0.4 percent difference in corn and 0.2 percent in idle area between the two runs. In the Intermediate model, area and production cost differ in small amounts between runs at the Region level. Valley area for six crops are larger in the Growth/Shift run than in the Growth run but always by less than 0.6 percent. See Table 5-4. Transportation flows from supply to requirement Regions often changed in this model: 35 out of a possible 90 (3 L.P.'s x 3 Regions x 10 crops) opportunities. Rice flows between these three models are compared in Tables 5-14 and 5-15. However, impact on objective function values is very small. These values of the Intermediate L.P. differed only 0.91 percent and those of the Aggregate L.P. only 0.006 percent between the two runs.

Consistent with the positive bias (with respect to the Detailed yields) of the Intermediate and Aggregate yields, solution crop area for all crops but rice are either less than or equal to the Detailed solutions in both runs. See Table 5-16. Recall that rice yields had little or no positive bias. As with the weighted yield models, differences between solution values seem to be greater at the Region than at the Valley level. Idle cropland is 17-24 percent greater in the Benchmark Intermediate and Aggregate than in the Detailed solution. See Table 5-17. Although the absolute amount of idle land is expectedly lower in the Growth than

Table 5-14. -- Rice Production, Transportation Flows, and Production Cost Differences Between the Detailed, Intermediate, and Aggregate Solutions - Benchmark Run

| Requirements Regions | Production | | | Total Transportation Flows[a] | | | Production Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Detailed | Intermediate | Aggregate | Detailed | Intermediate | Aggregate | Detailed | Intermediate | Aggregate |
| | | (1000 QQ) | | | (1000 QQ) | | | (1000 pesos) | |
| East | 1,317.4 | 1,620.0 | 1,778.2 | 540 | 540 | 540 | 12,324.8 | 13,374.7 | 14,568.0 |
| Central | 96.1 | 287.5 | 158.5 | 810 | 810 | 810 | 1,400.4 | 2,653.5 | 1,901.0 |
| West | 1,286.5 | 792.5 | 763.2 | 270 | 270 | 270 | 13,402.8 | 11,550.1 | 11,322.3 |
| Santo Domingo | - | - | - | 1,080 | 1,080 | 1,080 | - | - | - |
| Total | 2,700.0 | 2,700.0 | 2,700.0 | 2,700 | 2,700 | 2,700 | 27,128.0 | 27,578.3 | 27,791.3 |

[a]Includes amount produced within a region and transported to itself at zero cost. Reference to Appendix II shows that the flows from region to region differ between models.

Table 5-15. -- Rice Transportation Flow Differences Between Detailed, Intermediate, and Aggregate Solutions - Benchmark Run

| Requirements Regions | Detailed Supply Regions | | | | Intermediate Supply Regions | | | | Aggregate Supply Regions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | East | Central | West | Total | East | Central | West | Total | East | Central | West | Total |
| | (1000 QQ) | | | | (1000 QQ) | | | | (1000 QQ) | | | |
| East | 237.4 | 96.1 | 206.5 | 540.0 | 540.0 | - | - | 540.0 | 540.0 | - | - | 540.0 |
| Central | - | - | 810.0 | 810.0 | - | 287.5 | 522.5 | 810.0 | 158.2 | 158.5 | 493.2 | 809.9 |
| West | - | - | 270.0 | 270.0 | - | - | 270.0 | 270.0 | - | - | 270.0 | 270.0 |
| Santo Domingo | 1,080.0 | - | - | 1,080.0 | 1,080.0 | - | - | 1,080.0 | 1,080.0 | - | - | 1,080.0 |
| Total | 1,317.4 | 96.1 | 1,286.5 | 2,700.0 | 1,620.0 | 287.5 | 792.5 | 2,700.0 | 1,778.2 | 158.5 | 763.2 | 2,699.9 |

Table 5-16. -- Area, Production, and Cost Differences Between Detailed, Intermediate, and Aggregate Solutions - Benchmark Run

| Crop/Region | Area | | | Production | | | Production Costs | | |
|---|---|---|---|---|---|---|---|---|---|
| | Detailed | Intermediate | Aggregate | Detailed | Intermediate | Aggregate | Detailed | Intermediate | Aggregate |
| | (1000 hectares) | | | (1000 units) | | | (million pesos) | | |
| Rice | | | | | | | | | |
| East | 10.5 | 11.3 | 12.2 | 1,320 | 1,620 | 1,780 | 12.3 | 13.3 | 14.6 |
| Central | 1.2 | 2.2 | 1.6 | 100 | 290 | 160 | 1.4 | 2.7 | 1.9 |
| West | 13.1 | 11.3 | 11.1 | 1,290 | 790 | 760 | 13.4 | 11.6 | 11.3 |
| Valley | 24.8 | 24.8 | 24.9 | 2,700 | 2,700 | 2,700 | 27.1 | 27.6 | 27.8 |
| Tobacco | | | | | | | | | |
| East | 0.6 | 0.6 | 0.5 | 20 | 30 | 30 | 0.3 | 0.3 | 0.3 |
| Central | 12.7 | 11.6 | 12.4 | 360 | 350 | 370 | 6.7 | 6.1 | 6.5 |
| West | 3.6 | 3.4 | 2.8 | 90 | 80 | 60 | 1.9 | 1.8 | 1.5 |
| Valley | 17.0 | 15.6 | 15.6 | 470 | 470 | 470 | 8.9 | 8.2 | 8.2 |
| Plantain | | | | | | | | | |
| East | 7.6 | 7.2 | 5.7 | 170 | 200 | 150 | 4.5 | 4.2 | 3.4 |
| Central | 1.9 | 2.0 | 2.1 | 50 | 50 | 50 | 1.1 | 1.2 | 1.2 |
| West | 12.1 | 11.1 | 10.5 | 180 | 150 | 200 | 7.2 | 6.6 | 6.3 |
| Valley | 21.6 | 20.3 | 18.3 | 400 | 400 | 400 | 12.9 | 12.0 | 10.9 |
| Banana | | | | | | | | | |
| East | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Central | * | * | * | * | * | * | * | * | * |
| West | 4.0 | 4.0 | 4.0 | 4,320 | 3,350 | 5,120 | 2.6 | 2.6 | 2.6 |
| Valley | 4.0 | 4.0 | 4.0 | 4,320 | 3,350 | 5,120 | 2.6 | 2.6 | 2.6 |
| Sugar Cane | | | | | | | | | |
| East | * | * | * | * | * | * | * | * | * |
| Central | 0.2 | 0.2 | 0.2 | 10 | 10 | 10 | 0.1 | 0.1 | 0.1 |
| West | 8.0 | 8.0 | 8.0 | 350 | 300 | 360 | 4.4 | 4.4 | 4.4 |
| Valley | 8.2 | 8.2 | 8.2 | 370 | 310 | 370 | 4.5 | 4.5 | 4.5 |

(continued)

Table 5-16. (cont'd.)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Corn** | | | | | | | | | |
| East | 10.3 | 9.4 | 8.6 | 340 | 400 | 420 | 1.7 | 1.6 | 1.5 |
| Central | 3.1 | 1.2 | 0.9 | 100 | 50 | 30 | 0.5 | 0.2 | 0.2 |
| West | 0.8 | 0.1 | 0.3 | 20 | * | 10 | 0.1 | * | * |
| Valley | 14.1 | 10.8 | 9.7 | 460 | 460 | 460 | 2.3 | 1.8 | 1.7 |
| **Beans** | | | | | | | | | |
| East | 6.9 | 5.7 | 5.9 | 210 | 190 | 210 | 1.7 | 1.4 | 1.5 |
| Central | 1.1 | 1.2 | 0.9 | 40 | 40 | 30 | 0.3 | 0.3 | 0.2 |
| West | 0.1 | 1.0 | 0.2 | * | 30 | 10 | * | 0.3 | 0.1 |
| Valley | 8.1 | 7.9 | 7.0 | 250 | 250 | 260 | 2.0 | 2.0 | 1.7 |
| **Yucca** | | | | | | | | | |
| East | 13.0 | 9.8 | 9.8 | 1,440 | 1,590 | 1,970 | 2.7 | 2.1 | 2.1 |
| Central | 2.2 | 1.2 | 1.0 | 320 | 200 | 160 | 0.5 | 0.3 | 0.2 |
| West | 0.1 | 0.1 | 0.3 | 10 | 20 | 50 | * | * | 0.1 |
| Valley | 15.3 | 11.2 | 11.2 | 1,780 | 1,800 | 2,180 | 3.2 | 2.4 | 2.4 |
| **Sweet Potatoes** | | | | | | | | | |
| East | 5.7 | 4.9 | 4.9 | 820 | 930 | 1,180 | 1.3 | 1.1 | 1.1 |
| Central | 1.1 | 0.7 | 0.6 | 200 | 150 | 120 | 0.3 | 0.2 | 0.1 |
| West | 0.8 | 0.2 | 0.2 | 110 | 50 | 30 | 0.2 | 0.1 | * |
| Valley | 7.6 | 5.8 | 5.7 | 1,130 | 1,130 | 1,340 | 1.8 | 1.4 | 1.3 |
| **Cocoa** | | | | | | | | | |
| East | 8.4 | 8.4 | 8.5 | 40 | 60 | 50 | 1.9 | 1.9 | 1.9 |
| Central | 0.9 | 0.8 | 0.7 | 10 | 10 | 10 | 0.2 | 0.2 | 0.2 |
| West | 0.1 | 0.1 | 0.2 | * | * | * | * | * | * |
| Valley | 9.3 | 9.3 | 9.3 | 40 | 60 | 60 | 2.1 | 2.1 | 2.1 |
| **Interplanted** | | | | | | | | | |
| East | 14.6 | 14.0 | 14.0 | Reported in production of plantain, corn, beans, yucca, and sweet potatoes | | | 2.8 | 2.7 | 2.7 |
| Central | 2.2 | 1.6 | 1.0 | | | | 0.4 | 0.3 | 0.2 |
| West | 0.1 | 0.1 | 0.7 | | | | * | * | 0.1 |
| Valley | 17.0 | 15.7 | 15.7 | | | | 3.3 | 3.0 | 3.0 |

(continued)

Table 5-16. (cont'd.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pasture | | | | | | | |
| East | 4.5 | 6.8 | 6.2 | | | | |
| Central | 0.4 | 0.4 | 0.3 | | | | |
| West | 6.6 | 6.6 | 7.3 | | | | |
| Valley | 11.5 | 13.8 | 13.8 | | | | |
| Idle | | | | | | | |
| East | 36.6 | 41.1 | 43.1 | | | | |
| Central | 6.1 | 9.4 | 10.9 | | | | |
| West | 20.9 | 24.2 | 24.7 | | | | |
| Valley | 63.5 | 74.6 | 78.6 | | | | |
| Cropland Total | | | | | | | |
| East | 118.8 | 119.4 | 119.4 | | 29.4 | 28.8 | 29.0 |
| Central | 33.0 | 32.5 | 32.5 | | 11.4 | 11.5 | 10.8 |
| West | 70.3 | 70.2 | 70.2 | | 29.9 | 27.4 | 26.4 |
| Valley | 222.1 | 222.1 | 222.1 | | 70.8 | 67.6 | 66.3 |

*Less than 50 hectares, 5 units of production, or 50,000 pesos of cost

Table 5-17. -- Intermediate and Aggregate Solutions as Percentages of Detailed Solutions - Benchmark and Growth Runs

| | Benchmark Run[a] | | | | Growth Run[a] | | | |
|---|---|---|---|---|---|---|---|---|
| Solutions | East | Central | West | Valley | East | Central | West | Valley |
| | (%) | | | | (%) | | | |
| Intermediate | | | | | | | | |
| Crop areas | 75-151 | 39-183 | 13-1000 | 73-120 | 65-151 | 43-210 | 55-600 | 73-142 |
| Idle | 113 | 154 | 116 | 117 | 143 | 161 | 138 | 142 |
| Aggregate | | | | | | | | |
| Crop areas | 75-138 | 29-133 | 20-700 | 69-120 | 65-116 | 33-108 | 60-700 | 91-120 |
| Idle | 118 | 179 | 118 | 124 | 176 | 343 | 140 | 169 |
| Intermediate | | | | | | | | |
| Crop production | 90-150 | 50-290 | 61-200 | 78-101 | 95-150 | 60-377 | 53-800 | 78-150 |
| Aggregate | | | | | | | | |
| Crop production | 88-150 | 30-160 | 27-500 | 100-150 | 95-143 | 41-123 | 29-250 | 100-150 |
| Intermediate | | | | | | | | |
| Production costs | 78-108 | 40-193 | 50-95 | 75-102 | 68-104 | 40-229 | 50-100 | 70-100 |
| Total prod. costs | 98 | 101 | 92 | 95 | 97 | 110 | 83 | 94 |
| Aggregate | | | | | | | | |
| Production costs | 75-119 | 33-135 | 79-100 | 74-103 | 59-121 | 33-111 | 50-100 | 52-100 |
| Total prod. costs | 99 | 95 | 88 | 94 | 98 | 95 | 82 | 91 |

[a]Underlining shows which model solution has the smallest variation around the Detailed solution. For convenience, does not include areas smaller than 50 hectares, production levels below 5 units, or costs less than 50,000 pesos.

in the Benchmark run, the solution values, as compared to those of the Detailed L.P., are greater, 42 to 69 percent. This is partially due to widening the use of PPA area constraints from 70-120 percent of the Current Normal in the Benchmark to 70-130 percent in the Growth run. As the Table shows, crop area solution values as a percent of the Detailed solution vary widely both at the Region and less so at the Valley level.

Production shifts widely between Regions and models. Except for those crops whose areas are fixed, sugar cane, bananas, and cocoa, each of the L.P.s usually generated production levels near to the right-hand side constraint.

Except for rice, crop production cost in the Regions and for the Valley under both models is less than or equal to the Detailed solution; total production costs are less than the Detailed. This is again a consequence of the positive yield bias in the aggregated models.

Objective function values for the three models and runs are shown in Table 5-11. In each instance, the aggregated models have a lower optimal solution than the Detailed model. The differences range from $3.3 million in the Intermediate Benchmark which is 4.4 percent less than the Detailed solution to $7.4 million in the Aggregate Growth which is 8.7 percent less.

The Theil coefficients may have little explanatory value since the three L.P.'s have different input data and differences in solution values of the three models would be expected. See Table 5-18. It is interesting to note, however, that for crop area, 9 out of 16 possible (3 Regions plus 1 Valley x 2 L.P.'s x 2 runs) times these two models have Theil coefficients lower than the Intermediate Weighted and Aggregate Weighted L.P.'s. In other words, using the Theil statistic, it is not at all clear that the two L.P.s with the same yields data as the Detailed model are any better able to correspond to the Detailed L.P. cropping pattern.[1]

---

[1]"U" statistics for Intermediate and Aggregate production are much higher than for the weighted L.P.'s. This stems from not using the Detailed yields as was done in the weighted models.

Table 5-18. -- Correspondences Between Detailed, Intermediate, and Aggregate Solutions

| Solutions | Area | | | | Production | | | |
|---|---|---|---|---|---|---|---|---|
| | East | Central | West | Valley | East | Central | West | Valley |
| | (U Coefficient[a]) | | | | (U Coefficient[a]) | | | |
| Benchmark Run[b] | | | | | | | | |
| Intermediate | 0.614 | 1.268 | 0.477 | 0.682 | 2.327 | 1.203 | 1.088 | 1.102 |
| Aggregate | 0.754 | 1.492 | 0.572 | 0.838 | 2.370 | 0.913 | 0.963 | 0.829 |
| Growth Run[b] | | | | | | | | |
| Intermediate | 1.443 | 1.064 | 1.650 | 1.286 | 1.343 | 1.400 | 1.127 | 0.808 |
| Aggregate | 2.417 | 1.366 | 1.921 | 2.795 | 2.841 | 0.878 | 1.016 | 0.673 |
| Growth/Shift Run[b] | | | | | | | | |
| Intermediate | 1.517 | 0.841 | 1.660 | 1.300 | 2.320 | 0.910 | 1.129 | 0.838 |
| Aggregate | 2.436 | 1.366 | 0.958 | 2.311 | 3.541 | 0.767 | 1.022 | 0.673 |
| Benchmark Run[c] | | | | | | | | |
| Aggregate | 0.253 | 0.604 | 0.214 | 0.203 | 0.396 | 0.845 | 6.380 | 3.876 |
| Growth Run[c] | | | | | | | | |
| Aggregate | 1.334 | 1.607 | 0.222 | 1.878 | 1.057 | 0.903 | 5.529 | 2.832 |
| Growth/Shift Run[c] | | | | | | | | |
| Aggregate | 2.190 | 1.914 | 0.203 | 1.460 | 0.659 | 0.861 | 5.610 | 2.523 |

[a]The formula for the Theil Coefficient: $U = \frac{\sqrt{\Sigma (O_{2i} - O_{1i})^2}}{\sqrt{\Sigma O_{1i}^2}}$ where $A_i$ is the change in some parameter i from the Current Normal value to the Detailed solution; $P_i$ is the change from the Current Normal Value to the Int. Wt'd. or Agg. Wt'd. solution.

[b]Comparisons are made with Detailed solution.

[c]Comparisons are made with Intermediate solution.

Average signed error of the two aggregated models with respect to Detailed L.P. solutions was strongly negative (23 or 24) for area, on balance unbiased (12 positive and 12 negative) for production, and strongly negative (21 of 24) for production cost. See Table 5-19. This reflects the difference in yield input data. Similar bias held for the Aggregate model with respect to the Intermediate.

Table 5-19. -- Bias Between Detailed, Intermediate, and Aggregate Solutions

| | Cultivated Area | | | | Production | | | | Production Costs | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solutions | East | Central | West | Valley | East | Central | West | Valley | East | Central | West | Valley |
| | | (%) | | | | (%) | | | | (%) | | |
| Benchmark Run | | | | | | | | | | | | |
| Int.: Detailed | -4.8 | -14.1 | 55.7 | -39.1 | 30.3 | -9.7 | -25.2 | -3.3 | -2.3 | 0.8 | -8.7 | -4.5 |
| Agg.: Detailed | -7.2 | -19.9 | -7.8 | -9.6 | 33.0 | -19.8 | 3.7 | 9.6 | -1.4 | -4.8 | -11.7 | -6.3 |
| Growth Run | | | | | | | | | | | | |
| Int.: Detailed | -7.6 | -5.8 | -12.2 | -8.7 | 69.4 | 21.1 | -25.0 | -0.1 | -3.1 | 10.6 | -16.9 | -6.5 |
| Agg.: Detailed | -14.0 | -18.4 | -12.9 | -14.4 | 21.9 | -21.2 | -7.5 | 6.6 | -1.6 | -4.3 | -18.6 | -8.9 |
| Growth/Shift Run | | | | | | | | | | | | |
| Int.: Detailed | -7.7 | -6.0 | -12.3 | -8.8 | -18.6 | 148.2 | -25.0 | -7.5 | -1.0 | 4.9 | -16.9 | -6.5 |
| Agg.: Detailed | -14.1 | -18.4 | -12.9 | -14.5 | 21.4 | -21.1 | 0.2 | 6.6 | -1.7 | -4.3 | -18.6 | -8.9 |
| Positive (no.) | 0 | 0 | 1 | 0 | 5 | 2 | 2 | 3 | 0 | 3 | 0 | 0 |
| Negative (no.) | 6 | 6 | 5 | 6 | 1 | 4 | 4 | 3 | 6 | 3 | 6 | 6 |
| | | (%) | | | | (%) | | | | (%) | | |
| Benchmark Run | | | | | | | | | | | | |
| Agg.: Intermed. | -2.6 | -6.8 | -9.6 | -2.7 | 2.1 | -11.2 | 38.5 | 13.3 | 0.9 | -5.6 | -3.3 | -1.9 |
| Growth Run | | | | | | | | | | | | |
| Agg.: Intermed. | -6.9 | -13.3 | -0.7 | -6.3 | 14.0 | -34.9 | 33.0 | 15.3 | 1.5 | -13.5 | -2.0 | -2.6 |
| Growth/Shift Run | | | | | | | | | | | | |
| Agg.: Intermed. | -6.9 | -13.2 | -0.7 | -6.3 | 49.2 | -68.2 | 33.5 | 15.3 | -0.7 | -8.7 | -2.0 | -2.6 |
| Positive (no.) | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 3 | 2 | 0 | 0 | 0 |
| Negative (no.) | 3 | 3 | 3 | 3 | 0 | 3 | 0 | 0 | 1 | 3 | 3 | 3 |

# CHAPTER VI

## CONCLUSIONS

The objective of this dissertation has been to investigate how varying the amount and type of input data affects the information output of an agricultural information system. Using the conceptual framework of CRIES in the Dominican Republic, five systems of the Cibao Valley were prepared. The systems are intended to provide information to national planners concerned with the valley's agricultural production potential. One aspect of this area of concern -- the least costly way to meet crop requirements -- is the focus of this study. The information produced is the result of partial, non-comprehensive analysis. It is designed to meet some, but not all, of the user group's information needs.

Conceptually identical, the systems differ from one another only in terms of data inputs. Recall Figure 3-1. The real-world set of problems, the approaches of various disciplinary specialists to simplification, the means to operationalize these simplifications and the analyses undertaken are the same for all five systems. In addition, the intended user group -- policy analysts and planners concerned with the agricultural production potential of the Valley and its three Regions remain the same. The user is not as interested in the details of resource quality and use within the Regions as in the Regional location of important crops, in the Regional use of land for agriculture, in excess resource capacity, and in the ability of the Valley to meet domestic and export crop requirements. Since the Valley is treated as if it were a country, the hypothetical users are equivalent to national planners with a variety of backgrounds and experiences. With respect to

Figure 3-1, the necessary interaction between the user and other parts of the information system does not occur, and hence, the systems are incomplete.

The different information systems are as follows:

| | | |
|---|---|---|
| Detailed | - | a soil inventory was undertaken to identify 45 soil units (PPAs) classified as phases of soil families; crop yields were determined for each PPA. |
| Intermediated Weighted | - | a soil inventory was undertaken to identify 14 phases of soil subgroup PPAs; crop yields on these PPAs are weighted averages of the Detailed PPAs that compose each one. |
| Aggregate Weighted | - | 9 phases of soil great group PPAs were identified; crop yields on these PPAs are weighted averages of the Detailed PPAs. |
| Intermediate | - | crop yields on the 14 phases of soil subgroup PPAs are estimated independently from the Detailed estimates. |
| Aggregate | - | crop yields on the 9 phases of great group PPAs are estimated independently of the Detailed estimates. |

The differences in data do result in the production of different information. Although information output varies by system, no attempt is made to say which solution is better or worse. This can only be done by the user. L.P. solution values per se have limited utility due to the simplifying assumptions of L.P. and to the inability of the researcher to meet the four preconditions for maximization, see Chapter II. Model results, therefore, are used only to show ordinal differences between models.

First comparing soil maps, the Aggregate soil map (and then the Intermediate) would appear to best meet the user's decision-making needs. The map is legible and the scale could even be reduced before seriously harming legibility. The number of map units, 3, is the same as the number of socio-economic regions that result when the user defines his minimum area of interest. The reliability of soils data is lowest of the three inventories but so is the cost and time involved in surveying, doing laboratory analysis, and mapping. See Table 6-1.

It was first assumed that any of the soil inventories could be completed in one year. The author's experiences with agencies in several developing countries suggests that, due to administrative, logistical, and technical bottlenecks, this assumption underestimates the time needed for the more detailed inventories. It seems more reasonable, given the number of map delineations, to triple personnel time to 3 years, recall Table 5-3, in the Detailed inventory, and to increase personnel time 50 percent in the Intermediate inventory to 1.5 years. Per hectare costs would change. See Table 6-2. This change lends further support to selecting the Aggregate map.

Second, comparisons to a base solution, that of the Detailed model, are made in two groups in order to estimate aggregation error that results from measurement errors. The first involves the Intermediate Weighted and Aggregate Weighted solutions; the second involves the Intermediate and Aggregate solutions. As a result of system comparisons, summarized in Tables 6-1 and 6-3, statements about the relative acceptability of the systems by the user group are made.

Recall from Chapter II that the small, simple L.P. specified and run at three different levels of soil detail has a high level of specification error. This does not vary between the Detailed, Intermediate, or Aggregate levels. Measurement errors also occur at the Detailed level. Assuming these are not biased, aggregation to the more aggregate levels tends to reduce measurement error as

Table 6-1. -- Information Produced by the Detailed, Intermediate Weighted, and Aggregate Weighted Information Systems

| Item | Detailed System | Intermediate Weighted System | Aggregate Weighted System |
|---|---|---|---|
| Soil Inventory | | | |
| Data Collection | Most reliable basic soils data. | Reliability somewhat greater than Agg. | Least reliable basic soils data. |
| Map Legibility | | | |
| Average size of map units | 2,200 ha. | 20,200 ha. | 76,200 ha. |
| Units smaller than legibility minimum | 3 | 1 | 0 |
| Degree of map complexity | Complexity level somewhat greater than Int. | Least complex | Similar to the Int. |
| Smaller scale possible without unduly reducing legibility | Definitely | Definitely | Yes |
| Number of delineations (no.) | 95 | 11 | 3 |
| Map Units | | | |
| Amount of soils information | Most informative | Information between Det. and Agg. | Least informative |
| Purity of soils within any map unit | Purest - 19 consociations of 31 map units (61%) | Purity somewhat less than Detailed - 3 consociations of 7 (43%). | Least pure - 0 consociations |
| Reliability of boundaries | Greatest | Reliability somewhat greater than Agg. | Least |
| Cost | | | |
| Total | $570,000 (probably underestimated - see Table 6-2) | $175,000 (probably underestimated - see Table 6-2) | $55,000 |
| Per hectare | $2.28/ha. | $0.70/ha. | $0.22/ha. |

(continued)

Table 6-1. -- (cont'd.)

| | | | |
|---|---|---|---|
| **Linear Programming Models** | | | |
| Data Collection | | | |
| Reliability/region | Unknown reliability for area extents of crop-production method combinations, production and transport costs. The simple, aggregate nature of the L.P. structure common to all three models results in a high level of specification error (compared to some unspecified but more complex model).<br><br>Measurement errors may decrease with aggregation as unbiased errors tend to cancel. | | |
| Cost | Not estimated but for a given level of reliability would be greatest for Detailed, least for Aggregate Wt'd due to numbers of map units. | | |
| Solutions | | | |
| Amount of variation with respect to Detailed solutions | N.A. | In 13 of 18 instances has least Regional variations.[a] Total unsigned variation for 11 crops and idle area only is 516 percent in Benchmark.<br>In only 1 of 5 instances has least variation at Valley level.[b] | In only 5 of 18 instances has least Regional variation.[a] Total unsigned variation for 11 crops and idle area only is 1506 percent in Benchmark.<br>In 4 of 5 instances has least variation at Valley level.[b] |
| | | In general, variation of solutions is greater at the Regional level and closest to the Detailed solution at Valley level. Variations for parameters of crop area and production cost are greater than variation for crop production levels. | |
| Correspondence with Detailed solution shown by "U" Coefficient | N.A. | In general, correspondence for production is much closer than crop area and for the Valley than for Region values. | |
| | | Has lower U value in 11 of 18 instances for Regional area and production, but only 2 of 6 instances at Valley level. | Has lower U value only in 7 of 18 instances for Regional area and production, but 4 of 6 instances at Valley level. |

(continued)

Table 6-1. -- (cont'd.)

| | | | |
|---|---|---|---|
| Percentage bias with respect to Detailed solutions | N.A. | In general, the two models are positively biased for cultivated area and production cost and unbiased for production. In 34 of 54 instances they are positively biased at the Regional level and 17 of 18 times at the Valley level.[c] | |
| | | Least absolute (unsigned) bias at the Regional level (21 of 27 times) | Most absolute bias at the Regional level. |
| | | Most absolute bias at the Valley level. | Least absolute bias at the Valley level (9 of 9 times). |
| Objective function value with respect to Detailed solution | N.A. | | |
| Benchmark Run | | 5.2% or $3.9 million greater | 3.9% or $2.9 million greater |
| Growth Run | | 6.4% or $5.4 million greater | 5.4% or $4.7 million greater |

[a] 18 instances: (3 regions x 2 runs x 2 models x 3 parameters) - 2 = 18. The parameters are ranges of crop area, production, and production cost.

[b] 5 instances: (3 parameters x 2 runs x 2 models) - 2 = 6 less 1 tie = 5.

[c] 54 instances: (3 parameters x 3 runs x 2 models x 3 regions) = 54; 18 instances: (3 x 3 x 2 x 1) = 18.

Note: N.A. -- Not Applicable.

Table 6-2.-- Revised Soil Inventory Costs

| Inventory | Map Delineations | Initial Cost Assumptions | Revised Cost Estimates |
|---|---|---|---|
| | (no.) | ($/ha.) | |
| Detailed | 95 | 2.28 | 4.45 |
| Intermediate | 14 | 0.70 | 0.88 |
| Aggregate | 3 | 0.22 | 0.22 |

over- and underestimates tend to cancel out one another. To the extent that measurements at the Detailed level are biased, measurement error will increase along with aggregation. The net effect of aggregation error due to imperfect specifications and to inaccurate measurement is not known a priori but is shown by running the same L.P. model under different conditions.

Both specification and measurement errors are frequently encountered in building an L.P. This has been the case in each country in which CRIES has worked and is usually the case in U.S. studies. Primary data generation to determine representative crop production techniques, the extent of crop production techniques by political region and by soil type, and yield by technique and soil are examples of data that are needed for analysis and that can be reliably established only with statistical survey techniques at several points in time.

Statistical agronomic/economic surveys were not undertaken. Crop-production technique yields by soil type were ordinally estimated by a tropical agronomist. There was no reliable agronomic data from which to make estimates nor now was time-series data relating production, climate, soils or political regions available to infer relative productivity of different soils. Since Detailed crop yield estimates were not perfectly measured, their aggregation to Intermediate Weighted and to the Aggregate Weighted yield estimates resulted in measurement and aggregation errors. Crop yield estimates in the Intermediate and Aggregate inventories were based on progressively less soils data than in the Detailed inventory. Hence, their yield estimates are subject to greater variance

Table 6-3. -- Information Produced by the Detailed, Intermediate, and Aggregate Information Systems

| Item | Detailed System | Intermediate System | Aggregate System |
|---|---|---|---|
| **Soil Inventory** | See Table 6-1 | See table 6-1 | See Table 6-1 |
| **Linear Programming Models** | | | |
| Data Collection | | | |
| Crop yield estimates/ map unit | Unknown reliability but probably most accurate at the Detailed level due to the greater amount of soils information in the Detailed inventory; least accurate in the Aggregate inventory. | | |
| Other data/region | Unknown reliability but much specification error in this simple L.P. model comments all three systems. Measurement errors, if unbiased at the Detailed level tend to cancel out as aggregation proceeds. | | |
| Cost | Not estimated but for a given level of reliability would be greatest for the Detailed and least for the Aggregate due to the numbers of map units. | | |
| Solutions | | | |
| Yields bias with respect to Detailed yields | N.A. | Positive 79 out of 100 instances.[a] | Positive 61 out of 70 instances.[a] |
| Amount of variation with respect to Detailed solutions | N.A. | In only 5 of 18 instances has the least Regional variation.[b]* In 4 of 6 instances has the least variation at Valley level.[c]* | In 13 of 18 instances has the least Regional variation.[b]* In only 2 of 6 instances has the least variation at Valley level.[c]* |
| | | As with weighted models, Regional variation exceeds Valley variation. Variation ranges for production levels are often greater than those for crop area and production costs.* | |
| | | In comparison to the ranges of variation shown by the 2 weighted models, the non-weighted models have smaller ranges 21 of 36 times at the Regional level.[d]* However, at the Valley level, weighted models have less variation 8 of 12 times.* | |

(continued)

Table 6-3. -- (cont'd.)

| | | | |
|---|---|---|---|
| Correspondence with Detailed solution shown by "U" Coefficient | N.A. | Neither regional crop nor production seem to correspond more closely to the Detailed solution.* While Valley production does correspond more closely, the "U" Coefficient ranges from 0.7-1.1 indicating much difference.<br><br>Neither model consistently shows closer correspondence to the Detailed.* | |
| Percentage bias with respect to Detailed solutions | N.A. | In general, the two models were strongly negatively biased for crop area* and for production cost* and unbiased for production. In 41 of 54 instances they were negatively biased at the Regional level and 15 of 18 times at the Valley level.* | |
| | | Least absolute (unsigned) bias at both Regional and Valley levels. | Most absolute (unsigned) bias at both Regional and Valley levels. |
| Objective function value with respect to Detailed solution | N.A. | | |
| Benchmark Run | | 4.4% (or $3.2 million) less | 6.1% (or $4.5 million) less |
| Growth Run | | 6.4% (or $5.5 million) less | 8.7% (or $7.4 million) less |

*indicates a notable difference from the Detailed comparison with the weighted models. See Table 6-1.

[a]100 instances: 10 crops x 14 PPAs less 40 PPA - Crop situations with no yield estimate; 70 instances: 10 crops x 9 PPAs less 20 no yield situations.

[b]See Table 6-1 footnote a.

[c]See Table 6-1 footnote b.

[d]36 instances: (3 parameters x 2 models x 3 regions x 2 runs x 2 sets of models (Wt'd. and non-Wt'd.)) - 2 = 36.

Note: N.A. -- Not Applicable.

than the more detailed estimates. Similarly, aggregation of the Intermediate map unit-level land use inventory to Aggregate map units would possibly decrease measurement error; disaggregation of the Intermediate land use to Detailed map units would increase both types of error. Aggregation produces errors in each of the aggregated L.P.'s, but more error in the Intermediate and Aggregate L.P.'s than in the Intermediate Weighted and Aggregate Weighted L.P.'s. However, the aggregated L.P.'s are progressively less costly and less time-consuming to build.

The user is interested in Regional location, production, and costs of specific crops. Other things being equal, the Intermediate Weighted model would be preferable to the Aggregate Weighted model since in 13 of 18 instances its solution values were closest to the Detailed solution, the base model for comparison. Furthermore, for one parameter, crop area, total unsigned variation from the Detailed Regional values is only one-third the variation resulting from the Aggregate Weighted solution. This preference must be tentative in view of the very large variations from the Detailed solutions that occur for some crops. For example, area of plantain in the West is 36 percent greater than the Detailed solution value; interplanted area in the East is 62 percent greater. In general, the large values of the Theil coefficient indicated a lack of correspondence among solution values of all three models.

Objective function values for the three models are very close. That is, the "most efficient" cropping patterns of the two aggregate weighted models had associated costs of just 4-6 percent greater than the Detailed model.

Comparisons of the Detailed with the Intermediate and Aggregate models entailed using "independent" yield estimates in the three models. Given the lower reliability of soils data in the Intermediate and, even lower, in the Aggregate inventory, it is concluded that the yield estimates are subject to progressively more measurement error in the aggregated models. Recall that yield estimates in both unweighted models with respect to the Detailed yield estimates have a strong positive bias. This positive bias has the direct effect of producing a negative bias in solution values for crop area and production cost. The use of these estimates changed the bias of their L.P. solutions (with respect to the Detailed model solution for crop areas) from positive to strongly and consistently negative.

The Aggregate model may appear most suited to the user's needs since it is the least costly to generate data for and to construct. It also most often (13 of 18 times) has the least variation with respect to Regional Detailed solutions of crop area, production, and costs and has an Objective Function value 6-9 percent below that of the Detailed model. However, it may not be preferable to the Intermediate model due to its less accurate crop yields. Therefore, preference for the Intermediate model's information could derive from its more accurate crop yields, from the fact that it has the smallest amount of absolute (unsigned) bias with respect to the Detailed Regional and Valley solutions, and third, from its ability to produce an optimum solution 4-6 percent less than that of the Detailed model.

In comparison to the ranges of variation around Detailed solutions shown by the two weighted models, the non-weighted models have smaller ranges 21 of 36 times at the Regional level. This should not be interpreted as producing a smaller amount of aggregation error. It does show how measurement errors can significantly affect results. Given this sensitivity to yields, one building such a system ought to obtain approximately consistent levels of reliability between parameters. This certainly did not occur in the Detailed system where physical and spatial soils information was more reliable than the yield estimates. It may, or may not, have occurred for the more aggregated systems.

A final note on costs supports constructing systems more aggregated than the Detailed. It is reasonable to assume that the variable costs of generating such data at a given level of reliability and of preparing data in the format necessary for the L.P. algorithm would also be at least directly proportional to the number of map delineations. The least cost and time would be incurred in generating the Aggregate (and then the Intermediate) data set. Assuming that the agronomic/economic surveys could begin once the soil mapping was one-half completed, a total time requirement for all surveys, analyses, and publication of results could require 4.5 years (Detailed), 2.3 years (Intermediate), and 1.5 years (Aggregate). Including L.P. analyses and report writing, total study time could then require approximately 5, 3, and 2 years respectively, and costs of $2.23 million, $0.44 million, and $0.11 million, respectively.

As stated repeatedly in this dissertation, the utility of any one information system can only be determined by the user. In view of the relatively long time and high cost of the Detailed soil inventory — linear programming system, the ability of L.P. to provide only a limited amount of information on the subject matter under analysis, and the interest of the user in information about just three regions, it seems obvious that the user would prefer one of the more aggregated information systems. A clear choice between the Intermediate or Aggregate system could be made only by the user. He would give priority either to cost-time considerations or less aggregation error.

## Recommendations

Possibly the most general and most important recommendation that can be made is that the resource specialist(s) building the information system be objective. That is, that the system be logically consistent; that its assumptions, relationships between parameters, data inputs, and information outputs correspond, not totally but in important ways, to reality; that the conceptual approach and use of analytical tools be clear; and, that it produce information which will assist the user develop/modify policies relevant to his area of concern or to a specific problem. To accomplish this, it is suggested that the resource team periodically work through steps of a process such as shown in Figure 3-1.

Second, it is recommended that this process work be done with the user or his representative. The team should clarify the user's perception of the area of concern and his needs and values in this regard. Discussion of the type of information produced in previous studies of similar resource issues would help the team and user strengthen each of the linkages in the process of Figure 3-1. For example, if an L.P. of the type structured in this dissertation was one of the analytical tools under consideration, discussion with the user of the strengths and weaknesses of L.P. in this subject-matter research would improve the credibility of the team's recommendations.

Third, it is recommended that future research regarding the appropriateness of alternative models for analyses of agricultural production potential focus upon the values, perceptions of production potentials, and needs of various kinds of user groups. This should be the focus rather than on means to reduce and/or control aggregation errors. First, cost and timeliness considerations and the ability to make informed statements about only his minimum geographic regions of interest may be very important to the decision-maker. Second, since it will always be impossible to specify perfectly relationships among important parameters -- edafological, agronomic, economic, social, and so forth -- aggregation of large into small models will increase aggregation error. In the face of almost always unreliable data from secondary sources and the possibly prohibitive costs of generating primary data with a known reliability, measurement errors will exist even in large and complex models. Depending upon the amount of measurement bias that exists, aggregation will lead to growing amounts of measurement and hence aggregation error. Finally, even if specification and measurement errors could be avoided, it would be impossible, in practical terms, to meet Day's homogeneity conditions to aggregate without error.

A final recommendation is that researchers avoid developing highly reliable estimates for one parameter, e.g., soil area and type, and much less or unknown reliability for other parameters, e.g., crop yield by soil-climate type. Not to do so precludes developing an internally consistent system and one whose results will correspond to reality. System results may be costly in that their reliability is unknown. Given these concerns, the team should attempt to determine, from previous studies or a hypothetical model of the work under discussion with the user, the parameters to which production of information is the most sensitive. Similar levels of reliability should be developed for each of these key parameters. This may mean achieving much lower reliability levels for some parameters than currently occurs in many studies.

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# APPENDIX

Table A-1. -- Measured Areas of Soil Map Units

| Detailed Map Unit No. | Detailed Map Unit (km²) | Intermediate Map Unit No. | Intermediate Map Unit (km²) | Aggregate Map Unit No. | Aggregate Map Unit (km²) |
|---|---|---|---|---|---|
| 1 | 71.9333 | A | 282.2585 | I | 302.6215 |
| 2 | 37.8478 | B | 1008.8568 | II | 1526.1653 |
| 3 | 54.9364 | C | 242.7887 | III | 457.5544 |
| 4 | 30.3693 | D | 23.9850 | | |
| 5 | 109.8743 | E | 571.1855 | | |
| 6 | 607.4416 | F | 33.8481 | | |
| 7 | 98.1878 | G | 58.4022 | | |
| 8 | 87.1817 | | | | |
| 9 | 23.5748 | | | | |
| 10 | 29.2654 | | | | |
| 11 | 37.7887 | | | | |
| 12 | 6.4423 | | | | |
| 13 | 8.0943 | | | | |
| 14 | 50.8096 | | | | |
| 15 | 37.2069 | | | | |
| 16 | 13.6180 | | | | |
| 17 | 29.2592 | | | | |
| 18 | 29.1648 | | | | |
| 19 | 11.2257 | | | | |
| 20 | 162.4731 | | | | |
| 21 | 15.5636 | | | | |
| 22 | 19.7731 | | | | |
| 23 | 18.4843 | | | | |
| 24 | 70.5966 | | | | |
| 25 | 19.4060 | | | | |
| 26 | 49.9989 | | | | |
| 27 | 176.2529 | | | | |
| 28 | 45.6754 | | | | |
| 29 | 84.6362 | | | | |
| 30 | 41.4802 | | | | |
| 31 | 100.9671 | | | | |
| Total Area | 2179.5303 | | 2221.3248 | | 2286.3412 |

Table A-2. -- Measured Area Estimates of Intermediate PPAs

| Map Unit | PPA | Measured Map Unit Area (Ha.) | Percent of Map Unit (%) | Percentage Adjusted for Inclusions (%) | PPA Area (Ha.) | Idle[a] (Ha.) | PPA Active Cropland (Ha.) |
|---|---|---|---|---|---|---|---|
| A | | 28,226 | | | | | |
| | A1 | | 50 | 55 | 15,524 | 3,105 | 12,419 |
| | A2 | | 20 | 22 | 6,210 | 1,242 | 4,968 |
| | A3 | | 20 | 23 | 6,492 | 1,298 | 5,194 |
| | Inclusions | | 10 | -- | | | |
| B | | 100,886 | | | | | |
| | B1 | | 80 | 100 | 100,886 | 20,177 | 80,709 |
| | Inclusions | | 20 | -- | | | |
| C | | 24,279 | | | | | |
| | C1 | | 70 | 100 | 24,279 | 4,586 | 19,423 |
| | Inclusions | | 30 | -- | | | |
| D | | 2,399 | | | | | |
| | D1 | | 80 | 100 | 2,399 | 480 | 1,919 |
| | Inclusions | | 20 | -- | | | |
| E | | 57,119 | | | | | |
| | E1 | | 60 | 75 | 42,839 | 8,568 | 34,271 |
| | E2 | | 10 | 12 | 6,854 | 1,371 | 5,483 |
| | E3 | | 10 | 13 | 7,425 | 1,485 | 5,940 |
| | Inclusions | | 20 | -- | | | |
| F | | 3,385 | | | | | |
| | F1 | | 40 | 50 | 1,693 | 339 | 1,354 |
| | F2 | | 40 | 50 | 1,692 | 338 | 1,354 |
| | Inclusions | | 20 | -- | | | |
| G | | 5,840 | | | | | |
| | G1 | | 50 | 59 | 3,446 | 689 | 2,756 |
| | G2 | | 20 | 23 | 1,343 | 269 | 1,075 |
| | G3 | | 15 | 18 | 1,051 | 210 | 841 |
| | Inclusions | | 15 | -- | | | |
| | | 222,134 | | | 222,134 | 44,426 | 177,709 |

[a] Assume idle is 20% of total PPA area

Table A-3. -- Measured Area Estimates of Aggregate PPAs

| Map Unit | PPA | Measured Map Unit Area (Ha.) | Percent of Map Unit (%) | Percentage Adjusted for Inclusions (%) | PPA Area (Ha.) | Idle (Ha.) | PPA Active Cropland (Ha.) |
|---|---|---|---|---|---|---|---|
| I | | 30,262 | | | | | |
| | I1 | | 50 | 56 | 16,946.72 | 3,389.34 | 13,557.38 |
| | I2 | | 20 | 22 | 6,657.64 | 1,331.53 | 5,326.11 |
| | I3 | | 20 | 22 | 6,657.64 | 1,331.53 | 5,326.11 |
| | Inclusions | | 10 | -- | | | |
| II | | 152,617 | | | | | |
| | II1 | | 60 | 75 | 114,462.75 | 22,892.55 | 91,570.20 |
| | II2 | | 10 | 12 | 18,314.04 | 3,662.81 | 14,651.23 |
| | II3 | | 10 | 13 | 19,840.21 | 3,968.04 | 15,872.17 |
| | Inclusions | | 20 | -- | | | |
| III | | 45,755 | | | | | |
| | III1 | | 60 | 75 | 34,316.25 | 6,863.25 | 27,453.00 |
| | III2 | | 10 | 12 | 5,490.60 | 1,098.12 | 4,392.48 |
| | III3 | | 10 | 13 | 5,948.15 | 1,189.63 | 4,758.52 |
| | Inclusions | | 20 | -- | | | |
| Total Area | | 228,634 | | | 228,634.00 | 45,726.80 | 182,907.20 |

Table A-4. -- Measured Area Estimates of Detailed PPAs

| Map Unit Number | PPA | Measured Map Unit Area[a] (Hectare) | PPA Percent of Map Unit (%) | PPA Area[a] (Hectare) |
|---|---|---|---|---|
| 01 | | 7,193 | ... | ... |
| | 011 | ... | 75 | 5,395 |
| | 012 | ... | 10 | 719 |
| | 013 | ... | 15 | 1,079 |
| 02 | 021 | 3,785 | 100 | 3,785 |
| 03 | 031 | 5,494 | 100 | 5,494 |
| 04 | | 3,037 | ... | ... |
| | 041 | ... | 80 | 2,430 |
| | 042 | ... | 20 | 607 |
| 05 | 051 | 10,987 | 100 | 10,987 |
| 06 | 061 | 60,744 | 100 | 60,744 |
| 07 | | 9,819 | ... | ... |
| | 071 | ... | 65 | 6,382 |
| | 072 | ... | 35 | 3,437 |
| 08 | 081 | 8,718 | 100 | 8,718 |
| 09 | | 2,357 | ... | ... |
| | 091 | ... | 35 | 825 |
| | 092 | ... | 65 | 1,532 |
| 10 | 101 | 2,927 | 100 | 2,927 |
| 11 | 111 | 3,779 | 100 | 3,779 |
| 12 | 121 | 644 | 100 | 644 |
| 13 | 131 | 809 | 100 | 809 |
| 14 | 141 | 5,081 | 100 | 5,081 |
| 15 | 151 | 3,721 | 100 | 3,721 |
| 16 | 161 | 1,362 | 100 | 1,362 |
| 17 | 171 | 2,926 | 100 | 2,926 |
| 18 | 181 | 2,916 | 100 | 2,916 |
| 19 | 191 | 1,123 | 100 | 1,123 |
| 20 | 201 | 16,247 | 100 | 16,247 |
| 21 | 211 | 1,556 | 100 | 1,556 |
| 22 | 221 | 1,977 | 100 | 1,977 |
| 23 | | 1,848 | ... | ... |
| | 231 | ... | 80 | 1,478 |
| | 232 | ... | 20 | 370 |
| 24 | | 7,060 | ... | ... |
| | 241 | ... | 60 | 4,236 |
| | 242 | ... | 40 | 2,824 |
| 25 | 251 | 1,941 | 100 | 1,941 |
| 26 | | 5,000 | ... | ... |
| | 261 | ... | 60 | 3,000 |
| | 262 | ... | 40 | 2,000 |
| 27 | | 17,625 | ... | ... |
| | 271 | ... | 75 | 13,219 |
| | 272 | ... | 25 | 4,406 |

(continued)

Table A-4. -- (cont'd.)

| Map Unit Number | PPA | Measured Map Unit Area[a] (Hectare) | PPA Percent of Map Unit (%) | PPA Area[a] (Hectare) |
|---|---|---|---|---|
| 28 | | 4,568 | ... | ... |
| | 281 | ... | 60 | 2,741 |
| | 282 | ... | 40 | 1,827 |
| 29 | | 8,463 | ... | ... |
| | 291 | ... | 50 | 4,231 |
| | 292 | ... | 50 | 4,232 |
| 30 | | 4,148 | ... | ... |
| | 301 | ... | 50 | 2,074 |
| | 302 | ... | 50 | 2,074 |
| 31 | | 10,097 | ... | ... |
| | 311 | ... | 33 | 3,332 |
| | 312 | ... | 33 | 3,332 |
| | 313 | ... | 34 | 3,433 |
| | | 217,952 | | 217,952 |

[a]The total 217,952 hectares differ from the 2179.5303 $km^2$ in Appendix A-1 due to rounding error.

Table A-5.-- Detailed PPA Measured Areas Normalized to Intermediate PPA Measured Areas

| Intermediate PPA | | Detailed PPA | | | | Meas'd. Int. Area | Normalized | Int. Area |
|---|---|---|---|---|---|---|---|---|
| No. | Measured Area (Ha.) | No. | Region | Percent (%) | Measured Area (Ha.) | Meas'd. Det. Area | Detailed Area (Ha.) | to Detailed Area (%) |
| A1 | 15,524 | 011 | E | 100.0 | 5,395 | 0.9090 | 4,904.0 | 31.6 |
| | | 012 | E | 100.0 | 719 | | 653.6 | 4.2 |
| | | 013 | E | 100.0 | 1,079 | | 980.0 | 6.3 |
| | | 021 | E | 100.0 | 3,785 | | 3,440.6 | 22.2 |
| | | 031 | E | 100.0 | 5,494 | | 4,994.0 | 32.1 |
| | | 042 | E | 100.0 | 607 | | 551.8 | 3.6 |
| | | | | | 17,079 | | 15,524.0 | 100.0 |
| A2 | 6,210 | 041 | E | 100.0 | 2,430 | 0.5056 | 1,228.6 | 19.8 |
| | | 051 | E | 100.0 | 5,493 | | 2,777.5 | 44.7 |
| | | 081 | E | 100.0 | 4,359 | | 2,203.9 | 35.5 |
| | | | | | 12,282 | | 6,210.0 | 100.0 |
| A3 | 6,492 | 101 | E | 100.0 | 2,927 | 2.2180 | 6,492.0 | 100.0 |
| | | | | | | | 6,492.0 | 100.0 |
| B1 | 100,886 | 051 | E | 100.0 | 5,493 | 1.1578 | 6,360.0 | 6.3 |
| | | 061 | E | 92.7 | 56,310 | | 65,194.4 | 64.5 |
| | | 061 | C | 7.3 | 4,434 | | 5,133.7 | 5.1 |
| | | 071 | E | 90.3 | 5,763 | | 6,672.4 | 6.6 |
| | | 071 | C | 9.7 | 619 | | 716.7 | 0.7 |
| | | 072 | E | 90.3 | 3,104 | | 3,593.8 | 3.6 |
| | | 072 | C | 9.7 | 333 | | 385.5 | 0.4 |
| | | 081 | E | 100.0 | 4,359 | | 5,046.9 | 5.0 |
| | | 091 | E | 90.0 | 743 | | 860.2 | 0.9 |
| | | 091 | C | 10.0 | 82 | | 94.9 | 0.1 |
| | | 092 | E | 90.0 | 1,379 | | 1,596.6 | 1.6 |
| | | 092 | C | 10.0 | 153 | | 177.1 | 0.2 |

(continued)

Table A-5. -- (cont'd.)

| Intermediate PPA | | Detailed PPA | | | | Meas'd. Int. Area | Normalized | Int. Area |
|---|---|---|---|---|---|---|---|---|
| No. | Measured Area (Ha.) | No. | Region | Percent (%) | Measured Area (Ha.) | Meas'd. Det. Area | Detailed Area (Ha.) | to Detailed Area (%) |
| | | 121 | W | 100.0 | 644 | | 745.6 | 0.7 |
| | | 151 | C | 100.0 | 3,721 | | 4,308.2 | 4.3 |
| | | | | | 87,137 | | 100,886.0 | 100.0 |
| C1 | 24,279 | 131 | C | 100.0 | 809 | 0.9565 | 773.8 | 3.2 |
| | | 161 | W | 18.1 | 247 | | 236.3 | 1.0 |
| | | 161 | C | 81.9 | 1,115 | | 1,066.5 | 4.4 |
| | | 171 | E | 45.0 | 1,317 | | 1,259.7 | 5.2 |
| | | 171 | C | 55.0 | 1,609 | | 1,539.0 | 6.3 |
| | | 181 | W | 45.5 | 1,327 | | 1,269.3 | 5.2 |
| | | 181 | C | 54.5 | 1,589 | | 1,520.0 | 6.3 |
| | | 191 | W | 3.3 | 37 | | 35.4 | 0.1 |
| | | 191 | C | 96.7 | 1,086 | | 1,038.8 | 4.3 |
| | | 201 | W | 22.6 | 3,672 | | 3,512.2 | 14.5 |
| | | 201 | C | 77.4 | 12,575 | | 12,028.0 | 49.5 |
| | | | | | 25,383 | | 24,279.0 | 100.0 |
| D1 | 2,399 | 221 | W | 100.0 | 1,977 | 1.2135 | 2,399.0 | 100.0 |
| | | | | | 1,977 | | 2,399.0 | 100.0 |
| E1 | 42,839 | 262 | W | 100.0 | 2,000 | 1.5071 | 3,014.2 | 7.0 |
| | | 271 | W | 100.0 | 13,219 | | 19,923.5 | 46.6 |
| | | 272 | W | 100.0 | 4,406 | | 6,640.3 | 15.5 |
| | | 281 | W | 100.0 | 2,741 | | 4,131.0 | 9.6 |
| | | 282 | W | 100.0 | 1,827 | | 2,753.5 | 6.4 |
| | | 291 | W | 100.0 | 4,231 | | 6,376.5 | 14.9 |
| | | | | | 28,424 | | 42,839.0 | 100.0 |
| E2 | 6,854 | 141 | W | 97.6 | 4,959 | 1.3489 | 6,689.2 | 97.6 |
| | | 141 | C | 2.4 | 122 | | 164.8 | 2.4 |
| | | | | | 5,081 | | 6,854.0 | 100.0 |

(continued)

Table A-5. -- (cont'd.)

| Intermediate PPA | | Detailed PPA | | | | Meas'd. Int. Area / Meas'd. Det. Area | Normalized Detailed Area (Ha.) | Int. Area to Detailed Area (%) |
|---|---|---|---|---|---|---|---|---|
| No. | Measured Area (Ha.) | No. | Region | Percent (%) | Measured Area (Ha.) | | | |
| E3 | 7,425 | 111 | W | 100.0 | 3,779 | 0.3171 | 1,198.3 | 16.1 |
| | | 211 | W | 100.0 | 1,556 | | 493.4 | 6.6 |
| | | 231 | W | 100.0 | 1,478 | | 468.7 | 6.3 |
| | | 232 | W | 100.0 | 370 | | 117.3 | 1.6 |
| | | 241 | W | 100.0 | 4,236 | | 1,343.0 | 18.1 |
| | | 242 | W | 100.0 | 2,824 | | 895.5 | 12.1 |
| | | 251 | W | 100.0 | 1,941 | | 615.5 | 8.3 |
| | | 261 | W | 100.0 | 3,000 | | 951.3 | 12.8 |
| | | 292 | W | 100.0 | 4,232 | | 1,342.0 | 18.1 |
| | | | | | 23,416 | | 7,425.0 | 100.0 |
| F1 | 1,693 | 301 | C | 100.0 | 2,074 | 0.8163 | 1,693.0 | 100.0 |
| | | | | | 2,074 | | 1,693.0 | 100.0 |
| F2 | 1,692 | 302 | C | 100.0 | 2,074 | 0.8158 | 1,692.0 | 100.0 |
| | | | | | 2,074 | | 1,692.0 | 100.0 |
| G1 | 3,446 | 311 | W | 87.8 | 2,925 | 1.0342 | 3,025.0 | 87.8 |
| | | 311 | C | 12.2 | 407 | | 421.0 | 12.2 |
| | | | | | 3,332 | | 3,446.0 | 100.0 |
| G2 | 1,343 | 312 | W | 87.8 | 2,925 | 0.4031 | 1,179.1 | 87.8 |
| | | 312 | C | 12.2 | 407 | | 163.9 | 12.2 |
| | | | | | 3,332 | | 1,343.0 | 100.0 |
| G3 | 1,051 | 313 | W | 87.8 | 3,014 | 0.3061 | 922.5 | 87.8 |
| | | 313 | C | 12.2 | 419 | | 128.5 | 12.2 |
| | | | | | 3,433 | | 1.051.0 | 100.0 |
| Total | 222,133 | | | | | | 222,133.0 | |

Table A-6. -- Allocators of Intermediate PPA Areas to Aggregate PPA Normalized Areas

| Intermediate PPA No. | Intermediate PPA Measured Area (Ha.) | Percent to Aggregate PPA (%) | Aggregate PPA No. | Aggregate PPA Normalized Area (Ha.) |
|---|---|---|---|---|
| A1 | 15,524 | 100.0 | I1 | 15,524.0 |
| | | 100.0 | | 15,524.0 |
| A2 | 2,210 | 19.8 | I1 | 1,228.6 |
| | | 80.2 | I2 | 4,981.4 |
| | | 100.0 | | 6,210.0 |
| A3 | 6,492 | 100.0 | I3 | 6,492.0 |
| B1 | 100,886 | 89.8 | II1 | 90,593.9 |
| | | 6.4 | II2 | 6,502.4 |
| | | 3.8 | II3 | 3,789.7 |
| | | 100.0 | | 100,886.0 |
| C1 | 24,279 | 100.0 | II2 | 24,279.0 |
| D1 | 2,399 | 100.0 | III3 | 2,399.0 |
| E1 | 42,839 | 100.0 | III1 | 42,839.0 |
| E2 | 6,854 | 100.0 | III2 | 6,854.0 |
| E3 | 7,425 | 100.0 | III3 | 7,425.0 |
| F1 | 1,693 | 100.0 | II3 | 1,693.0 |
| F2 | 1,692 | 100.0 | II2 | 1,692.0 |
| G1 | 3,446 | 50.0 | I3 | 1,723.0 |
| | | 50.0 | II3 | 1,723.0 |
| | | 100.0 | | 3,446.0 |
| G2 | 1,343 | 50.0 | I3 | 671.5 |
| | | 50.0 | II3 | 671.5 |
| | | 100.0 | | 1,343.0 |
| G3 | 1,051 | 50.0 | I3 | 525.5 |
| | | 50.0 | II3 | 525.5 |
| | | 100.0 | | 1,051.0 |
| Total | 222,133 | | | 222,133.0 |

Table A-7. -- Normalized Areas of Aggregate PPAs and Regions

| Aggregate PPA No. | Normalized Area (Ha.) | | Regions East (Ha.) | | Central | | West | | Total |
|---|---|---|---|---|---|---|---|---|---|
| I1 | 16,752.6 | | 16,752.6 | | - | | - | | 16,752.6 |
| I2 | 4,981.4 | | 4,981.4 | | - | | - | | 4,981.4 |
| I3 | 9,412.0 | | 6,588.4 | | - | | 2,823.6 | | 9,412.0 |
| II1 | 90,593.9 | | 89,869.1 | | 724.8 | | - | | 90,593.9 |
| II2 | 32,473.4 | | 1,266.5 | | 26,173.6 | | 5,033.3 | | 32,473.4 |
| II3 | 8,402.7 | | - | | 5,487.0 | | 2,915.7 | | 8,402.7 |
| III1 | 42,839.0 | | - | | - | | 42,839.0 | | 42,839.0 |
| III2 | 6,854.0 | | - | | 164.5 | | 6,689.5 | | 6,854.0 |
| III3 | 9,824.0 | | - | | - | | 9,824.0 | | 9,824.0 |
| Total | 222,133.0 | = | 119,458.0 | + | 32,549.9 | + | 70,125.1 | = | 222,133.0 |

Table A-8. -- Allocators of Intermediate PPAs to Regions

| Intermediate PPA | Regions East (%) | Central (%) | West (%) | Total (%) |
|---|---|---|---|---|
| A1 | 100.0 | - | - | 100.0 |
| A2 | 100.0 | - | - | 100.0 |
| A3 | 100.0 | - | - | 100.0 |
| B1 | 89.1 | 10.2 | 0.7 | 100.0 |
| C1 | 5.2 | 74.0 | 20.8 | 100.0 |
| D1 | - | - | 100.0 | 100.0 |
| E1 | - | - | 100.0 | 100.0 |
| E2 | - | 2.4 | 97.6 | 100.0 |
| E3 | - | - | 100.0 | 100.0 |
| F1 | - | 100.0 | - | 100.0 |
| F2 | - | 100.0 | - | 100.0 |
| G1 | - | 12.2 | 87.8 | 100.0 |
| G2 | - | 12.2 | 87.8 | 100.0 |
| G3 | - | 12.2 | 87.8 | 100.0 |

Table A-9. -- Intermediate PPA Cropland Use, Field Estimates

(% of Active Cropland)[a]

| | Intermediate PPAs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop | A1 | A2 | A3 | B1 | C1 | D1 | E1 | E2 | E3 | F1 | F2 | G1 | G2 | G3 |
| Rice | 80 | 5 | 45 | -- | -- | -- | 25 | 50 | 50 | 10 | 80 | 50 | 70 | -- |
| Annuals[b] | 10 | 5 | 10 | 90 | 10 | -- | -- | -- | -- | -- | -- | -- | 5 | 10 |
| Pasture | -- | 90 | 45 | -- | -- | 100 | 10 | 10 | 10 | 20 | 10 | -- | 5 | 10 |
| Cocoa | 10 | -- | -- | 10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tobacco | -- | -- | -- | -- | 90 | -- | -- | 10 | 10 | 20 | -- | -- | -- | -- |
| Plantain | -- | -- | -- | -- | -- | -- | 35 | 15 | 15 | 50 | 10 | 50 | 20 | 80 |
| Banana | -- | -- | -- | -- | -- | -- | 10 | 5 | 5 | -- | -- | -- | -- | -- |
| Sugar Cane | -- | -- | -- | -- | -- | -- | 20 | 10 | 10 | -- | -- | -- | -- | -- |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

[a]PPAs A and B roughly correspond to the East Region; C and F to the Central; and D and E to the West.

[b]In the East only is there intercropping; 30% of annuals are intercropped. This includes tobacco, plantain, corn, beans, yucca, and sweet potatoes.

Table A-10. -- Allocation of Crop Areas to Intermediate PPAs

| Crop | Intermediate PPA: A1 Percent of Active Cropland (%) | A1 Cropland (Ha.) | A1 Crops (Ha.) | A2 Percent of Active Cropland (%) | A2 Cropland (Ha.) | A2 Crops (Ha.) | A3 Percent of Active Cropland (%) | A3 Cropland (Ha.) | A3 Crops (Ha.) | Map Unit Total (Ha.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Idle | -- | 3,105 | -- | -- | 1,242 | -- | -- | 1,298 | -- | 5,645 |
| Active Cropland | -- | 12,419 | -- | -- | 4,968 | -- | -- | 5,194 | -- | 22,581 |
| Pasture | 0 | -- | 0 | 90 | -- | 4,472 | 45 | -- | 2,337 | 6,809 |
| Rice | 80 | -- | 9,935 | 5 | -- | 248 | 45 | -- | 2,337 | 12,520 |
| Cocoa | 10 | -- | 1,242 | 0 | -- | 0 | 0 | -- | 0 | 1,242 |
| Annuals | 10 | -- | 1,242 | 5 | -- | 248 | 10 | -- | 520 | 2,010 |
| | 100 | 15,524 | 12,419 | 100 | 6,210 | 4,968 | 100 | 6,492 | 5,194 | 28,226 |
| Distribution of Annuals[a] | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | (Ha.) |
| Intercropped | 30 | -- | 373 | 30 | -- | 75 | 30 | -- | 156 | 604 |
| Planted Alone | 70 | -- | -- | 70 | -- | -- | 70 | -- | -- | -- |
| Yucca | 21.0 | -- | 261 | 21.0 | -- | 52 | 21.0 | -- | 109 | 422 |
| Corn | 17.5 | -- | 217 | 17.5 | -- | 43 | 17.5 | -- | 91 | 351 |
| Plantain | 10.5 | -- | 130 | 10.5 | -- | 26 | 10.5 | -- | 55 | 211 |
| Sweet Potatoes | 10.5 | -- | 130 | 10.5 | -- | 26 | 10.5 | -- | 55 | 211 |
| Beans | 10.5 | -- | 131 | 10.5 | -- | 26 | 10.5 | -- | 54 | 211 |
| | | 1,242 | 1,242 | | 248 | 248 | | 520 | 520 | 2,010 |

[a]Intermediate Map Units A, B, and G support "annuals" grown alone (70%) as well as grown intercropped (30%). The composition of the intercropped areas is: 20.0% plantain, 15% corn, 12.5% yucca, 10% sweet potatoes, 37.5% beans and 5% tobacco. The relative importance of individual crops planted alone is: 30% yucca, 25% corn, 15% each in plantain, sweet potatoes and beans.

(continued)

Table A-10. -- (cont'd.)

| Crop | B1 Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) |
|---|---|---|---|
| Idle | -- | 20,177 | -- |
| Active Cropland | -- | 80,709 | -- |
| Annuals | 90 | -- | 72,638 |
| Cocoa | 10 | -- | 8,071 |
| | 100 | 100,886 | 80,709 |
| Distribution of Annuals[a] | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) |
| Intercropped | 30 | -- | 21,791 |
| Planted Alone | 70 | -- | -- |
| Yucca | 21.0 | -- | 15,254 |
| Corn | 17.5 | -- | 12,712 |
| Plantain | 10.5 | -- | 7,627 |
| Sweet Potatoes | 10.5 | -- | 7,627 |
| Beans | 10.5 | -- | 7,627 |
| | 100 | 72,638 | 72,638 |

(continued)

Table A-10. -- (cont'd.)

| Crop | C1 | | |
|---|---|---|---|
| | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) |
| Idle | -- | 4,856 | -- |
| Active Cropland | -- | 19,423 | -- |
| Annuals | 10 | -- | 1,942 |
| Tobacco | 90 | -- | 17,481 |
| | 100 | 24,279 | 19,423 |
| Corn | 12.5 | -- | 243 |
| Beans | 12.5 | -- | 243 |
| Yucca | 12.5 | -- | 243 |
| Sweet Potatoes | 12.5 | -- | 243 |
| Plantain | 12.5 | -- | 243 |
| Tobacco | 12.5 | -- | 243 |
| Rice | 12.5 | -- | 243 |
| Sugar Cane | 12.5 | -- | 241 |
| | 100 | 1,942 | 1,942 |

| Crop | D1 | | |
|---|---|---|---|
| | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) |
| Idle | -- | 480 | -- |
| Active Cropland | -- | 1,919 | -- |
| Pasture | 100 | -- | 1,919 |
| | 100 | 2,399 | 1,919 |

(continued)

Table A-10. -- (cont'd.)

| Crop | Intermediate PPA | | | | | | | | | Map Unit Total (Ha.) |
|---|---|---|---|---|---|---|---|---|---|---|
| | E1 | | | E2 | | | E3 | | | |
| | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | |
| Idle | -- | 8,568 | -- | -- | 1,371 | -- | -- | 1,485 | -- | 11,424 |
| Active Cropland | -- | 34,271 | -- | -- | 5,483 | -- | -- | 5,940 | -- | 45,694 |
| Rice | 25 | -- | 8,568 | 50 | -- | 2,742 | 50 | -- | 2,970 | 14,280 |
| Plantain | 35 | -- | 11,994 | 15 | -- | 822 | 15 | -- | 891 | 13,707 |
| Banana | 10 | -- | 3,427 | 5 | -- | 274 | 5 | -- | 297 | 3,998 |
| Sugar Cane | 20 | -- | 6,854 | 10 | -- | 548 | 10 | -- | 594 | 7,996 |
| Pasture | 10 | -- | 3,428 | 10 | -- | 548 | 10 | -- | 594 | 4,570 |
| Tobacco | -- | -- | -- | 10 | -- | 549 | 10 | -- | 594 | 1,143 |
| | 100 | 42,839 | 34,271 | 100 | 6,854 | 5,483 | 100 | 7,425 | 5,940 | 57,118 |

(continued)

Table A-10. -- (cont'd.)

| Crop | F1 | | | F2 | | | |
|---|---|---|---|---|---|---|---|
| | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Map Unit Total (Ha.) |
| Idle | -- | 339 | -- | -- | 339 | -- | 678 |
| Active Cropland | -- | 1,354 | -- | -- | 1,353 | -- | 2,707 |
| Rice | 10 | -- | 135 | 80 | -- | 1,082 | 1,217 |
| Tobacco | 20 | -- | 270 | -- | -- | -- | 270 |
| Plantain | 50 | -- | 677 | 10 | -- | 135 | 812 |
| Pasture | 20 | -- | 272 | 10 | -- | 136 | 408 |
| | 100 | 1,693 | 1,354 | 100 | 1,692 | 1,353 | 6,092 |

(continued)

Table A-10. -- (cont'd.)

| | Intermediate PPA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | G1 | | | G2 | | | G3 | | | |
| Crop | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Percent of Active Cropland (%) | Cropland (Ha.) | Crops (Ha.) | Map Unit Total (Ha.) |
| Idle | -- | 689 | -- | -- | 269 | -- | -- | 210 | -- | 1,168 |
| Active Cropland | -- | 2,757 | -- | -- | 1,074 | -- | -- | 841 | -- | 4,672 |
| Pasture | 50 | -- | 1,378 | 70 | -- | 752 | -- | -- | -- | 2,130 |
| Rice | -- | -- | -- | 5 | -- | 54 | 10 | -- | 84 | 138 |
| Cocoa | -- | -- | -- | 5 | -- | 54 | 10 | -- | 84 | 138 |
| Annuals | 50 | -- | 1,379 | 20 | -- | 214 | 80 | -- | 673 | 2,266 |
| | 100 | 3,446 | 2,757 | 100 | 1,343 | 1,074 | 100 | 1,051 | 841 | 5,840 |
| Distribution of Annuals[a] | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | Percent (%) | Annuals Area (Ha.) | Crop Areas (Ha.) | (Ha.) |
| Intercropped | 30 | -- | -- | -- | -- | 16 | -- | -- | 24 | 40 |
| Planted Alone | 70 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Yucca | 21.0 | -- | -- | -- | -- | 11 | -- | -- | 18 | 29 |
| Corn | 17.5 | -- | -- | -- | -- | 9 | -- | -- | 15 | 24 |
| Plantain | 10.5 | -- | -- | -- | -- | 6 | -- | -- | 9 | 15 |
| Sweet Potatoes | 10.5 | -- | -- | -- | -- | 6 | -- | -- | 9 | 15 |
| Beans | 10.5 | -- | -- | -- | -- | 6 | -- | -- | 9 | 15 |
| | | -- | -- | | 54 | 54 | -- | 84 | 84 | 138 |

Table A-11. -- Rice Cost of Production, By Planting

(Pesos/Tarea/Planting)

| ACTIVITY | METHOD I** | | METHOD II | | METHOD III | |
|---|---|---|---|---|---|---|
| Land Preparation | 5.25 | | 10.50 | | 10.50 | |
| Inputs | 4.68 | | 9.68 | | 11.56 | |
| Seeds (Porte Bajo) | | 3.08 | | 3.08 | | 3.08 |
| Herbicides Stan F-34 | | -- | | 2.75 | | 2.75 |
| 2-4-D | | -- | | -- | | 0.24 |
| Fertilizer 12-24-12 | | -- | | 1.80 | | 2.85 |
| Ammonium Sulfate | | 1.25 | | 1.25 | | 1.25 |
| Insecticide (Nuvacron) | | -- | | 0.45 | | 0.62 |
| Monitor (600) | | -- | | -- | | 0.30 |
| Pesticide | | -- | | -- | | 0.12 |
| Water tax | | 0.35 | | 0.35 | | 0.35 |
| Labor | 14.00 | | 16.70 | | 18.90 | |
| Irrigation | | 0.60 | | 0.60 | | 0.60 |
| Clean channels | | 0.50 | | 0.50 | | 0.50 |
| Weeding (2) | | 3.50 | | 2.00 | | 3.50 |
| Application of chemicals | | -- | | 1.40 | | 1.90 |
| Application of fertilizer | | 0.40 | | 0.20 | | 0.40 |
| Harvest/Threshing | | 6.00 | | 8.00 | | 8.00 |
| Acarreo | | 3.00 | | 4.00 | | 4.00 |
| Total Cost | 23.93 | | 36.88 | | 40.96 | |
| Average Yield (qq[a]) | | 3.30 | | 4.40 | | 6.50 |
| Farm Price ($/120 kg) | | 27.50 | | 27.50 | | 27.50 |
| Gross Income | 40.25 | | 66.00 | | 82.50 | |
| Net Income | 16.32 | | 29.12 | | 41.54 | |

*Annual costs and yields per hectare: I - $765.76 and 105.6 qq.; II - $1,180.16 and 140.8 qq.; III - $1,310.72 and 208.0 qq.

[a] 1 quintal = 55 kilograms; 1 tarea = 0.0625 hectares.

Source: Secretaria de Estado de Agricultura, Division of Administracion Rural, Regional Nordeste, April 1979 for Method II. Method I based on judgement of Cibao Valley Agronomists in the Centro de Desarrollo Agropecuario in May 1979.

(continued)

Table A-11. -- Tobacco Annual Cost of Production, By Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation | 2.00 | | 2.00 | |
| Inputs | 5.35 | | 5.81 | |
| Plants | | 5.00 | | 5.00 |
| Insecticide (Azodrin) | | -- | | 0.46 |
| Water tax | | 0.35 | | 0.35 |
| Labor | 22.67 | | 25.97 | |
| Cleaning drains | | 0.50 | | 0.50 |
| Planting | | 3.00 | | 3.00 |
| Application of insecticides | | -- | | 0.30 |
| Weeding | | 1.50 | | 3.50 |
| Pruning | | 3.00 | | 4.00 |
| Harvesting operations | | 14.07 | | 14.07 |
| Irrigation | | 0.60 | | 0.60 |
| Total Cost | 30.02 | | 33.78 | |
| Average Yield (qq) | | 1.50 | | 2.00 |
| Farm Price ($/qq) | | 25.00 | | 25.00 |
| Gross Income ($) | 37.50 | | 50.00 | |
| Net Income ($) | 7.48 | | 16.22 | |

*Annual costs and yields per hectare are: I - $480.32 and 24 qq.; II - $540.48 and 32 qq.

(continued)

Table A-11. -- Plantain Annual Cost of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I** | | METHOD II | | METHOD III | |
|---|---|---|---|---|---|---|
| Land Preparation | 1.50 | | 3.00 | | 3.00 | |
| Inputs | 0.60 | | 8.46 | | 14.89 | |
| Plants (macho y hembra) | | 0.60 | | 1.20 | | 1.20 |
| Nemacide | | -- | | 1.75 | | 3.50 |
| Fertilizer (16-28-0) | | -- | | 4.00 | | 8.00 |
| Fungicide | | -- | | 0.45 | | 0.95 |
| Agricultural oil | | -- | | 0.20 | | 0.38 |
| Adherent (Agral) | | -- | | 0.06 | | 0.06 |
| Control (Sigatoka) | | -- | | 0.45 | | 0.45 |
| Irrigation water | | -- | | 0.35 | | 0.35 |
| Labor | 9.40 | | 21.95 | | 25.40 | |
| Cleaning drains | | -- | | 0.50 | | 0.50 |
| Pruning plants | | 0.20 | | 0.40 | | 0.40 |
| Disinfection of plants | | -- | | 0.20 | | 0.20 |
| Making holes and planting | | -- | | 6.50 | | 6.50 |
| Replanting | | 3.25 | | 0.50 | | 1.00 |
| Weeding (3) | | 0.10 | | 9.00 | | 11.00 |
| Application of chemicals (2) | | 4.50 | | 1.75 | | 2.05 |
| Pruning | | -- | | 1.50 | | 2.00 |
| Harveting and collection | | 0.75 | | 1.00 | | 1.15 |
| Irrigating | | 0.60 | | 0.60 | | 0.60 |
| Total Cost | 11.50 | | 33.41 | | 43.29 | |
| Average Yield (millar) | | 0.60 | | 1.60 | | 2.00 |
| Farm Price ($/millar) | | 40.00 | | 40.00 | | 40.00 |
| Gross Income | 24.00 | | 64.00 | | 80.00 | |
| Net Income | 12.50 | | 29.95 | | 36.71 | |

*Includes both establishment and maintenance activities. Planting and harvesting is done continuously. Establishment generally done only every 20 years. Yield is expressed in millars (1000 fingers). Annual costs and yields per hectare are: I -$184.00 and 9.6 millars; II - $534.56 and 25.6 millars; III - $692.64 and 32.0 millars.

(continued)

Table A-11. -- Banana Annual Cost of Production, by Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation | 1.50 | | 3.00 | |
| Inputs | 0.60 | | 14.89 | |
| Plants | | -- | | 1.20 |
| Nemacide | | -- | | 3.50 |
| Fertilizer (16-28-0) | | -- | | 8.00 |
| Fungicide | | -- | | 0.95 |
| Agricultural oil | | -- | | 0.38 |
| Adherant (Agrel) | | -- | | 0.06 |
| Control (Sigatoka) | | -- | | 0.45 |
| Irrigation water | | -- | | 0.35 |
| Labor | 9.40 | | 23.15 | |
| Cleaning drains | | -- | | 0.50 |
| Pruning plants | | 0.20 | | 0.40 |
| Disinfection of plants | | -- | | 0.20 |
| Making holes and planting | | 3.25 | | 6.50 |
| Replanting | | 0.10 | | 0.50 |
| Weeding (3) | | 4.50 | | 9.00 |
| Application of chemicals | | -- | | 2.05 |
| Pruning | | 0.75 | | 1.50 |
| Harvesting and collection | | 0.60 | | 1.15 |
| Irrigating | | -- | | 0.60 |
| Propping | | -- | | 0.75 |
| Total Cost | 11.50 | | 41.04 | |
| Average Yield (stalk) | | 60.00 | | 144.00 |
| Farm Price ($/stalk) | | 1.50 | | 1.50 |
| Gross Income | 90.00 | | 216.00 | |
| Net Income | 78.50 | | 174.96 | |

*Annual costs and yelds per hectare are: I - $184.00 and 960 stalks; II - $656.64 and 2,304 stalks.

(continued)

Table A-11. -- Cane Cost of Production - Esperanza*

| | Pesos/Ton | Pesos/Hectare |
|---|---|---|
| Cane | | |
| Cultivation | 1.85 | 146.15 |
| Harvesting | 2.22 | 175.38 |
| Maintenance | 0.50 | 39.50 |
| Field irrigation overhead | 1.04 | 82.16 |
| Field transport | 1.10 | 94.01 |
| Depreciation-transport | 0.12 | 9.48 |
| | 6.92 | 546.68 |

*Per hectare yield is 79 metric tons.

Source: Bookers Agricultural and Technical Services Ltd. CONFIDENTIAL REPORT, Appendix I, p. V 3.2 Estadio de Rehabilitacion y Expansion de la Industria Azucorera 1975.

Corn Annual Cost of Production, by Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation | 3.00 | | 4.50 | |
| Inputs | 0.30 | | 1.17 | |
| Seed (Frances Large) | | 0.30 | | 0.30 |
| Insecticide (Dipterez) | | — | | 0.54 |
| Fertilizer | | — | | 0.33 |
| Labor | 4.15 | | 7.12 | |
| Planting | | 0.80 | | 0.80 |
| Weeding | | 1.75 | | 3.50 |
| Application of insecticides and fertilizer | | — | | 0.82 |
| Harvest and sacking | | 1.60 | | 2.00 |
| Total Cost | 7.45 | | 12.75 | |
| Average Yield (qq) | | 2.00 | | 2.90 |
| Farm Price ($/qq) | | 6.02 | | 6.02 |
| Gross Income | 12.04 | | 17.45 | |
| Net Income | 4.59 | | 4.71 | |

*Annual costs and yields per hectare are: I - $119.20 and 32 qq.; II - $204.00 and 46.4 qq.

(continued)

Table A-11. -- Red Beans Annual Cost of Production, by Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation | 2.00 | | 2.00 | |
| Inputs | 4.00 | | 4.83 | |
| Seed | | 4.00 | | 4.00 |
| Babozida Karmeta | | -- | | 0.45 |
| Insecticide (Dipterez) | | -- | | 0.38 |
| Labor | 6.60 | | 9.75 | |
| Planting | | 1.85 | | 1.85 |
| Weeding | | 1.75 | | 3.50 |
| Pesticide application | | -- | | 0.40 |
| Harvest | | 3.00 | | 4.00 |
| Total Cost | 12.60 | | 16.58 | |
| Average Yield (qq) | | 1.50 | | 2.00 |
| Farm Price ($/qq) | | 27.08 | | 27.08 |
| Gross Income | 40.62 | | 54.16 | |
| Net Income | 28.02 | | 37.58 | |

*Annual costs and yields per hectare are: I - $201.60 and 24 qq.; II - $265.28 and 32 qq.

Yuca Annual Cost of Production by Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation ** | 2.00 | | 4.00 | |
| Inputs | -- | | 0.66 | |
| Insecticides (Endrin) | | -- | | 0.23 |
| Insecticides (Azodrin) | | -- | | 0.43 |
| Labor | 7.60 | | 10.10 | |
| Planting | | 0.60 | | 0.60 |
| Weeding*** | | 2.00 | | 3.00 |
| Application of Chemicals | | -- | | 0.50 |
| Harvest | | 5.00 | | 6.00 |
| Total Cost | 9.60 | | 14.76 | |
| Average Yield (qq) | | 9.00 | | 12.00 |
| Farm Price ($/qq) | | 6.00 | | 6.00 |
| Gross Income | 54.00 | | 72.00 | |
| Net Income | 44.40 | | 57.24 | |

*Annual costs and yields per hectare: I - $153.60 and 144 qq.; II - $236.16 and 192 qq.

**Cutting of past crops in I; cutting and harrow in II.

***2 in I, 3 in II.

(continued)

Table A-11. -- Sweet Potatoes Annual Cost of Production, by Method of Production*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| Land Preparation | 2.00 | | 3.00 | |
| Inputs | -- | | 0.40 | |
| Insecticide (Trithion) | | -- | | 0.40 |
| Labor | 10.00 | | 12.20 | |
| Planting | | 2.00 | | 2.00 |
| Weeding and tilling | | 3.00 | | 4.00 |
| Insecticide | | -- | | 0.20 |
| Harvesting and on-farm operations | | 5.00 | | 6.00 |
| Total Cost | 12.00 | | 15.60 | |
| Average Yield (qq) | | 8.00 | | 15.00 |
| Farm Price ($/qq) | | 4.00 | | 4.00 |
| Gross Income | 32.00 | | 60.00 | |
| Net Income | 20.00 | | 44.40 | |

*Annual costs and yields per hectare are: I - $192.00 and 128 qq.; II - 249.60 and 240 qq.

(continued)

Table A-11. -- Cocoa Annual Cost of Production, by Production Method*

(Pesos/Tarea)

| ACTIVITY | METHOD I | | METHOD II | |
|---|---|---|---|---|
| First Year | -- | | 22.30 | |
| Clearing brush and trees | | -- | | 12.00 |
| Fertilizer (10 lbs) | | -- | | 0.80 |
| Plants (40) | | -- | | 4.00 |
| Land preparation for planting | | -- | | 3.30 |
| Fertilizer application (2) | | -- | | 1.00 |
| Disease control | | -- | | 1.20 |
| Second Year | -- | | 15.00 | |
| Selective thinning | | -- | | 3.50 |
| Chapeo (3) | | -- | | 6.00 |
| Fertilizer (20 lbs) | | -- | | 1.60 |
| Disease control | | -- | | 1.00 |
| Fertilizer application (2) | | -- | | 1.00 |
| Reseeding (9 plants) | | -- | | 1.40 |
| Reseeding new shade | | -- | | 0.50 |
| Third-Fifteenth Year Rate | 13.90 | | 13.90 | |
| Weed control | | 7.50 | | 7.50 |
| Thinning | | 2.00 | | 2.00 |
| Fertilizer (30 lbs) | | 2.40 | | 2.40 |
| Fertilizer application (2) | | 1.00 | | 1.00 |
| Disease control | | 1.00 | | 1.00 |
| Total Costs | 13.90 | | 51.25 | |
| Average Annual Costs[a] | 13.90 | | 14.53 | |
| Average Yield (qq) | | 0.5 | | 0.70 |
| Farm Price ($/qq) | | 91.75 | | 91.75 |
| Gross Income | 45.88 | | 64.23 | |
| Net Income | 31.98 | | 49.70 | |

*Annual costs and yields per hectare: I - $222.40 and 8.0 qq.; II - $232.48 and 11.2 qq.

[a]Does not include interest on capital.

Table A-11. -- Interplanted Annual Cost of Production

(Pesos/Tarea)

| Crop | Cost When Planted Alone[a] ($) | Percent of Tarea When Interplanted (%) | Cost When Interplanted ($) |
|---|---|---|---|
| Beans | 12.60 | 37.5 | 4.73 |
| Plantain | 11.50 | 20.0 | 2.30 |
| Corn | 7.45 | 15.0 | 1.12 |
| Yucca | 9.60 | 12.5 | 1.20 |
| Sweet Potatoes | 12.00 | 10.0 | 1.20 |
| Tobacco | 30.02 | 5.0 | 1.50 |
| Total | | 100.0 | 12.05[b] |

[a]"Low" production method only.

[b]The cost/hectare is $192.80.

Table A-12. -- Distribution of Production Methods by Intermediate Map Unit

(% of Crop Area)

| Crop | Production Method | Intermediate Map Unit[c] ABG | CF | DE |
|---|---|---|---|---|
| Rice | Low | 20 | 25 | 50 |
| | Medium | 40 | 40 | 25 |
| | High | 40 | 35 | 25 |
| | | 100 | 100 | 100 |
| Tobacco | Low | 30 | 30 | 30 |
| | Medium | 70 | 70 | 70 |
| | | 100 | 100 | 100 |
| Plantain | Low | a | b | b |
| | Medium | 60 | 60 | 60 |
| | High | 40 | 40 | 40 |
| | | 100 | 100 | 100 |
| Banana | Low | 40 | 40 | b |
| | Medium | 60 | 60 | 100 |
| | | 100 | 100 | 100 |
| Sugar Cane | Low | 100 | 100 | 100 |
| Corn | Low | 30 | 30 | b |
| | Medium | 70 | 70 | b |
| | | 100 | 100 | |
| Beans | Low | 30 | 30 | b |
| | Medium | 70 | 70 | b |
| | | 100 | 100 | |
| Yucca | Low | 30 | 30 | b |
| | Medium | 70 | 70 | b |
| | | 100 | 100 | |
| Sweet Potatoes | Low | 30 | 30 | b |
| | Medium | 70 | 70 | b |
| | | 100 | 100 | |
| Cocoa | Low | 80 | b | b |
| | Medium | 20 | b | b |
| | | 100 | | |

[a]Plantain low is only used when intercropped with other crops.

[b]Not found in these map units.

[c]A, B, and G roughly correspond to the East region, C and F to the Central, and D and E to the west.

Table A-13. -- Sample Descriptions of Cibao Valley PPAs

| | PPA[a] | | |
|---|---|---|---|
| | Aggregate I1 | Intermediate A1 | Detailed 011 |
| General | | | |
| PPA Proportion of Map Unit (%) | 50 | 50 | -- |
| Position on Landscape | terrace | terrace | terrace |
| Average Annual Rainfall (mm) | | | |
| Average Annual Temperature ($^oC$) | | | |
| Soils | | | |
| Principal Component | Tropaqualfs | Abruptic Tropaqualfs | Abruptic Tropaqualfs |
| Slope (%) | 0-3 | 0-3 | 0-3 |
| Surface Texture | - | F | M |
| Depth to Bedrock (cm) | 150 | 150 | 150 |
| Stoniness | non-stony | non-stony | non-stony |
| Permeability | very slow | very slow | very slow |
| Available Water Capacity | - | - | - |
| Drainage | imperfect | imperfect | imperfect |
| Flooding | none | none | none |
| Reaction | med. acidity | med. acidity | slight/med. acidity |
| Base Saturation | 50 | 50 | 50 |
| Salinity | non-saline | non-saline | non-saline |

Notes: [a]Detailed PPA 011 (and 5 others) is part of Intermediate PPA A1. A1 (and 5 other Intermediate PPAs which include an additional 7 Detailed PPAs) is part of Aggregate PPA I1.

Table A-14. -- Transportation Costs, by Region

(Pesos/Unit of Output)[a]

| Supply Regions | Requirements Regions East | Central | West | Santo Domingo |
|---|---|---|---|---|
| East | 0.00 | 0.05 | 0.25 | 0.45 |
| Central | 0.05 | 0.00 | 0.20 | 0.50 |
| West | 0.25 | 0.20 | 0.00 | 0.70 |

[a]The tariff structure on which these costs were developed is based on truck transport; cargo weight is in quintales. For plantains which are measured in "fingers" (thousands of fingers are "millars") and bananas which are measured in stalks, no specific tariffs could be found. These tariffs were therefore arbitrarily applied to the units of production used in this study for plantain (millar) and for banana (stalk).

Table A-15. -- Benchmark Crop Requirements[a]

| Crop | Unit | Requirements |
|---|---|---|
| Rice | qq. | 2,700,000 |
| Tobacco | qq. | 465,000 |
| Plantain | millar | 400,000 |
| Banana | stalk | 3,350,000 |
| Sugar Cane | mt. | 300,000 |
| Corn | qq. | 460,000 |
| Beans | qq. | 250,000 |
| Yucca | qq. | 1,775,000 |
| Sweet Potato | qq. | 1,130,000 |
| Cocoa | qq. | 40,000 |

[a]Based on current cropping pattern and yields.

Table A-16. -- Percentage Distribution of Crop Requirements

(% of Total Production)

| Crop | West | Central | East | Santo Domingo | Total |
|---|---|---|---|---|---|
| Rice | 10 | 30 | 20 | 40 | 100 |
| Tobacco | 0 | 100 | 0 | 0 | 100 |
| Sugar Cane | 50 | 0 | 0 | 50 | 100 |
| Corn | 5 | 20 | 5 | 70 | 100 |
| Plantain | 10 | 18 | 28 | 44 | 100 |
| Banana | 10 | 18 | 28 | 44 | 100 |
| Beans | 10 | 18 | 28 | 44 | 100 |
| Yucca | 10 | 18 | 28 | 44 | 100 |
| Sweet Potatoes | 10 | 18 | 28 | 44 | 100 |
| Cocoa | 2 | 3 | 5 | 90 | 100 |

Table A-17. -- Percentage Distribution of Crop Requirements, Assuming Population Shifts

(% of Total Production)

| Crop | West | Central | East | Santo Domingo | Total |
|---|---|---|---|---|---|
| Rice | 5 | 30 | 15 | 50 | 100 |
| Tobacco | 0 | 100 | 0 | 0 | 100 |
| Sugar Cane | 50 | 0 | 0 | 50 | 100 |
| Corn | 4 | 20 | 4 | 72 | 100 |
| Plantain | 8 | 17 | 26 | 49 | 100 |
| Banana | 8 | 17 | 26 | 49 | 100 |
| Beans | 8 | 17 | 26 | 49 | 100 |
| Yucca | 8 | 17 | 26 | 49 | 100 |
| Sweet Potatoes | 8 | 17 | 26 | 49 | 100 |
| Cocoa | 2 | 3 | 5 | 90 | 100 |

Table A-18. -- Allocators of Detailed PPAs[a] to Intermediate PPAs, Aggregate PPAs, and Regions

| Detailed | Portion of Detailed PPA to: | | | | | |
|---|---|---|---|---|---|---|
| | Int. PPA | | Agg. PPA | | Region | |
| | (%) | No. | (%) | No. | (%) | No. |
| 011 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 012 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 013 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 021 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 031 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 041 | 100.0 | A2 | 100.0 | I2 | 100.0 | E |
| 042 | 100.0 | A1 | 100.0 | I1 | 100.0 | E |
| 051 | 31.4 | A2 | 31.4 | I2 | 31.4 | E |
| 051 | 68.6 | B1 | 68.6 | II1 | 68.6 | E |
| 061 | 100.0 | B1 | 100.0 | II1 | 92.7 | E |
| | | | | | 7.3 | C |
| 071 | 100.0 | B1 | 100.0 | II1 | 90.3 | E |
| | | | | | 9.7 | C |
| 072 | 100.0 | B1 | 100.0 | II3 | 90.3 | E |
| | | | | | 9.7 | C |
| 081 | 18.7 | A2 | 18.7 | I2 | 18.7 | E |
| | 81.3 | B1 | 81.3 | II1 | 81.3 | E |
| 091 | 100.0 | B1 | 100.0 | II1 | 90.0 | E |
| | | | | | 10.0 | C |
| 092 | 100.0 | B2 | 100.0 | II2 | 90.0 | E |
| | | | | | 10.0 | C |
| 101 | 100.0 | A3 | 100.0 | I3 | 100.0 | E |
| 111 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 121 | 100.0 | B1 | 100.0 | II2 | 100.0 | W |
| 131 | 100.0 | C1 | 100.0 | II2 | 100.0 | C |
| 141 | 100.0 | E2 | 100.0 | III2 | 97.6 | W |
| | | | | | 2.4 | C |
| 151 | 100.0 | B1 | 100.0 | II2 | 100.0 | C |
| 161 | 100.0 | C1 | 100.0 | II2 | 18.1 | W |
| | | | | | 81.9 | C |
| 171 | 100.0 | C1 | 100.0 | II2 | 45.0 | E |
| | | | | | 55.0 | C |
| 181 | 100.0 | C1 | 100.0 | II2 | 45.5 | W |
| | | | | | 54.5 | C |
| 191 | 100.0 | C1 | 100.0 | II2 | 3.3 | W |
| | | | | | 96.7 | C |
| 201 | 100.0 | C1 | 100.0 | II2 | 22.6 | W |
| | | | | | 77.4 | C |
| 211 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 221 | 100.0 | D1 | 100.0 | III3 | 100.0 | W |
| 231 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 232 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |

See footnotes at end of table

(continued)

Table A-18. -- (cont'd.)

| Detailed | Portion of Detailed PPA to: | | | | | |
|---|---|---|---|---|---|---|
| | Int. PPA | | Agg. PPA | | Region | |
| | (%) | No. | (%) | No. | (%) | No. |
| 241 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 242 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 251 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 261 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 262 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 271 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 272 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 281 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 282 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 291 | 100.0 | E1 | 100.0 | III1 | 100.0 | W |
| 292 | 100.0 | E3 | 100.0 | III3 | 100.0 | W |
| 301 | 100.0 | F1 | 100.0 | II3 | 100.0 | C |
| 302 | 100.0 | F2 | 100.0 | II2 | 100.0 | C |
| 311 | 100.0 | G1 | 50.0 | I3 | 87.8 | W |
| | | | 50.0 | II3 | 12.2 | C |
| 312 | 100.0 | G2 | 50.0 | I3 | 87.8 | W |
| | | | 50.0 | II3 | 12.2 | C |
| 313 | 100.0 | G3 | 50.0 | I3 | 87.8 | W |
| | | | 50.0 | II3 | 12.2 | C |

[a]Detailed PPA measured areas have been expanded (or contracted) to be consistent with the measured areas of Intermediate PPAs.

Table A-19. -- Allocators of Aggregate PPAs to Regions

(%)

| Aggregate PPA | Regions | | | |
|---|---|---|---|---|
| | East | Central | West | Total |
| I1 | 100.0 | -- | -- | 100.0 |
| I2 | 100.0 | -- | -- | 100.0 |
| I3 | 70.0 | -- | 30.0 | 100.0 |
| II1 | 99.2 | 0.8 | -- | 100.0 |
| II2 | 3.9 | 80.6 | 15.5 | 100.0 |
| II3 | -- | 65.3 | 34.7 | 100.0 |
| III1 | -- | -- | 100.0 | 100.0 |
| III2 | -- | 2.4 | 97.6 | 100.0 |
| III3 | -- | -- | 100.0 | 100.0 |

Table A-20. -- Cartographic Relationship Between Map Units[a]

| Intermediate Map Units | Detailed Map Units |
|---|---|
| A | 1-5, 8, 10, 31 |
| B | 3, 5-9, 12, 15, 17, 20, 31 |
| C | 13, 16-20 |
| D | 22, 27 |
| E | 11, 14, 18, 19, 20, 21, 22, 23-29 |
| F | 30 |
| G | 31 |
| Aggregate Map Units | |
| I | 1-5, 8, 10, 31 |
| II | 2, 3, 5-9, 12, 13, 15-20, 30, 31 |
| III | 11, 14, 16, 18, 19, 20, 21, 22, 23-29 |

[a]Detailed Map Units not taxonomically in the more generalized Map Units are underlined.

Table A-21. — Comparison of Measured and Summed Map Unit Areas

| Intermediate Map Unit | Map Unit Area: Intermediate Measured (Km$^2$) | Map Unit Area: Detailed Summed[a] (Km$^2$) | Difference: Area (Km$^2$) | Difference: Percent of Measured Area (%) |
|---|---|---|---|---|
| A | 282.2585 | 238.7384 | 43.5201 | 15.4 |
| B | 1008.8568 | 955.5242 | 53.3326 | 5.3 |
| C | 242.7887 | 253.8351 | -11.0464 | - 4.5 |
| D | 23.9850 | 19.7731 | 4.2119 | 17.6 |
| E | 571.1855 | 569.2122 | 1.9733 | 0.3 |
| F | 33.8481 | 41.4802 | - 7.6321 | -22.5 |
| G | 58.4022 | 100.9671 | -42.5649 | -72.9 |
| Total | 2221.3248 | 2179.5303 | 41.7945 | 1.9 |

| Aggregate Map Unit | Map Unit Area: Aggregate Measured (Km$^2$) | Map Unit Area: Detailed Summed[a] (Km$^2$) | Difference: Area (Km$^2$) | Difference: Percent of Measured Area (%) |
|---|---|---|---|---|
| I | 302.6215 | 239.7384 | 62.8831 | 20.8 |
| II | 1526.1653 | 1350.4964 | 175.6689 | 11.5 |
| III | 457.5544 | 588.9853 | -131.4309 | -28.7 |
| Total | 2286.3412 | 2179.2201 | 107.1211 | 4.7 |
| | | 0.3102[b] | | |
| | | 2179.5303 | | |

[a]Sums of Detailed map delineations to the Intermediate level and to the Aggregate level.

[b]Error accounted for by cartographic errors.

Table A-22. -- Comparison of First and Second Measurements of Planimetered Areas[a]

| Delineation Number | Area as First Measured (Km²) | Area as Second Measured (Km²) | Difference: Area (Km²) | Difference: Percent of First Measured Area (%) |
|---|---|---|---|---|
| Detailed | | | | |
| 26 | 49.9989 | 49.8974 | .1015 | -0.20 |
| 22 | 9.8580 | 9.8740 | .0160 | 0.16 |
| 20 | 15.1716 | 14.9955 | .1761 | -1.16 |
| 21 | 1.2472 | 1.2258 | .0214 | -1.72 |
| 11 | 2.1532 | 2.1383 | .0149 | -0.69 |
| 2 | 0.4368 | 0.4316 | .0052 | -1.19 |
| 31 | 4.3720 | 4.4520 | .0800 | 1.83 |
| 23 | 5.7583 | 5.7549 | .0034 | -0.06 |
| 27 | 15.4717 | 15.6283 | .1566 | 1.01 |
| 6 | 3.8552 | 3.9001 | .0449 | 1.17 |
| 31 | 8.5464 | 8.5185 | .0279 | -0.33 |
| 10 | 21.6482 | 21.7365 | .0883 | 0.41 |
| 20 | 13.1632 | 12.9723 | .1909 | -1.45 |
| 17 | 13.1560 | 13.0450 | .1110 | -0.84 |
| 6 | 49.0721 | 49.1864 | .1143 | 0.23 |
| 6 | 16.1515 | 16.2016 | .0501 | 0.31 |
| Average of Absolute Differences | - | - | - | 0.80 |
| Intermediate | | | | |
| C | 5.6922 | 5.7352 | .0430 | 0.76 |
| A | 59.1494 | 57.1212 | 2.0282 | -3.43 |
| E | 9.3119 | 9.2575 | .0544 | -0.58 |
| G | 15.7029 | 15.8036 | .1007 | 0.64 |
| B | 6.6525 | 6.6707 | .0154 | 0.23 |
| F | 8.6361 | 8.6304 | .0057 | -0.07 |
| B | 86.2626 | 86.7439 | .4813 | 0.56 |
| Average of Absolute Differences | - | - | - | 0.90 |
| Aggregate | | | | |
| III | 211.5547 | 211.6197 | .0650 | - .03 |
| III | 205.1875 | 205.3168 | .1293 | - .06 |
| II | 37.6836 | 37.7212 | .0376 | - .10 |
| III | 4.7692 | 4.7697 | .0005 | - .01 |
| II | 474.0572 | 464.5413 | 9.5159 | 2.01 |
| II | 38.7266 | 40.2757 | 1.5491 | -4.00 |
| II | 265.1561 | 268.0198 | 2.8637 | -1.08 |
| Average of Absolute Differences | - | - | - | 1.04 |

[a]Map delineations were planimetered on the 1:50,000 base map which was in fourteen map sheets.

Table A-23. -- Estimated Costs of Three Cibao Valley Soil Inventories

| | | Detailed | Intermediate | Aggregate |
|---|---|---|---|---|
| Assumptions: | | | | |
| Area to Inventory (ha.) | | 250,000 | 250,000 | 250,000 |
| Work Days/Year | | 250 | 240 | 240 |
| Area/Soil Scientists/Year (ha.) | | 25,000 | 100,000 | 400,000 |
| Scale of Photography | | 1:20,000 | 1:60,000 | 1:70,000 |
| Scale of Topographic Map | | 1:50,000 | 1:250,000 | 1:250,000 |
| No. of Photos to Cover the Area | | | 275 | 70 |
| Field Time (months) | | 8 | 8 | 8 |
| Time to Publication (months) | | 12 | 12 | 12 |
| Published Scale | | 1:100,000 | 1:250,000 | 1:1,000,000 |
| Budget: | | | | |
| Soil Scientists | ($1000/mo.) | 120,000 (10) | 36,000 (3) | 7,200 (0.6) |
| Soil Scientists | ($ 440/mo.) | 52,800 (10) | 14,400 (3) | 3,168 (0.6) |
| Drivers | ($ 350/mo.) | 42,000 (10) | 12,600 (3) | 2,520 (0.6) |
| Laborers | ($ 200/mo.) | 24,000 (10) | - | 1,440 (0.6) |
| Laborers | ($ 150/mo.) | 18,000 (10) | 5,400 (3) | 1,080 (0.6) |
| Secretaries | ($ 400/mo.) | 9,600 ( 2) | 9,600 (2) | 2,880 (0.6) |
| Draftsman | ($ 400/mo.) | 4,800 ( 1) | 4,800 (1) | 2,880 (0.6) |
| | | 271,200 | 90,000 | 21,168 |
| Materials and Equipment:[a] | | | | |
| Aerial Photos ($6 each) | | 1,650 (275) | 420 (70) | 180 (30) |
| Topographic Maps | 18 ( 6) | 25 ( 1) | 25 ( 1) | |
| Stereoscopes of Mirrors ($700 each) | | 700 ( 10) | 210 ( 3) | 70 ( 1) |
| Abney Levels ($40 each) | | 40 ( 10) | 12 ( 3) | 4 ( 1) |
| Pocket Stereoscopes ($35 each) | | 35 ( 10) | 11 ( 3) | 4 ( 1) |
| Altimeters ($150 each) | | 150 ( 10) | 45 ( 3) | 15 ( 1) |
| Munsell Cards ($60 each) | | 600 ( 10) | 180 ( 3) | 60 ( 1) |
| Posthole Diggers ($35 each) | | 350 ( 10) | 105 ( 3) | 35 ( 1) |
| Picks ($7 each) | | 70 ( 10) | 21 ( 3) | 7 ( 1) |
| Posts ($6 each) | | 60 ( 10) | 18 ( 3) | 6 ( 1) |
| Knives for Soil Scientists ($25 each) | | 250 ( 10) | 75 ( 3) | 25 ( 1) |
| Cartons (Balsos) ($25 each) | | 250 ( 10) | 75 ( 3) | 25 ( 1) |
| Bags for Samples | 50 | 25 | 15 | |
| Other (4% of Materials/ Equipment) | | 200 | 50 | 20 |
| | | 4,423 | 1,272 | 491 |
| Rental of Vehicles | 60,000 | 18,000 | 3,600 | |
| Operation and Maintenance | | 10,000 | 3,000 | 600 |
| | | 70,000 | 21,000 | 4,200 |

See footnotes at end of table

(continued)

Table A-23. -- (cont'd.)

| | Detailed | Intermediate | Aggregate |
|---|---|---|---|
| Analysis of Samples ($15 each) | 150,000 | 33,750 | 20,250[b] |
| | (10,000) | (2,250) | (2,250) |
| Report Publication (20% of Costs) | 74,343[c] | 29,204 | 9,222 |
| Total Cost ($) | 569,900 | 175,300 | 55,400 |
| Cost/Hectare ($/ha.) | 2.28 | 0.70 | 0.22 |

Source: Personal communication from soil scientist, Jose Ogando, project SIEDRA, May 17, 1979, as based on Clasificacion de Suelos para Proyectos de Desarrollo de las Tierras de la Republica Dominicana, FAO, Rome, 1977.

[a]Stereoscopes (estereoscopio de espejos) costing $700 each with useful life of 10 years; 10 Abney levels (niveles Abney) costing $40 each with 10 year life; 10 pocket stereoscopes (estereoscopio de bolsillo) costing $35 each with 10-year life; 10 altimeters costing $150 each with 10 year life.

[b]$9 each.

[c]15%

PLEASE NOTE:

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Table A-24. -- Differences Between Crop Transportation Flows of the Detailed, Intermediate Weighted, and Aggregate Weighted Models - Benchmark Run

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | SUPPLY REGIONS INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| RICE (QQ) | | | | | | | | | |
| EAST | 237.4 | 96.1 | 206.5 | 540.0 | | | 540.0 | | |
| CENTRAL | | | 810.0 | | 103.6 | 706.4 | | 111.1 | 698.9 |
| WEST | | | 270.0 | | | 270.0 | | | 270.0 |
| SANTO DOMINGO | 1080.0 | | | 784.5 | | 291.5 | 851.9 | | 228.1 |
| SUBTOTAL | 1317.4 | 96.1 | 1286.5 | 1328.5 | 103.6 | 1267.8 | 1391.9 | 111.1 | 1197.0 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 22.2 | 357.4 | 85.4 | 35.7 | 353.2 | 76.1 | 30.6 | 378.0 | 56.4 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 22.2 | 357.4 | 85.4 | 35.7 | 353.2 | 76.1 | 30.6 | 378.0 | 56.4 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | . | 42.7 | 69.3 | | 49.8 | 62.2 | 32.8 | 37.7 | 41.5 |
| CENTRAL | | | 72.0 | | | 72.0 | | | 72.0 |
| WEST | | | 40.0 | | | 40.0 | | | 40.0 |
| SANTO DOMINGO | 173.6 | 2.4 | | 121.6 | | 54.4 | 176.0 | | |
| SUBTOTAL | 173.6 | 45.1 | 181.3 | 121.6 | 49.8 | 228.7 | 208.8 | 37.7 | 153.5 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 1304.3 | | | 1321.8 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 3.0 | 1471.0 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 4316.3 | | 3.0 | 4333.7 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 250.6 | | | 215.7 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | | 12.7 | 137.3 | .6 | 13.5 | 135.8 |
| SUBTOTAL | .8 | 12.8 | 353.5 | | 12.7 | 387.9 | .6 | 13.5 | 351.6 |
| CORN (QQ) | | | | | | | | | |
| EAST | 22.8 | .2 | | 23.0 | | | 23.0 | | |
| CENTRAL | | 92.0 | | 10.8 | 81.2 | | 48.5 | 43.5 | |
| WEST | | 5.6 | 17.4 | 8.1 | | 14.9 | 9.6 | | 13.4 |
| SANTO DOMINGO | 322.0 | | | 322.0 | | | 322.0 | | |
| SUBTOTAL | 344.6 | 97.8 | 17.4 | 363.9 | 81.2 | 14.9 | 403.1 | 43.5 | 13.4 |

Table A-24. -- (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| BEANS (QQ) | | | | | | | | | |
| EAST | 70.0 | | | 70.0 | | | 70.0 | | |
| CENTRAL | 8.0 | 37.0 | | 14.6 | 30.4 | | 31.0 | 14.0 | |
| WEST | 23.5 | | 1.5 | 22.1 | | 2.9 | 21.0 | | 4.0 |
| SANTO DOMINGO | 110.0 | | | 110.0 | | | 110.0 | | |
| SUBTOTAL | 211.4 | 37.0 | 1.5 | 216.8 | 30.4 | 2.9 | 231.9 | 14.0 | 4.0 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 497.0 | | | 497.0 | | | 497.0 | | |
| CENTRAL | | 319.5 | | 77.5 | 242.0 | | 118.0 | 201.5 | |
| WEST | 157.8 | 5.3 | 14.5 | 153.6 | | 23.9 | 121.3 | | 56.2 |
| SANTO DOMINGO | 781.0 | | | 781.0 | | | 781.0 | | |
| SUBTOTAL | 1435.8 | 324.8 | 14.5 | 1509.1 | 242.0 | 23.9 | 1517.3 | 201.5 | 56.2 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 316.4 | | | 316.4 | | | 316.4 | | |
| CENTRAL | 2.9 | 200.5 | | 50.6 | 152.8 | | 82.8 | 120.6 | |
| WEST | | | 113.0 | | | 113.0 | 77.8 | | 35.2 |
| SANTO DOMINGO | 497.2 | | | 497.2 | | | 497.2 | | |
| SUBTOTAL | 816.5 | 200.5 | 113.0 | 864.2 | 152.8 | 113.0 | 974.2 | 120.6 | 35.2 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 2.4 | | | 1.8 | .2 | |
| CENTRAL | | 4.7 | | | 3.4 | | | 3.3 | |
| WEST | | .7 | .1 | | .5 | .3 | | | .9 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 38.4 | 3.9 | .3 | 37.8 | 3.5 | .9 |

Table A-25. -- Difference Betweeen Area, Production, and Costs of the Detailed, Intermediate Weighted, and Aggregate Weighted Models - Growth Run

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE WEIGHTED DETAIL | | | | | | | | | |
| RICE (QQ) | | | | | | | | | |
| EAST | 12813.7 | 13840.4 | 13925.5 | 1616.7 | 1670.7 | 1680.9 | 14869.6 | 15834.2 | 15931.3 |
| CENTRAL | 1479.5 | 1400.9 | 1663.8 | 131.5 | 116.1 | 144.9 | 1693.5 | 1573.4 | 1870.9 |
| WEST | 14488.3 | 14595.8 | 14468.8 | 1491.8 | 1453.2 | 1414.2 | 15052.7 | 15222.3 | 15121.8 |
| SUBTOTAL | 28781.5 | 29837.1 | 30058.1 | 3240.0 | 3240.0 | 3240.0 | 31615.8 | 32630.0 | 32923.9 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | 642.1 | 1032.3 | 774.2 | 29.4 | 48.3 | 39.9 | 335.5 | 546.3 | 409.7 |
| CENTRAL | 14858.9 | 14888.0 | 17464.9 | 414.8 | 401.5 | 431.3 | 7772.9 | 7877.4 | 9176.4 |
| WEST | 4550.6 | 4508.1 | 3933.3 | 113.8 | 108.2 | 86.9 | 2393.3 | 2375.7 | 2075.7 |
| SUBTOTAL | 20051.6 | 20428.5 | 22172.5 | 558.0 | 558.0 | 558.0 | 10501.6 | 10799.4 | 11661.9 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | 8258.6 | 6591.9 | 9570.9 | 208.5 | 132.8 | 225.3 | 4929.6 | 4099.7 | 5721.4 |
| CENTRAL | 2540.0 | 2648.0 | 2780.6 | 61.3 | 55.3 | 49.1 | 1517.3 | 1583.7 | 1662.2 |
| WEST | 13828.7 | 20412.7 | 14606.4 | 210.2 | 291.8 | 205.6 | 8174.2 | 12248.0 | 8534.5 |
| SUBTOTAL | 24627.2 | 29652.5 | 26957.9 | 480.0 | 480.0 | 480.0 | 14621.1 | 17931.4 | 15918.1 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 13.2 | 6.6 | 6.6 | 4.3 | 3.0 | 3.0 | 5.5 | 4.3 | 4.3 |
| WEST | 3991.5 | 3991.4 | 3991.4 | 4316.4 | 4316.3 | 4333.7 | 2621.0 | 2620.9 | 2620.9 |
| SUBTOTAL | 4004.7 | 3998.0 | 3998.0 | 4320.7 | 4319.3 | 4336.8 | 2626.5 | 2625.2 | 2625.2 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | 12.5 | 12.5 | 9.4 | .8 | | .6 | 6.8 | 6.8 | 5.1 |
| CENTRAL | 191.5 | 191.5 | 207.3 | 12.8 | 12.7 | 13.5 | 104.7 | 104.7 | 113.3 |
| WEST | 8032.9 | 8033.0 | 8020.3 | 353.5 | 387.9 | 351.6 | 4391.4 | 4391.5 | 4384.5 |
| SUBTOTAL | 8236.9 | 8237.0 | 8237.0 | 367.1 | 400.6 | 365.7 | 4502.9 | 4503.0 | 4503.0 |
| CORN (QQ) | | | | | | | | | |
| EAST | 12431.4 | 12743.9 | 13878.6 | 443.1 | 461.8 | 491.0 | 2159.9 | 2216.4 | 2447.8 |
| CENTRAL | 2953.3 | 2726.4 | 1510.8 | 101.3 | 84.5 | 46.6 | 464.8 | 432.6 | 266.3 |
| WEST | 317.9 | 175.0 | 463.5 | 7.6 | 5.7 | 14.4 | 45.9 | 30.7 | 82.4 |
| SUBTOTAL | 15702.6 | 15645.2 | 15853.0 | 552.0 | 552.0 | 552.0 | 2669.5 | 2679.7 | 2796.5 |

Table A-25. -- (cont'd.)

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE WEIGHTED DETAIL | | | | | | | | | |
| BEANS (QQ) | | | | | | | | | |
| EAST | 7359.4 | 7621.4 | 9858.6 | 257.1 | 264.5 | 281.7 | 1853.3 | 1927.9 | 2186.8 |
| CENTRAL | 1135.1 | 998.5 | 611.3 | 41.3 | 32.5 | 14.2 | 281.5 | 252.0 | 150.9 |
| WEST | 82.0 | 114.1 | 164.4 | 1.5 | 3.0 | 4.0 | 20.2 | 28.1 | 40.5 |
| SUBTOTAL | 8576.6 | 8733.9 | 9634.4 | 300.0 | 300.0 | 300.0 | 2155.5 | 2208.0 | 2378.1 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 15035.5 | 16154.1 | 16694.2 | 1756.4 | 1842.0 | 1852.9 | 3139.5 | 3368.0 | 3496.5 |
| CENTRAL | 2334.9 | 2259.1 | 1761.3 | 358.6 | 262.2 | 216.5 | 493.6 | 477.5 | 368.3 |
| WEST | 152.9 | 222.3 | 546.3 | 15.0 | 25.8 | 60.6 | 32.2 | 47.0 | 115.1 |
| SUBTOTAL | 17523.3 | 18635.4 | 19001.8 | 2130.0 | 2130.0 | 2130.0 | 3665.3 | 3892.5 | 3980.0 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 6558.3 | 7644.6 | 7856.6 | 1007.3 | 1173.0 | 1171.8 | 1552.6 | 1823.2 | 1876.1 |
| CENTRAL | 1112.7 | 1074.0 | 1003.5 | 213.1 | 164.2 | 144.7 | 265.0 | 256.4 | 236.6 |
| WEST | 960.9 | 125.7 | 283.7 | 135.6 | 18.7 | 39.5 | 238.4 | 29.9 | 66.8 |
| SUBTOTAL | 8631.9 | 8844.2 | 9143.9 | 1356.0 | 1356.0 | 1356.0 | 2056.0 | 2109.0 | 2179.5 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 8388.1 | 8433.3 | 8451.9 | 37.8 | 36.4 | 37.8 | 1882.4 | 1892.6 | 1896.7 |
| CENTRAL | 868.6 | 823.2 | 674.5 | 5.6 | 5.9 | 3.5 | 194.9 | 184.7 | 151.4 |
| WEST | 56.5 | 56.3 | 186.6 | .1 | .3 | .9 | 12.7 | 12.6 | 41.9 |
| SUBTOTAL | 9313.2 | 9312.8 | 9313.0 | 43.5 | 42.6 | 42.2 | 2090.0 | 2089.9 | 2090.0 |
| INTERPLANTED (HECTARE) | | | | | | | | | |
| EAST | 23698.5 | 25981.0 | 25673.3 | ***** | ***** | ***** | 4569.1 | 5009.1 | 4949.8 |
| CENTRAL | 3014.0 | 2892.9 | 1069.6 | ***** | ***** | ***** | 581.1 | 557.8 | 206.2 |
| WEST | 131.3 | 222.8 | 702.6 | ***** | ***** | ***** | 25.3 | 43.0 | 135.5 |
| SUBTOTAL | 26843.9 | 29096.7 | 27445.5 | ***** | ***** | ***** | 5175.5 | 5609.8 | 5291.5 |
| PASTURE (HECTARE) | | | | | | | | | |
| EAST | 4472.1 | 6809.0 | 6161.5 | ***** | ***** | ***** | ***** | ***** | ***** |
| CENTRAL | 436.0 | 438.0 | 257.0 | ***** | ***** | ***** | ***** | ***** | ***** |
| WEST | 6596.9 | 6597.0 | 7337.0 | ***** | ***** | ***** | ***** | ***** | ***** |
| SUBTOTAL | 11507.0 | 13844.0 | 13755.5 | ***** | ***** | ***** | ***** | ***** | ***** |

Table A-25. -- (cont'd.)

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE WEIGHTED DETAIL | | | | | | | | | |
| IDLE CROPLAND (HECTARE) | | | | | | | | | |
| EAST | 19139.7 | 12496.5 | 7505.8 | ***** | ***** | ***** | ***** | ***** | ***** |
| CENTRAL | 2105.7 | 2188.4 | 3478.8 | ***** | ***** | ***** | ***** | ***** | ***** |
| WEST | 17087.1 | 11187.9 | 15537.7 | ***** | ***** | ***** | ***** | ***** | ***** |
| SUBTOTAL | 38332.5 | 25872.7 | 26522.3 | ***** | ***** | ***** | ***** | ***** | ***** |
| CROPLAND TOTAL | | | | | | | | | |
| EAST | 118809.9 | 119360.7 | 119360.7 | ***** | ***** | ***** | 35297.8 | 36724.3 | 38921.2 |
| CENTRAL | 33045.4 | 32535.4 | 32490.1 | ***** | ***** | ***** | 13375.4 | 13304.7 | 14206.8 |
| WEST | 70277.6 | 70242.1 | 70242.1 | ***** | ***** | ***** | 33007.3 | 37049.7 | 33219.7 |
| TOTAL | 222132.9 | 222138.2 | 222092.9 | ***** | ***** | ***** | 81680.4 | 87078.7 | 86347.6 |

Table A-26. -- Differences Between Crop Transportation Flows of the Detailed, Intermediate Weighted, and Aggregate Weighted Models - Growth Run

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | SUPPLY REGIONS DETAILED --1000-- EAST | CENTRAL | WEST | INTERMEDIATE --1000-- EAST | CENTRAL | WEST | AGGREGATE --1000-- EAST | CENTRAL | WEST |
|---|---|---|---|---|---|---|---|---|---|
| RICE (QQ) | | | | | | | | | |
| EAST | 320.7 | 131.5 | 195.8 | 648.0 | | | 648.0 | | |
| CENTRAL | | | 972.0 | | 116.1 | 855.9 | | 144.9 | 827.1 |
| WEST | | | 324.0 | | | 324.0 | | | 324.0 |
| SANTO DOMINGO | 1296.0 | | | 1022.7 | | 273.3 | 1032.9 | | 263.1 |
| SUBTOTAL | 1616.7 | 131.5 | 1491.8 | 1670.7 | 116.1 | 1453.2 | 1680.9 | 144.9 | 1414.2 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 29.4 | 414.8 | 113.8 | 48.3 | 401.5 | 108.2 | 39.9 | 431.3 | 86.9 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 29.4 | 414.8 | 113.8 | 48.3 | 401.5 | 108.2 | 39.9 | 431.3 | 86.9 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | | 58.6 | 75.8 | | 55.3 | 79.1 | 14.1 | 49.1 | 71.2 |
| CENTRAL | | | 86.4 | | | 86.4 | | | 86.4 |
| WEST | | | 48.0 | | | 48.0 | | | 48.0 |
| SANTO DOMINGO | 208.5 | 2.7 | | 132.8 | | 78.4 | 211.2 | | |
| SUBTOTAL | 208.5 | 61.3 | 210.2 | 132.8 | 55.3 | 291.8 | 225.3 | 49.1 | 205.6 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 1304.3 | | | 1321.8 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 3.0 | 1471.0 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 4316.3 | | 3.0 | 4333.7 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 250.6 | | | 215.7 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | | 12.7 | 137.3 | .6 | 13.5 | 135.8 |
| SUBTOTAL | .8 | 12.8 | 353.5 | | 12.7 | 387.9 | .6 | 13.5 | 351.6 |
| CORN (QQ) | | | | | | | | | |
| EAST | 27.6 | | | 27.6 | | | 27.6 | | |
| CENTRAL | 29.1 | 81.3 | | 25.9 | 84.5 | | 63.8 | 46.6 | |
| WEST | | 20.0 | 7.6 | 21.9 | | 5.7 | 13.7 | | 14.4 |
| SANTO DOMINGO | 386.4 | | | 386.4 | | | 386.4 | | |
| SUBTOTAL | 443.1 | 101.3 | 7.6 | 461.8 | 84.5 | 5.7 | 491.0 | 46.6 | 14.4 |

Table A-26. -- (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| BEANS | | | | | | | | | |
| (QQ) | | | | | | | | | |
| EAST | 84.0 | | | 84.0 | | | 84.0 | | |
| CENTRAL | 12.7 | 41.3 | | 21.5 | 32.5 | | 39.8 | 14.2 | |
| WEST | 28.5 | | 1.5 | 27.0 | | 3.0 | 26.0 | | 4.0 |
| SANTO DOMINGO | 132.0 | | | 132.0 | | | 132.0 | | |
| SUBTOTAL | 257.1 | 41.3 | 1.5 | 264.5 | 32.5 | 3.0 | 281.7 | 14.2 | 4.0 |
| YUCCA | | | | | | | | | |
| (QQ) | | | | | | | | | |
| EAST | 596.4 | | | 596.4 | | | 596.4 | | |
| CENTRAL | 24.8 | 358.6 | | 121.2 | 262.2 | | 166.9 | 216.5 | |
| WEST | 198.0 | | 15.0 | 187.2 | | 25.8 | 152.4 | | 60.6 |
| SANTO DOMINGO | 937.2 | | | 937.2 | | | 937.2 | | |
| SUBTOTAL | 1756.4 | 358.6 | 15.0 | 1842.0 | 262.2 | 25.8 | 1852.9 | 216.5 | 60.6 |
| SWEET POTATOES | | | | | | | | | |
| (QQ) | | | | | | | | | |
| EAST | 379.7 | | | 379.7 | | | 379.7 | | |
| CENTRAL | 31.0 | 213.1 | | 79.8 | 164.2 | | 99.3 | 144.7 | |
| WEST | | | 135.6 | 116.9 | | 18.7 | 96.1 | | 39.5 |
| SANTO DOMINGO | 596.6 | | | 596.6 | | | 596.6 | | |
| SUBTOTAL | 1007.3 | 213.1 | 135.6 | 1173.0 | 164.2 | 18.7 | 1171.8 | 144.7 | 39.5 |
| COCOA | | | | | | | | | |
| (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 2.4 | | | 1.8 | .2 | |
| CENTRAL | | 4.7 | | | 3.4 | | | 3.3 | |
| WEST | | .7 | .1 | | .5 | .3 | | | .9 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 38.4 | 3.9 | .3 | 37.8 | 3.5 | .9 |

Table A-27. -- Differences Between Crop Transportation Flows of the Detailed, Intermediate Weighted, and Aggregate Weighted Models - Growth/Shift Run

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | | | | SUPPLY REGIONS | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | DETAILED --1000-- | | | INTERMEDIATE --1000-- | | | AGGREGATE --1000-- | | |
| | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST |
| RICE (QQ) | | | | | | | | | |
| EAST | | 128.2 | 357.8 | 486.0 | | | 486.0 | | |
| CENTRAL | | | 972.0 | | 116.1 | 855.9 | | 144.9 | 327.1 |
| WEST | | | 162.0 | | | 162.0 | | | 162.0 |
| SANTO DOMINGO | 1616.7 | 3.3 | | 1184.7 | | 435.3 | 1194.9 | | 425.1 |
| SUBTOTAL | 1616.7 | 131.5 | 1491.8 | 1670.7 | 116.1 | 1453.2 | 1680.9 | 144.9 | 1414.2 |
| TUBACCO (QQ) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 29.4 | 414.8 | 113.8 | 48.3 | 401.5 | 108.2 | 37.9 | 431.3 | 86.9 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 29.4 | 414.8 | 113.8 | 43.3 | 401.5 | 108.2 | 39.9 | 431.3 | 86.9 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | | 34.6 | 90.2 | | 55.3 | 69.5 | 39.2 | | 85.6 |
| CENTRAL | | | 81.6 | | | 81.6 | | | 81.6 |
| WEST | | | 38.4 | | | 38.4 | | | 38.4 |
| SANTO DOMINGO | 208.5 | 26.7 | | 132.8 | | 102.4 | 186.1 | 49.1 | |
| SUBTOTAL | 208.5 | 61.3 | 210.2 | 132.8 | 55.3 | 291.8 | 225.3 | 49.1 | 205.6 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 1304.3 | | | 1321.8 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 3.0 | 1471.0 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 4316.3 | | 3.0 | 4333.7 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 250.6 | | | 215.7 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | | 12.7 | 137.3 | .6 | 13.5 | 135.8 |
| SUBTOTAL | .8 | 12.8 | 353.5 | | 12.7 | 387.9 | .6 | 13.5 | 351.6 |
| CORN (QQ) | | | | | | | | | |
| EAST | 22.1 | | | 22.1 | | | 22.1 | | |
| CENTRAL | 19.4 | 91.0 | | 25.9 | 84.5 | | 63.8 | 46.6 | |
| WEST | | 10.2 | 11.8 | 16.4 | | 5.7 | 7.7 | | 14.4 |
| SANTO DOMINGO | 397.4 | | | 397.4 | | | 397.4 | | |
| SUBTOTAL | 438.9 | 101.3 | 11.8 | 461.8 | 84.5 | 5.7 | 491.0 | 46.6 | 14.4 |

Table A-27. -- (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE WEIGHTED DETAIL | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| BEANS (QQ) | | | | | | | | | |
| EAST | 78.0 | | | 78.0 | | | 78.0 | | |
| CENTRAL | 9.7 | 41.3 | | 13.5 | 32.5 | | 36.8 | 14.2 | |
| WEST | 22.5 | | 1.5 | 21.0 | | 3.0 | 20.0 | | 4.0 |
| SANTO DOMINGO | 147.0 | | | 147.0 | | | 147.0 | | |
| SUBTOTAL | 257.1 | 41.3 | 1.5 | 264.5 | 32.5 | 3.0 | 281.7 | 14.2 | 4.0 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 553.8 | | | 553.8 | | | 553.8 | | |
| CENTRAL | 3.5 | 358.6 | | 99.9 | 262.2 | | 145.8 | 216.5 | |
| WEST | 155.4 | | 15.0 | 144.6 | | 25.8 | 109.6 | | 60.6 |
| SANTO DOMINGO | 1043.7 | | | 1043.7 | | | 1043.7 | | |
| SUBTOTAL | 1756.4 | 358.6 | 15.0 | 1842.0 | 262.2 | 25.8 | 1852.9 | 216.5 | 60.6 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 352.6 | | | 352.6 | | | 352.6 | | |
| CENTRAL | 17.4 | 213.1 | | 66.3 | 164.2 | | 85.8 | 144.7 | |
| WEST | | | 108.5 | 89.7 | | 18.7 | 69.0 | | 39.5 |
| SANTO DOMINGO | 664.4 | | | 664.4 | | | 664.4 | | |
| SUBTOTAL | 1034.4 | 213.1 | 108.5 | 1173.0 | 164.2 | 18.7 | 1171.8 | 144.7 | 39.5 |
| CUCOA (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 2.4 | | | 1.8 | .2 | |
| CENTRAL | | 4.7 | | | 3.4 | | | 3.3 | |
| WEST | | .7 | .1 | | .5 | .3 | | | .9 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 38.4 | 3.9 | .3 | 37.8 | 3.5 | .9 |

Table A-28 -- Variance and Coefficient of Variation of Detailed Yield Estimates Within the Respective Intermediate Weighted Yield

| Intermediate | Rice | Tobacco | Plantain | Banana | Sugar Cane | Corn | Beans | Yucca | Sweet Potatoes | Cocoa |
|---|---|---|---|---|---|---|---|---|---|---|
| PPA | | | | | | | | | | |
| A1 | | | | | | | | | | |
| Variance | 93.68 | 4.61 | 1.32 | 7,334.70 | 49.93 | 4.86 | 1.84 | 237.04 | 228.2 | 0.51 |
| Coeff. of Variation | 0.13 | 0.24 | 0.31 | 0.24 | 0.19 | 0.30 | 0.17 | 0.35 | 0.25 | 0.22 |
| A2 | | | | | | | | | | |
| Variance | 782.98 | 1.98 | 1.63 | 10,829.70 | 0 | 4.02 | 1.48 | 70.94 | 71.62 | 0.78 |
| Coeff. of Variation | 0.38 | 0.16 | 0.36 | 0.36 | 0 | 0.10 | 0.12 | 0.22 | 0.15 | 0.37 |
| A3 | | | | | | | | | | |
| Variance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B1 | | | | | | | | | | |
| Variance | 706.05 | 25.75 | 6.97 | 60,714.40 | 169.90 | 6.41 | 29.98 | 1,598.76 | 687.97 | 4.82 |
| Coeff. of Variation | 0.37 | 0.37 | 0.53 | 0.56 | 0.26 | 0.11 | 0.33 | 0.56 | 0.36 | 0.60 |
| C1 | | | | | | | | | | |
| Variance | 127.62 | 38.60 | 0 | 10,737.84 | 74.07 | 5.84 | 8.06 | 673.81 | 114.56 | 0.78 |
| Coeff. of Variation | 0.43 | 0.35 | 0 | 0.16 | 0.13 | 0.12 | 0.19 | 0.25 | 0.12 | 0.18 |
| D1 | | | | | | | | | | |
| Variance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E1 | | | | | | | | | | |
| Variance | 1,119.27 | 210.14 | 0 | 0 | 460.07 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0.64 | 1.74 | 0 | 0 | 0.51 | 0 | 0 | 0 | 0 | 0 |

(continued)

Table A-28 -- (cont'd.)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| E2 | | | | | | | | | | |
| Variance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E3 | | | | | | | | | | |
| Variance | 330.38 | 33.74 | 0 | 0 | 248.30 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0.47 | 0.59 | 0 | 0 | 0.39 | 0 | 0 | 0 | 0 | 0 |

F1 through G3 have only one detailed soil for each intermediate soil and hence, there are no variances.

$$\text{Variance} = {}^{2} = \frac{(Y_i - Y)^2}{n-1}$$

$$\text{Coefficient of Variation} = \overline{\quad Y}$$

Table A-29 -- Variance and Coefficient of Variation of Detailed Yield Estimates Within the Respective Aggregate Weighted Yield

| Aggregate PPA | Rice | Tobacco | Plantain | Banana | Sugar Cane | Corn | Beans | Yucca | Sweet Potatoes | Cocoa |
|---|---|---|---|---|---|---|---|---|---|---|
| I1 | | | | | | | | | | |
| Variance | 93.68 | 4.61 | 1.32 | 7,334.70 | 49.93 | 4.86 | 1.84 | 237.04 | 228.2 | 0.51 |
| Coeff. of Variation | 0.13 | 0.24 | 0.31 | 0.24 | 0.19 | 0.30 | 0.17 | 0.35 | 0.25 | 0.22 |
| I2 | | | | | | | | | | |
| Variance | 1,424.34 | 2.44 | 0.02 | 5,070.08 | 0 | 5.14 | 2.96 | 107.06 | 1.62 | 0.34 |
| Coeff. of Variation | 0.48 | 0.19 | 0.05 | 0.30 | 0 | 0.11 | 0.16 | 0.29 | 0.02 | 0.29 |
| I3 | | | | | | | | | | |
| Variance | 74.27 | 6.89 | 3.01 | 22,689.30 | 257.31 | 56.95 | 23.73 | 379.73 | 193.50 | 1.92 |
| Coeff. of Variation | 0.10 | 0.29 | 0.40 | 0.32 | 0.31 | 0.39 | 0.37 | 0.38 | 0.21 | 0.36 |
| II1 | | | | | | | | | | |
| Variance | 847.49 | 28.37 | 5.41 | 29,274.80 | 63.02 | 5.12 | 28.37 | 1,086.33 | 317.81 | 3.15 |
| Coeff. of Variation | 0.43 | 0.43 | 0.48 | 0.49 | 0.17 | 0.10 | 0.36 | 0.53 | 0.26 | 0.53 |
| II2 | | | | | | | | | | |
| Variance | 939.09 | 41.68 | 17.09 | 27,420.60 | 229.42 | 19.80 | 18.79 | 1,587.96 | 748.43 | 3.89 |
| Coeff. of Variation | 0.69 | 0.39 | 1.87 | 0.24 | 0.25 | 0.20 | 0.28 | 0.43 | 0.34 | 0.43 |
| II3 | | | | | | | | | | |
| Variance | 413.12 | 21.41 | 1.24 | 15,719.17 | 114.68 | 22.13 | 32.69 | 452.02 | 137.16 | 0.96 |
| Coeff. of Variation | 0.28 | 0.37 | 0.30 | 0.27 | 0.22 | 0.23 | 0.38 | 0.34 | 0.18 | 0.27 |
| III1 | | | | | | | | | | |
| Variance | 1,016.99 | 49.92 | 0 | 0 | 3,409.12 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0.46 | 0.88 | 0 | 0 | 0.50 | 0 | 0 | 0 | 0 | 0 |

(continued)

Table A-29 -- (cont'd.)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| III2 | | | | | | | | | | |
| Variance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III3 | | | | | | | | | | |
| Variance | 312.90 | 29.82 | 0 | 0 | 257.33 | 0 | 0 | 0 | 0 | 0 |
| Coeff. of Variation | 0.47 | 0.51 | 0 | 0 | 0.38 | 0 | 0 | 0 | 0 | 0 |

Table A-30 -- Bias Between Intermediate and Detailed Yield Estimates

| Intermediate | Rice | Tobacco | Plantain | Banana | Sugar Cane | Corn | Beans | Yucca | Sweet Potatoes | Cocao | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PPA | % | | | | | | | | | | |
| A1 | 13.4 | 56.6 | 26.2 | 56.6 | 64.4 | 49.8 | 44.3 | 78.1 | 38.1 | 56.6 | |
| A2 | 10.5 | 39.8 | 52.5 | 50.4 | 20.0 | -6.4 | -7.1 | 57.0 | 44.1 | 88.0 | |
| A3 | -12.5 | 167.6 | 79.2 | 50.0 | 25.0 | 14.3 | - | 40.0 | 33.3 | 16.7 | |
| B1 | 91.0 | 46.8 | 34.2 | 34.2 | 45.3 | 26.4 | 9.4 | 56.6 | 55.3 | 59.1 | |
| C1 | 102.4 | 19.9 | - | 45.6 | -6.1 | 15.4 | 7.1 | 21.5 | 37.2 | 7.8 | |
| D1 | -20.0 | -25.0 | - | - | 20.0 | - | - | - | - | - | |
| E1 | 3.8 | 67.7 | - | - | 16.6 | - | - | - | - | - | |
| E2 | -30.1 | 50.0 | - | - | -33.3 | - | - | - | - | - | |
| E3 | 20.5 | -76.0 | - | - | -58.1 | - | - | - | - | - | |
| F1 | - | -25.0 | - | 50.0 | 28.6 | -14.3 | - | 60.0 | 20.0 | 60.0 | |
| F2 | - | -25.0 | - | -44.4 | 14.3 | -28.6 | 14.3 | 40.0 | 40.0 | - | |
| G1 | -50.0 | 233.3 | 39.6 | 16.7 | 25.0 | -14.3 | 14.3 | 100.0 | 66.7 | 66.7 | |
| G2 | -33.3 | 75.0 | 100.0 | 66.7 | 15.8 | -20.0 | 50.0 | 133.3 | 50.0 | 66.7 | |
| G3 | -85.7 | -20.0 | - | -20.0 | 20.0 | 40.0 | 75.0 | 66.7 | - | - | |
| Times Positive (no.) | 6 | 9 | 6 | 8 | 11 | 5 | 7 | 10 | 9 | 8 | 79 |
| Times Negative (no.) | 6 | 4 | 0 | 2 | 3 | 5 | 1 | 0 | 0 | 0 | 21 |

Table A-31 -- Bias Between Aggregate and Detailed Yield Estimates

| Aggregate | Rice | Tobacco | Plantain | Banana | Sugar Cane | Corn | Beans | Yucca | Sweet Potatoes | Cocao | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PPA | | | | | | % | | | | | |
| I1 | 13.4 | 56.6 | 26.2 | 56.6 | 64.4 | 49.8 | 44.3 | 78.1 | 38.1 | 56.6 | |
| I2 | 4.4 | 32.5 | 26.3 | 37.3 | 33.9 | -21.0 | -25.3 | 46.4 | 21.2 | 79.2 | |
| I3 | -26.0 | 124.0 | 67.9 | 62.4 | 34.6 | 50.2 | 25.2 | 95.3 | 40.0 | 28.3 | |
| II1 | 93.2 | 46.3 | 18.0 | 100.6 | 52.2 | 43.1 | 25.1 | 99.0 | 76.1 | 40.6 | |
| II2 | 76.4 | 33.5 | -7.9 | 50.6 | 11.8 | 2.2 | 63.2 | 90.9 | 46.6 | 71.4 | |
| II3 | -33.2 | 61.7 | 44.9 | 55.5 | 11.0 | 14.4 | 14.8 | 43.2 | 46.5 | 24.6 | |
| III1 | 32.4 | 68.0 | - | - | 21.8 | - | - | - | - | - | |
| III2 | -40.0 | 50.0 | - | 100.0 | -33.3 | - | - | - | - | - | |
| III3 | 10.7 | -45.3 | - | - | -31.9 | - | - | - | - | - | |
| Times Positive (no.) | 6 | 8 | 5 | 7 | 7 | 5 | 5 | 6 | 6 | 6 | 61 |
| Times Negative (no.) | 3 | 1 | 1 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 9 |

Table A-32. — Differences Between Crop Transportation Flows of the Detailed, Intermediate, and Aggregate Models - Benchmark Run

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | SUPPLY REGIONS DETAILED --1000-- | | | INTERMEDIATE --1000-- | | | AGGREGATE --1000-- | | |
|---|---|---|---|---|---|---|---|---|---|
| | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST |
| RICE (QQ) | | | | | | | | | |
| EAST | 237.4 | 96.1 | 206.5 | 540.0 | | | 540.0 | | |
| CENTRAL | | | 810.0 | | 287.5 | 522.5 | 158.2 | 158.5 | 493.2 |
| WEST | | | 270.0 | | | 270.0 | | | 270.0 |
| SANTO DOMINGO | 1080.0 | | | 1080.0 | | | 1080.0 | | |
| SUBTOTAL | 1317.4 | 96.1 | 1286.5 | 1620.0 | 287.5 | 792.5 | 1778.2 | 158.5 | 763.2 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 22.2 | 357.4 | 85.4 | 34.4 | 348.3 | 82.3 | 29.6 | 370.9 | 64.5 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 22.2 | 357.4 | 85.4 | 34.4 | 348.3 | 82.3 | 29.6 | 370.9 | 64.5 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | | 42.7 | 69.3 | 23.8 | 49.0 | 39.2 | | 23.4 | 88.6 |
| CENTRAL | | | 72.0 | | | 72.0 | | | 72.0 |
| WEST | | | 40.0 | | | 40.0 | | | 40.0 |
| SANTO DOMINGO | 173.6 | 2.4 | | 176.0 | | | 149.3 | 26.7 | |
| SUBTOTAL | 173.6 | 45.1 | 181.3 | 199.8 | 49.0 | 151.2 | 149.3 | 50.1 | 200.6 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 335.0 | | | 2111.9 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 6.1 | 1467.9 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 3347.0 | | 6.1 | 5120.8 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 150.0 | | | 223.4 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | .8 | 11.3 | 137.9 | .7 | 14.2 | 135.1 |
| SUBTOTAL | .8 | 12.8 | 353.5 | .8 | 11.3 | 287.9 | .7 | 14.2 | 358.5 |
| CORN (QQ) | | | | | | | | | |
| EAST | 22.8 | .2 | | 23.0 | | | 23.0 | | |
| CENTRAL | | 92.0 | | 41.0 | 51.0 | | 62.1 | 29.9 | |
| WEST | | 5.6 | 17.4 | 18.2 | | 4.8 | 13.6 | | 9.4 |
| SANTO DOMINGO | 322.0 | | | 322.0 | | | 322.0 | | |
| SUBTOTAL | 344.8 | 97.8 | 17.4 | 404.2 | 51.0 | 4.8 | 420.7 | 29.9 | 9.4 |

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Table A-32. -- (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| BEANS (QQ) | | | | | | | | | |
| EAST | 70.0 | | | 70.0 | | | 70.0 | | |
| CENTRAL | 8.0 | 37.0 | | 8.0 | 37.0 | | 17.9 | 27.1 | |
| WEST | 23.5 | | 1.5 | | | 25.0 | 18.0 | | 7.0 |
| SANTO DOMINGO | 110.0 | | | 110.0 | | | 110.0 | | |
| SUBTOTAL | 211.4 | 37.0 | 1.5 | 188.0 | 37.0 | 25.0 | 215.9 | 27.1 | 7.0 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 497.0 | | | 524.4 | | | 904.6 | | |
| CENTRAL | | 319.5 | | 121.9 | 197.6 | | 155.3 | 164.2 | |
| WEST | 157.8 | 5.3 | 14.5 | 157.6 | | 19.9 | 131.1 | | 46.4 |
| SANTO DOMINGO | 781.0 | | | 781.0 | | | 781.0 | | |
| SUBTOTAL | 1435.8 | 324.8 | 14.5 | 1585.0 | 197.6 | 19.9 | 1972.0 | 164.2 | 46.4 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 316.4 | | | 316.4 | | | 523.7 | | |
| CENTRAL | 2.9 | 200.5 | | 58.2 | 145.2 | | 82.6 | 120.8 | |
| WEST | | | 113.0 | 58.6 | | 54.4 | 80.1 | | 32.9 |
| SANTO DOMINGO | 497.2 | | | 497.2 | | | 497.2 | | |
| SUBTOTAL | 816.5 | 200.5 | 113.0 | 930.4 | 145.2 | 54.4 | 1183.5 | 120.8 | 32.9 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 20.2 | | | 14.0 | | |
| CENTRAL | | 4.7 | | | 5.3 | | | 5.0 | |
| WEST | | .7 | .1 | | .4 | .4 | | | 1.2 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 56.2 | 5.7 | .4 | 50.0 | 5.0 | 1.2 |

Table A-33. -- Differences Between Area, Production, and Cost of the Detailed, Intermediate, and Aggregate Models - Growth Run

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE NOT WEIGHTED | | | | | | | | | |
| RICE (QQ) | | | | | | | | | |
| EAST | 12813.7 | 12917.6 | 14814.2 | 1616.7 | 1959.9 | 2321.6 | 14869.6 | 15516.7 | 17992.4 |
| CENTRAL | 1479.5 | 3160.1 | 1621.0 | 131.5 | 487.5 | 155.1 | 1693.5 | 3914.3 | 1879.6 |
| WEST | 14488.3 | 11294.4 | 11099.5 | 1491.8 | 792.5 | 763.2 | 15052.7 | 11550.1 | 11322.3 |
| SUBTOTAL | 28781.5 | 27372.1 | 27534.7 | 3240.0 | 3240.0 | 3240.0 | 31615.8 | 30981.1 | 31194.3 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | 642.1 | 645.2 | 483.9 | 29.4 | 41.7 | 29.6 | 335.5 | 337.1 | 252.8 |
| CENTRAL | 14858.9 | 14240.0 | 15270.7 | 414.8 | 433.9 | 463.9 | 7772.9 | 7527.2 | 8070.6 |
| WEST | 4550.6 | 3371.4 | 2779.5 | 113.8 | 82.4 | 64.5 | 2393.3 | 1761.3 | 1452.1 |
| SUBTOTAL | 20051.6 | 18256.6 | 18534.1 | 558.0 | 558.0 | 558.0 | 10501.6 | 9625.6 | 9775.6 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | 8258.6 | 9031.3 | 8407.9 | 208.5 | 262.9 | 198.7 | 4929.6 | 5398.8 | 4873.6 |
| CENTRAL | 2540.0 | 2509.1 | 2747.7 | 61.3 | 65.1 | 65.6 | 1517.3 | 1499.9 | 1642.5 |
| WEST | 13828.7 | 11117.0 | 11171.7 | 210.2 | 152.0 | 215.6 | 8174.2 | 6645.6 | 6678.3 |
| SUBTOTAL | 24627.2 | 22657.5 | 22327.3 | 480.0 | 480.0 | 480.0 | 14621.1 | 13544.4 | 13194.4 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 13.2 | 6.6 | 6.6 | 4.3 | 3.0 | 6.1 | 5.5 | 4.3 | 4.3 |
| WEST | 3991.5 | 3991.4 | 3991.4 | 4316.4 | 3350.0 | 5120.8 | 2621.0 | 2620.9 | 2620.9 |
| SUBTOTAL | 4004.7 | 3998.0 | 3998.0 | 4320.7 | 3353.0 | 5126.9 | 2626.5 | 2625.2 | 2625.2 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | 12.5 | 12.5 | 9.4 | .8 | .8 | .7 | 6.8 | 6.8 | 5.1 |
| CENTRAL | 191.5 | 191.5 | 207.3 | 12.8 | 11.3 | 14.2 | 104.7 | 104.7 | 113.3 |
| WEST | 8032.9 | 8033.0 | 8020.3 | 353.5 | 300.2 | 358.5 | 4391.4 | 4391.5 | 4384.5 |
| SUBTOTAL | 8236.9 | 8237.0 | 8237.0 | 367.1 | 312.2 | 373.4 | 4502.9 | 4503.0 | 4503.0 |
| CORN (QQ) | | | | | | | | | |
| EAST | 12431.4 | 10969.2 | 11065.5 | 443.1 | 486.2 | 511.5 | 2158.8 | 1355.1 | 1875.0 |
| CENTRAL | 2953.3 | 1301.3 | 903.0 | 101.3 | 58.7 | 30.4 | 464.8 | 216.0 | 160.2 |
| WEST | 317.9 | 175.0 | 275.1 | 7.6 | 7.1 | 10.1 | 45.9 | 30.7 | 49.1 |
| SUBTOTAL | 15702.6 | 12445.5 | 12243.5 | 552.0 | 552.0 | 552.0 | 2669.5 | 2102.3 | 2084.4 |

Table A-33. -- (cont'd.)

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE NOT WEIGHTED | | | | | | | | | |
| BEANS (QQ) | | | | | | | | | |
| EAST | 7359.4 | 7699.7 | 7528.1 | 257.1 | 264.6 | 263.8 | 1853.8 | 1948.6 | 1902.8 |
| CENTRAL | 1135.1 | 779.6 | 940.2 | 41.3 | 30.6 | 28.9 | 281.5 | 191.9 | 231.4 |
| WEST | 82.0 | 144.4 | 232.4 | 1.5 | 4.6 | 7.3 | 20.2 | 35.5 | 57.2 |
| SUBTOTAL | 8576.6 | 8623.7 | 8700.7 | 300.0 | 300.0 | 300.0 | 2155.5 | 2176.0 | 2191.5 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 15035.5 | 9820.4 | 9824.8 | 1756.4 | 1680.8 | 1972.0 | 3139.5 | 2075.8 | 2076.9 |
| CENTRAL | 2334.9 | 1749.3 | 1036.2 | 358.6 | 287.1 | 164.2 | 493.6 | 343.7 | 219.1 |
| WEST | 152.9 | 1104.6 | 302.5 | 15.0 | 162.1 | 46.4 | 32.2 | 182.5 | 64.0 |
| SUBTOTAL | 17523.3 | 12674.2 | 11163.6 | 2130.0 | 2130.0 | 2182.6 | 3665.3 | 2602.1 | 2359.9 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 6558.3 | 5079.3 | 4915.8 | 1007.3 | 976.3 | 1183.5 | 1552.6 | 1182.9 | 1142.0 |
| CENTRAL | 1112.7 | 1050.1 | 617.1 | 213.1 | 244.1 | 128.1 | 265.6 | 250.5 | 143.9 |
| WEST | 960.9 | 575.5 | 212.1 | 135.6 | 135.6 | 44.4 | 238.4 | 142.2 | 50.1 |
| SUBTOTAL | 8631.9 | 6704.9 | 5745.0 | 1356.0 | 1356.0 | 1356.0 | 2056.6 | 1575.6 | 1336.0 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 8388.1 | 8433.3 | 8451.9 | 37.8 | 56.2 | 50.0 | 1882.4 | 1892.6 | 1896.7 |
| CENTRAL | 868.6 | 823.2 | 674.5 | 5.6 | 5.7 | 5.0 | 194.9 | 184.7 | 151.4 |
| WEST | 56.5 | 56.3 | 186.6 | .1 | .4 | 1.2 | 12.7 | 12.6 | 41.9 |
| SUBTOTAL | 9313.2 | 9312.8 | 9313.0 | 43.5 | 62.3 | 56.3 | 2090.0 | 2089.9 | 2090.0 |
| INTERPLANTED (HECTARE) | | | | | | | | | |
| EAST | 23698.5 | 20646.4 | 14026.2 | ***** | ***** | ***** | 4569.1 | 3980.6 | 2704.3 |
| CENTRAL | 3014.0 | 2892.9 | 975.7 | ***** | ***** | ***** | 581.1 | 557.8 | 188.1 |
| WEST | 131.3 | 222.8 | 702.6 | ***** | ***** | ***** | 25.3 | 43.0 | 135.5 |
| SUBTOTAL | 26843.9 | 23762.2 | 15704.6 | ***** | ***** | ***** | 5175.5 | 4581.3 | 3027.8 |
| PASTURE (HECTARE) | | | | | | | | | |
| EAST | 4472.1 | 6809.0 | 6161.5 | ***** | ***** | ***** | ***** | ***** | ***** |
| CENTRAL | 438.0 | 438.0 | 257.0 | ***** | ***** | ***** | ***** | ***** | ***** |
| WEST | 6596.9 | 6597.0 | 7337.0 | ***** | ***** | ***** | ***** | ***** | ***** |
| SUBTOTAL | 11507.0 | 13844.0 | 13755.5 | ***** | ***** | ***** | ***** | ***** | ***** |

Table A-33. -- (cont'd.)

| CROP-REGION | AREA DETAILED | AREA INTERMEDIATE --HECTARE-- | AREA AGGREGATE | PRODUCTION DETAILED | PRODUCTION INTERMEDIATE --1000 UNITS-- | PRODUCTION AGGREGATE | COST DETAILED | COST INTERMEDIATE --1000 PESOS-- | COST AGGREGATE |
|---|---|---|---|---|---|---|---|---|---|
| YIELDS ARE NOT WEIGHTED | | | | | | | | | |
| IDLE CROPLAND (HECTARE) | | | | | | | | | |
| EAST | 19139.7 | 27296.7 | 33671.5 | ***** | ***** | ***** | ***** | ***** | ***** |
| CENTRAL | 2105.7 | 3393.6 | 7233.1 | ***** | ***** | ***** | ***** | ***** | ***** |
| WEST | 17087.1 | 23559.2 | 23931.3 | ***** | ***** | ***** | ***** | ***** | ***** |
| SUBTOTAL | 38332.5 | 54249.5 | 64835.9 | ***** | ***** | ***** | ***** | ***** | ***** |
| CROPLAND TOTAL | | | | | | | | | |
| EAST | 118809.9 | 119360.7 | 119360.7 | ***** | ***** | ***** | 35297.8 | 34195.0 | 34721.8 |
| CENTRAL | 33045.4 | 32535.4 | 32490.1 | ***** | ***** | ***** | 13375.4 | 14795.7 | 12804.6 |
| WEST | 70277.6 | 70242.1 | 70242.1 | ***** | ***** | ***** | 33007.3 | 27416.0 | 26855.8 |
| TOTAL | 222132.9 | 222138.1 | 222092.8 | ***** | ***** | ***** | 81680.4 | 76406.6 | 74382.1 |

Table A-34. -- Differences Between Crop Transportation Flows of the Detailed, Intermediate, and Aggregate Models - Growth Run

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | SUPPLY REGIONS DETAILED --1000-- | | | SUPPLY REGIONS INTERMEDIATE --1000-- | | | SUPPLY REGIONS AGGREGATE --1000-- | | |
|---|---|---|---|---|---|---|---|---|---|
| | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST | EAST | CENTRAL | WEST |
| **RICE (QQ)** | | | | | | | | | |
| EAST | 320.7 | 131.5 | 195.8 | 648.0 | | | 648.0 | | |
| CENTRAL | | | 972.0 | 15.9 | 487.5 | 468.5 | 377.6 | 155.1 | 439.2 |
| WEST | | | 324.0 | | | 324.0 | | | 324.0 |
| SANTO DOMINGO | 1296.0 | | | 1296.0 | | | 1296.0 | | |
| SUBTOTAL | 1616.7 | 131.5 | 1491.8 | 1959.9 | 487.5 | 792.5 | 2321.6 | 155.1 | 763.2 |
| **TOBACCO (QQ)** | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 29.4 | 414.8 | 113.8 | 41.7 | 433.9 | 82.4 | 29.6 | 463.9 | 64.5 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 29.4 | 414.8 | 113.8 | 41.7 | 433.9 | 82.4 | 29.6 | 463.9 | 64.5 |
| **PLANTAIN (MILLAR)** | | | | | | | | | |
| EAST | | 58.6 | 75.8 | 51.7 | 65.1 | 17.6 | | 53.2 | 81.2 |
| CENTRAL | | | 86.4 | | | 86.4 | | | 86.4 |
| WEST | | | 48.0 | | | 48.0 | | | 48.0 |
| SANTO DOMINGO | 208.5 | 2.7 | | 211.2 | | | 198.7 | 12.5 | |
| SUBTOTAL | 208.5 | 61.3 | 210.2 | 262.9 | 65.1 | 152.0 | 198.7 | 65.6 | 215.6 |
| **BANANA (STALK)** | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 335.0 | | | 2111.9 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 6.1 | 1467.9 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 3347.0 | | 6.1 | 5120.8 |
| **SUGAR CANE (MT)** | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 150.0 | | | 223.4 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | .8 | 11.3 | 137.9 | .7 | 14.2 | 135.1 |
| SUBTOTAL | .8 | 12.8 | 353.5 | .8 | 11.3 | 287.9 | .7 | 14.2 | 358.5 |
| **CORN (QQ)** | | | | | | | | | |
| EAST | 27.6 | | | 27.6 | | | 27.6 | | |
| CENTRAL | 29.1 | 81.3 | | 51.7 | 58.7 | | 80.0 | 30.4 | |
| WEST | | 20.0 | 7.6 | 20.5 | | 7.1 | 17.5 | | 10.1 |
| SANTO DOMINGO | 386.4 | | | 386.4 | | | 386.4 | | |
| SUBTOTAL | 443.1 | 101.3 | 7.6 | 486.2 | 58.7 | 7.1 | 511.5 | 30.4 | 10.1 |

Table A-34. -- (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| BEANS (QQ) | | | | | | | | | |
| EAST | 84.0 | | | 84.0 | | | 84.0 | | |
| CENTRAL | 12.7 | 41.3 | | 23.2 | 30.8 | | 25.1 | 28.9 | |
| WEST | 28.5 | | 1.5 | 25.4 | | 4.6 | 22.7 | | 7.3 |
| SANTO DOMINGO | 132.0 | | | 132.0 | | | 132.0 | | |
| SUBTOTAL | 257.1 | 41.3 | 1.5 | 264.6 | 30.8 | 4.6 | 263.8 | 28.9 | 7.3 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 596.4 | | | 596.4 | | | 649.0 | | |
| CENTRAL | 24.8 | 358.6 | | 96.3 | 287.1 | | 219.2 | 164.2 | |
| WEST | 198.0 | | 15.0 | 50.9 | | 162.1 | 166.6 | | 46.4 |
| SANTO DOMINGO | 937.2 | | | 937.2 | | | 937.2 | | |
| SUBTOTAL | 1756.4 | 358.6 | 15.0 | 1680.8 | 287.1 | 162.1 | 1972.0 | 164.2 | 46.4 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 379.7 | | | 379.7 | | | 379.7 | | |
| CENTRAL | 31.0 | 213.1 | | | 244.1 | | 116.0 | 128.1 | |
| WEST | | | 135.6 | | | 135.6 | 91.2 | | 44.4 |
| SANTO DOMINGO | 596.6 | | | 596.6 | | | 596.6 | | |
| SUBTOTAL | 1007.3 | 213.1 | 135.6 | 976.3 | 244.1 | 135.6 | 1183.5 | 128.1 | 44.4 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 20.2 | | | 14.0 | | |
| CENTRAL | | 4.7 | | | 5.3 | | | 5.0 | |
| WEST | | .7 | .1 | | .4 | .4 | | | 1.2 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 56.2 | 5.7 | .4 | 50.0 | 5.0 | 1.2 |

Table A-35. -- Differences Between Crop Transportation Flows of the Detailed, Intermediate, and Aggregate Models - Growth/Shift Run

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | SUPPLY REGIONS DETAILED EAST | DETAILED CENTRAL --1000-- | DETAILED WEST | INTERMEDIATE EAST | INTERMEDIATE CENTRAL --1000-- | INTERMEDIATE WEST | AGGREGATE EAST | AGGREGATE CENTRAL --1000-- | AGGREGATE WEST |
|---|---|---|---|---|---|---|---|---|---|
| RICE (QQ) | | | | | | | | | |
| EAST | | 128.2 | 357.8 | 486.0 | | | 486.0 | | |
| CENTRAL | | | 972.0 | | 341.5 | 630.5 | 215.6 | 155.1 | 601.2 |
| WEST | | | 162.0 | | | 162.0 | | | 162.0 |
| SANTO DOMINGO | 1616.7 | 3.3 | | 1620.0 | | | 1620.0 | | |
| SUBTOTAL | 1616.7 | 131.5 | 1491.8 | 2106.0 | 341.5 | 792.5 | 2321.6 | 155.1 | 763.2 |
| TOBACCO (QQ) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | 29.4 | 414.8 | 113.8 | 41.3 | 434.3 | 82.4 | 29.6 | 463.9 | 64.5 |
| WEST | | | | | | | | | |
| SANTO DOMINGO | | | | | | | | | |
| SUBTOTAL | 29.4 | 414.8 | 113.8 | 41.3 | 434.3 | 82.4 | 29.6 | 463.9 | 64.5 |
| PLANTAIN (MILLAR) | | | | | | | | | |
| EAST | | 34.6 | 90.2 | 26.6 | 66.2 | 32.0 | | 29.2 | 95.6 |
| CENTRAL | | | 81.6 | | | 81.6 | | | 81.6 |
| WEST | | | 38.4 | | | 38.4 | | | 38.4 |
| SANTO DOMINGO | 208.5 | 26.7 | | 235.2 | | | 198.7 | 36.5 | |
| SUBTOTAL | 208.5 | 61.3 | 210.2 | 261.8 | 66.2 | 152.0 | 198.7 | 65.6 | 215.6 |
| BANANA (STALK) | | | | | | | | | |
| EAST | | | 938.0 | | | 938.0 | | | 938.0 |
| CENTRAL | | | 603.0 | | | 603.0 | | | 603.0 |
| WEST | | | 1305.7 | | | 335.0 | | | 2111.9 |
| SANTO DOMINGO | | 4.3 | 1469.7 | | 3.0 | 1471.0 | | 6.1 | 1467.9 |
| SUBTOTAL | | 4.3 | 4316.4 | | 3.0 | 3347.0 | | 6.1 | 5120.8 |
| SUGAR CANE (MT) | | | | | | | | | |
| EAST | | | | | | | | | |
| CENTRAL | | | | | | | | | |
| WEST | | | 217.1 | | | 150.0 | | | 223.4 |
| SANTO DOMINGO | .8 | 12.8 | 136.4 | .8 | 11.3 | 137.9 | .7 | 14.2 | 135.1 |
| SUBTOTAL | .8 | 12.8 | 353.5 | .8 | 11.3 | 237.9 | .7 | 14.2 | 358.5 |
| CORN (QQ) | | | | | | | | | |
| EAST | 22.1 | | | 22.1 | | | 22.1 | | |
| CENTRAL | 19.4 | 91.0 | | 29.0 | 81.4 | | 60.0 | 30.4 | |
| WEST | | 10.2 | 11.8 | 15.0 | | 7.1 | 12.0 | | 10.1 |
| SANTO DOMINGO | 397.4 | | | 397.4 | | | 397.4 | | |
| SUBTOTAL | 438.9 | 101.3 | 11.8 | 463.5 | 81.4 | 7.1 | 511.5 | 30.4 | 10.1 |

Table A-35. — (cont'd.)

| CROP REQUIREMENT REGIONS YIELDS ARE NOT WEIGHTED | DETAILED | | | SUPPLY REGIONS INTERMEDIATE | | | AGGREGATE | | |
|---|---|---|---|---|---|---|---|---|---|
| | EAST | CENTRAL --1000-- | WEST | EAST | CENTRAL --1000-- | WEST | EAST | CENTRAL --1000-- | WEST |
| BEANS (QQ) | | | | | | | | | |
| EAST | 78.0 | | | 78.0 | | | 78.0 | | |
| CENTRAL | 9.7 | 41.3 | | 18.0 | 33.0 | | 22.1 | 28.9 | |
| WEST | 22.5 | | 1.5 | 19.4 | | 4.6 | 16.7 | | 7.3 |
| SANTO DOMINGO | 147.0 | | | 147.0 | | | 147.0 | | |
| SUBTOTAL | 257.1 | 41.3 | 1.5 | 262.4 | 33.0 | 4.6 | 263.8 | 28.9 | 7.3 |
| YUCCA (QQ) | | | | | | | | | |
| EAST | 553.8 | | | 553.8 | | | 606.4 | | |
| CENTRAL | 3.5 | 358.6 | | 77.9 | 284.2 | | 197.9 | 164.2 | |
| WEST | 155.4 | | 15.0 | | | 170.4 | 124.0 | | 46.4 |
| SANTO DOMINGO | 1043.7 | | | 1043.7 | | | 1043.7 | | |
| SUBTOTAL | 1756.4 | 358.6 | 15.0 | 1675.4 | 284.2 | 170.4 | 1972.0 | 164.2 | 46.4 |
| SWEET POTATOES (QQ) | | | | | | | | | |
| EAST | 352.6 | | | 352.6 | | | 352.6 | | |
| CENTRAL | 17.4 | 213.1 | | | 230.5 | | 102.4 | 128.1 | |
| WEST | | | 108.5 | | | 108.5 | 64.1 | | 44.4 |
| SANTO DOMINGO | 664.4 | | | 664.4 | | | 664.4 | | |
| SUBTOTAL | 1034.4 | 213.1 | 108.5 | 1017.0 | 230.5 | 108.5 | 1183.5 | 128.1 | 44.4 |
| COCOA (QQ) | | | | | | | | | |
| EAST | 2.0 | | | 20.2 | | | 14.0 | | |
| CENTRAL | | 4.7 | | | 5.3 | | | 5.0 | |
| WEST | | .7 | .1 | | .4 | .4 | | | 1.2 |
| SANTO DOMINGO | 35.8 | .2 | | 36.0 | | | 36.0 | | |
| SUBTOTAL | 37.8 | 5.6 | .1 | 56.2 | 5.7 | .4 | 50.0 | 5.0 | 1.2 |