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DEVELOPMENT AND INSTITUTIONALIZATION OF AGRICULTURAL RESOURCE PLANNING CONCEPTS AND PROCEDURES IN DEVELOPING COUNTRIES

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ABSTRACT

This report documents the development and adaptation of agricultural resource planning concepts and procedures for use in developing countries. Major concepts were those applicable to land resource delineation, major land use delineation, and the disaggregation of agricultural production and cropping pattern statistics to land resource delineations. The procedures used in the five developing countries are discussed. A limited discussion is presented on the design and application of two information systems that manage information obtained by inventory and assessment. The goals, purposes, and products of institutionalization activities in each of the five countries are presented.

Keywords: Agricultural planning; resource delineation; resource use; internalization methods.

ACKNOWLEDGEMENTS

The concepts and procedures discussed in this report were developed by the project staff in its provision of technical assistance to five developing countries. The summarizations of concepts and procedures presented were drawn from country-level working documents prepared for each country. Institutionalization activities reflect the efforts of the CRIES project staff with chief responsibilities in each country. These people were Gary Kemph, Mark Cochran, John Sutton, Dan Kugler, James B. Johnson, and John Putman. Appendix A of this report was submitted to the project by Gary Kemph at the culmination of his assignment as the project resident in the Dominican Republic. The views presented in his end-of-assignment report are his own; incorporation of his report does not imply concurrence in his views by other members of the project staff. This draft of this report benefited considerably from review comments submitted by other project participants. John Sutton was instrumental in the incorporation of the review comments in this draft.

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FOREWORD

This report is part of an effort by the Comprehensive Resource Inventory and Evaluation System (CRIES) Project to develop, adapt, and document general procedures for classifying, inventorying, and analyzing, on a national basis the extent, current use, and agricultural development potential of land resources.[1/] The work is joint between the U.S. Department of Agriculture (USDA) and Michigan State University (MSU) in cooperation with the U.S. Agency for International Development under PASA #AG/TAB 263-14-76. Participation of MSU is covered under Research Agreement #12-17-07-8-1955 between the USDA and MSU.

The CRIES project uses a multidisciplinary approach to assist developing countries in analyzing their agricultural production potential and to enhance their capabilities to conduct analyses for country-level policy evaluations. The CRIES staff collaborates with country representatives to design information acquisition and information management and analytical techniques tailored to the country's resource problems and needs. At the same time, CRIES retains a consistent approach to resource inventory procedures so that transfer of land resource information among countries may become feasible. Efforts are focused on the use of existing data, supplemented by primary data collection and informed judgement. The approach is designed to use reconnaissance-grade data sets to establish a single, nationally consistent resource information base and to develop in-country capability for systematic collection and refinement, and to undertake national-level assessments of agricultural production potential issues.

1/ "Land" is broadly considered to include not only the soil surface and profile but also naturally occurring vegetation, mineral deposits, and water resources as well as exposure to climatic features such as sunlight, temperature, precipitation, etc.

The report documents the development of land resource planning concepts and procedures for use in developing countries, the development of information management capabilities, and the development of analytical capabilities appropriate for land resource policy evaluation. A chronological presentation is used to discuss the development and institutionalization of concepts and procedures; the presentation is ordered in the same sequence as the technical assistance was provided to the five countries.[2/]

The section of this report on institutionalization discusses the project's linkages with participating country agencies; these agencies' use of project concepts, techniques, and products; and the training offered to collaborators from participating country agencies.

The overall intent of the report is to illustrate the pattern adaptation and development of the major concepts. There are apparent differences in the development of procedures to implement these concepts. There are also apparent differences in the abilities of developing countries to accommodate technical assistance in the different aspects of agricultural resource planning and policy analyses.

[2/] Dominican Republic, Costa Rica, Nicaragua, Syria, and Honduras.

SUMMARY

Since July 1976, the CRIES project has provided technical assistance and training in land resource inventory and analysis to the Dominican Republic, Costa Rica, Nicaragua, Syria, and Honduras. The intent of the assistance has been to provide a means for each country to evaluate, on a national level, policy alternatives directed at achieving agricultural production potential. Through these technical assistance and training activities the staff has developed and refined inventory and analytical concepts and procedures appropriate to the needs and conditions of the participating countries.

Land Inventory Concepts and Procedures

Development of the land resource inventory concepts and procedures has been dynamic. The latest modifications are found in the Syrian and Honduran efforts. Soil classification concepts of the USDA Soil Taxonomy have been the basis for the land resource inventory. Repeated attempts were made to introduce, in an explicit way, climate concepts into the resource inventory. It was, and still is, felt that such a comprehensive approach could provide the set of land resource information most suitable for agronomic interpretations of plant adaptability and productivity. Problems of classifying resource areas with a homogeneity in production potential sufficient for national analysis were encountered in the joint application of the USDA Soil Taxonomy and the CRIES-developed "Crop-Climate Taxonomy" because of the high correlation of parameters common to both. Currently, land resources are delineated according to soil taxonomic concepts with an accompanying description of general climatic conditions in the delineation.

The land resources of each country have been delineated into Resource Planning Units (RPUs) and Production Potential Areas (PPAs). RPUs are cartographically delineated units of land that are relatively uniform with respect to land

forms, kinds and patterns of soil bodies, and climate. They form legible map units on national-scale maps. RPUs are conceptually very similar to the Land Resource Areas delineated by the Soil Conservation Service, U.S. Department of Agriculture, in its Conservation Needs Inventory. RPUs provide the geographic reference for associated field work and the base for associating agronomic and economic information to PPAs for evaluation and analyses of agricultural production potential. PPAs are an aggregate of individual soil bodies and associated microclimates within an RPU. In contrast to RPUs, each PPA 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. The PPAs provide the base for agronomic interpretation and for future use in land resource information transfer. In one country, the agronomically homogeneous PPAs were grouped according to characteristics visually identifiable by non-soils scientists. This was useful in order to determine PPA land use.

Two levels of PPA agronomic interpretation, best represented in the Honduran and Syrian studies, have been made. In all cases, it must be emphasized that no recommendation of an economic nature has been made. In Honduras, interpretations for general agriculture concentrated on soil potential for cropland use under four types of cropland management and on limitations and restrictive features of the land resource base for production. In Syria, greater availability of resource data permitted making recommendations by PPA to denote where major crops or crop groups are adaptable and to provide some qualitative indications of crop yield potentials. The interpretations made for each country have varied because of the quantity and quality of natural resource data available for incorporation into the land resource inventory. Therefore, while inter-country transferability of CRIES land classification concepts per se is possible, the transferability of agronomic interpretations needs further research.

Land Use Inventory Concepts and Procedures

Several methods have been used to develop major land use estimates (cropland, rangeland, forest, urban, etc.) by RPU and then inferentially by PPA. The choice of methods has been a function of the availability and reliability of data sources. Association of major land use with RPUs allows assessments to be made of the proportions of land use suitable for agriculture that are currently under cultivation and/or grazing. Those areas suitable for agriculture but currently not used for agriculture can also be identified.

Some developing countries have "census" data suitable for establishing baseline information on current land use. Others have similar information collected annually. Both types of information are generally collected and summarized by internal political boundaries. Allocation systems are required to distribute these land use data to RPUs. In the absence of such data, visual interpretation of Landsat imagery has been used to develop maps of major land use and/or cover types. The mapped information on land use so derived is digitally recorded and referenced to the RPUs through the use of the Geographic Information System. Other uses have been made of such mapped information. Among the uses have been both the verification of national-level land use statistics and for strata delineations to be used in area sample frame construction. Sufficient experience has been gained in visual Landsat interpretation to identify major land use to be able to specify the appropriateness of its application and limitations in its use to potential users in developing countries.

Varying methods have been used to disaggregate cultivated agriculture areas to provide baseline information sets on cropping patterns and associated production statistics. The primary concept employed has been that of "crop occupation of land". Generally unavailable, except from mapped land use from Landsat imagery, were adequate measures of the physical (as compared to planted or harvested areas) areas of land used for agricultural purposes. Crop area harvested had to be inferentially reduced to physical land area available for crop production through the use of auxiliary data on crop calendars, multiple cropping patterns, and intercropping patterns to establish crude estimates of physical areas of land used for agricultural purposes by RPU.

Alternative concepts to the "crop occupation of land" concept are now being researched by the CRIES project staff. From experience gained in the Dominican Republic, a country in which considerable effort was directed towards primary data collection, it appears there may be considerable justification for pursuing the following sequence: (1) conduct the land resource inventory; (2) identify major land use by RPU by visually interpreting Landsat imagery or aerial photography; (3) use sample survey methods to determine farm types by PPA; and (4) use sample survey methods to identify farming systems by type of farm within PPA. It needs to be pointed out that this approach would generate much more reliable land use data than that done by "crop occupation of land". It would also be much more costly. Methods of identifying constraints and conditions for change in farming systems are also being researched through a review of available literature. The inter-country transferability of information on crop production techniques, crop yields, and production costs by crop by PPA needs to be researched further to determine the effects of cultural practices, customs, and institutional arrangements.

<u>Data and Information Management</u>

A Geographic Information System has been developed and used in each country to capture, verify, and analyze mapped information. Analytical results can be displayed in the form of statistical summaries and computer printer-maps. Typical products include area measurements of map units on single maps, overlay combinations of several maps, and two to nine-way cross-tabulations of data from a set of maps. Among the more important uses of the System has been the cross-referencing of major land use by RPU and political unit, and RPU by political unit. The intent in the development of this system as in other means of capturing and analyzing resource data has been to provide an effective but inexpensive tool for use by country personnel. Training modules have been developed and used for this System.

An Agroeconomic Information System has been developed to provide the capacity to capture, verify, and analyze socioeconomic data such as agricultural production, cost of production, and other information initially formatted in tabular data sets. Generalizing this System for use in many countries, as was done with the Geographic Information System, is not desireable given the radically different data sets and resource problems in each country. CRIES provided assistance in each country to begin the design of relevant aspects of an Agroeconomic Information System. The most complete Systems were developed in the Dominican Republic and Syria.

Information available from these two information systems were used in several economic analyses. The economic models used linear programming (Dominican Republic), goal programming with multiple objective functions (Costa Rica), and single equation econometric models (Syria) to estimate crop area planting responses to government-set target prices.

CRIES economic analysis activities were faced with several constraints. In particular, secondary data needed to measure impacts of alternative policy options were inadequate. Crop yield estimates expressed in relation to land resource characteristics were usually absent. Likewise, little useable secondary data were available from which to establish meaningful input/output relationships and production cost estimates.

Internalization

One of the general goals of the CRIES project relates to internalization. In particular, it has been a project goal to: "expand the number and enhance the capability of developing country personnel to construct and use such an information base and analytical system". Among the expected outputs of the project, that most specific to internalization was: "In-country capability to construct, refine, and utilize the system in each country as an integrated component of the sector planning activities". Short-term technical assistance and training, both in-country and in the U.S., and a resident advisor are the two methods used to internalize CRIES concepts and procedures.

The level of internalization achieved can probably best be viewed through the assessment of the outputs of the overall project activity and the means used to affect these outputs. In the Dominican Republic, a department-level staff, entitled SIEDRA, evolved as the unit to evaluate natural resource and agricultural issues for the Subsecretariate of Natural Resources, Secretariate of Agriculture. The unit, assisted by a resident agricultural eonomist, revised most of the major information sets initially developed by the CRIES project staff. These refined information sets provided national coverage, on a regional basis, of the natural resource base, land use, cropping patterns and practices, and production costs. Short-course offerings were used to strengthen use of soil classification, aerial photo and remote sensing interpretation, economic modelling, and information system management. These short-courses were enhanced by day-to-day technical guidance provided by a resident advisor.

An initial land inventory and associated interpretations, an evaluation of secondary sources of agricultural production data, and the Geographic Information System were provided to several Costa Rican agencies and institutions. Informal arrangements were established with the Technical Institute of Costa Rica, as well as with the Inter-American Institute of Agricultural Sciences (IICA). The Institute is continuing to use the initial information sets, concepts and procedures, and the Geographic Information System in its teaching and research programs.

Project activities were suspended in Nicaragua in late 1978 prior to the scheduled internalization phase of the technical assistance activity.

CRIES activities in Syria assisted the Syrian Arab Republic Government in the conduct of an agricultural sector assessment to be used in developing a five-year plan. The project was in place as a joint U.S.-Syrian activity for only the duration of the technical assistance. Syrian participants on the project were scheduled to be reassigned to their respective ministries at the culmination of the technical assistance activity. Training was provided in interpretation of major land use from Landsat imagery, in systems analysis, and in program implementation associated with the information management systems transferred to Syria.

The first phase of the Honduran activity, an inventory of priority resource issues, data and training needs, and a national land resource inventory, has been completed. The second phase, provision of short-term technical assistance in response to requests by the Honduran staff in the Ministry of Natural Resources, is being directed toward internalizing concepts and procedures of resource inventory and analysis.

INTRODUCTION

The Comprehensive Resource Inventory and Evaluation System (CRIES) project was initiated in 1976. The objective of the project was to:

> Adapt existing methodology and techniques in the design and testing of a computerized system for comprehensive land and water inventory and evaluation for agricultural planning purposes in the Dominican Republic and in one other Latin American country to be selected.

The goals of the activity were:

1. To assist two developing countries to develop their capability to identify and analyze the consequences of alternative policies, programs, and prospects for agricultural and rural development in terms of their own multiple economic and social goals.

2. To improve the information and analytical basis for making decisions on agricultural and rural development strategies, policies and investments.

3. To expand the number and enhance the capability of developing country planning personnel to construct and use such an information base and analytical system.

More specifically, the purposes of the activity were:

1. To select and apply techniques for collecting, classifying, collating and documenting data on a country's land and water resources, land use, production inputs and expected outputs for different technological options, production costs, and institutional constraints.

2. To establish a system, using existing data management techniques and analytical processes, for evaluating these data.

3. To demonstrate the analytical capabilities of this system and test the reliability and usefulness of the results.

4. To develop procedures for linking the resource data and analytical system into a complete sector analysis.

5. To internalize utilization of the techniques developed as part of the project and integrate the system with sector analysis activities in the countries.

The expected outputs of the activity were:

1. A data management and evaluation system capable of estimating the resource/production potential of a developing country applied specifically to the land and water resource data...

2. A data bank including information on land and water resources, production possibilities, and costs, technology options and institutional constraints for each country.

3. Selected analyses of resource constraints, production potentials, resource development programs, etc., for each country.

4. In-country capability to construct, refine, and utilize the system in each country as an integrated component of the sector planning activities (TA/AGR/ESP, March 30, 1976).

The procedures that were to be followed are described in the cited project proposal. Country activities were organized in two phases. The first phase would emphasize the development of methods for organizing and analyzing the basic information sets on agricultural resources and their use whereas the second phase would focus on the use of basic information sets and methods in actual sector planning situations.

The first phase in each country was to be completed in approximately 15 months. A nominal overlap of the two phases was intended with phase II lasting approximately two years to bring the overall project length in each country to three years. Phase I activities were initiated in the Dominican Republic in July 1976; in Nicaragua in May 1977; and in Costa Rica in May 1977. Phase II was initiated in the Dominican Republic in October 1977. Phase II was never formally initiated in Nicaragua and Costa Rica.

LAND RESOURCE PLANNING CONCEPTS AND PROCEDURES

CRIES has adapted U.S.-developed concepts and procedures to fulfill the specific needs of each country provided assistance. RPU/PPA resource inventory concepts have been modified as experience has been gained in each country. As the quality of the resource inventory is a function of both the concepts applied and data available, application of a uniform set of concepts does not assure uniformity in quality of the resource inventories. Methods used for identifying major land uses and for collecting cropping pattern and production statistics have also varied and have been a function of the availability and reliability of existing data sets.

The evolution of these concepts and procedures is addressed.

RPU/PPA Concepts and Procedures

The resource production unit (later to be renamed the resource planning unit) concept was initially explained in the project proposal as:

> The supply, quality, and location of land resource factors will be identified on series of overlays on a base map prepared from currently available editions of topographic maps at a scale of 1:1,000,000. ...
>
> The factors which will be mapped in the overlays are soil associations, climatic zones, and selected inherent constraints and development potentials. The combination of overlays will identify unique Resource Production Units (RPU) that are defined as geographic areas of land, usually several thousand hectares in extent, that are characterized as having similar patterns of soil, slope, climate, water resources, type of farming, productivity, problems, and potentials. RPU's may occur as one continuous area or as several separate but nearby areas. Some RPU's will be further subdivided into slope, problem, development and/or other relevant parameters which are too dispersed for map delineation by dividing the total area of mapping units into more detailed data units. At this level of detail, RPUs can be depicted by single-valued estimates of agricultural inputs and outputs which provide reliable analytical results for regional and national planning purposes (USAID, March 30, 1976)."6/

This definition provided for the subdivisions of RPUs that would be suitable for agronomic interpretations. Methods for obtaining the RPU delineations were:

> "The soil association overlays will be developed by revising existing soil maps using all available documented information about soils of the study area supplemented by field reconnaissance and consultation with local soil scientists. Soils will be classified in categories of Soil Taxonomy, the system of soil classification use by the National Cooperative Soil Survey and applicable to soil classification on a worldwide basis. In addition to kinds of soils, the nature of underlying materials and topographic features on which the soil associations occur will be identified. Each map unit of the soil association overlay will be described in terms of important component soils.
>
> While there is a high correlation between soils and climate of the areas where they occur, a more explicit evaluation of

> climatological data supplemented by techniques of correlating natural vegetation, cropping and weed patterns will be made and an overlay of climatic zones will be prepared. These climatic zones will consider altitude, seasonal and annual rainfall, temperature, growing season and other parameters relevant to plant growth and adaptability. In most cases, these boundaries will be co-extensive with the soil associations, but climatic subdivisions will be established if necessary.
>
> Other physical parameters to be incorporated into the land inventory are inherent conditions which exert constraints on land use and productivity (wetness, flooding, salinity, etc.), resource development potentials (irrigation, land clearing, etc.) and such insititutional constraints as lack of transportation. Large enough contiguous areas to be mapped will be identified in the overlays. Others of a more dispersed nature such as upstream flood plains, scattered wetlands, clearing and potential irrigated areas will be estimated as portions of RPUs for data purposes without precise map location.
>
> The final parameter considered, water, will be analyzed in terms of quantity and quality available for supplemental irrigation. It will be mapped and screened for proximity to suitable soils on a case-by-case basis and added and evaluated as a development potential where appropriate (ibid.).

To summarize, the RPUs were to be delimited with respect to soil association, climate, water quality and quantity, and development/institutional constraints. Inherent constraints and development potentials were to be described. Most RPUs were expected to be several thousand hectares in extent. Some RPUs were expected to be internally subdivided, based on slope or some other parameter, into more detailed data units homogeneous enough for agronomic interpretations.

Dominican Republic:

These initial land classification concepts were modified from experiences in the Dominican Republic (CRIES, December 1977).

> ... The land classification concept is based on two principal components -- soil resources and plant life zones. Later stratifications are made for irrigation, drainage, and political regions. The soil classification used is based upon

USDA's Soil Taxonomy (USDA, December 1975). The plant life zones are based upon "Life Zone Ecology" (Holdridge, 1967). Both of these components have systematic, hierarchial classification systems that are suitable and appropriate to create ranges for analysis at several levels of geographic detail.

The classification scheme employed by CRIES uses these two components to partition the land surface into Resource Production Units (RPU). Since the current level of CRIES analysis is national planning, the level of detail (number of RPUs and amount and degree of variability within them) was adjusted to create a manageable-sized data system with sufficient homogeneity within the geographic strata (RPUs) to produce reliable estimates of impacts from national policy changes. Where more detailed data are available, both component systems can be disaggregated for more microanalysis.

An RPU is specifically defined as a unit of land with components sufficiently homogeneous with respect to agrophysical factors of soil, climate, and water resources to be depicted by one or a few unique estimates of agricultural factors such as crop adaptability and input-output coefficients. Separate unique estimates of the agriculture factors for two or more dominant components are required for the RPUs in which the areas of major dissimilar soil components are larger than the smallest areas that can be considered for planning. These estimates are designed for national/regional agricultural policy-level analysis of resource use, potentials, and options. The soil map units and plant life zones on which these RPUs are based are associations of individual soils and ecosystems which have considerable variation on a farm-by-farm basis. These RPUs and attendant parameter estimates are not suitable and should not be used for detailed land use planning and evaluation of project and/or individual local situations without field analysis involving greater soil and agronomic detail. ...

In compiling the soil map for the Dominican Republic, the subgroup level of soil taxonomy was chosen as appropriate for national and regional agricultural resource planning. Phases of subgroups are adequately homogeneous to indicate their general potential for agricultural production by a single value in a model, yet few enough in number to keep the system within reasonable computational and comprehensible limits. ...

The classification and mapping of agrophysical plant life zones relied heavily on an ecological map, classification of Natural Life Zones or World Plant Formations prepared by Leslie R. Holdridge. This system permits a depiction of the relationship existing between climate and other environmental factors by quantitatively relating three climatic factors: biotemperature, precipitation, and humidity. ...

> For purposes of constructing RPUs of national planning scope, plant life zones were developed which were considered to support a relative homogeneous and characteristic group of plants when left undisturbed. With this characteristic in mind, the Holdridge map was re-evaluated by CRIES agronomists through field reconnaissance and review of secondary data and information. On this basis, a re-evaluation of actual boundaries on the map and redefinition of agronomic implications was used to integrate plant life zone concepts and boundaries with the soil map to create a RPU map. ...
>
> RPUs in the Dominican Republic were formed by overlaying the soil resource map with the revised and reinterpreted Holdridge plant life zone map and integrating the two concepts. The result is 37 RPU units which, in the professional judgement of the scientists involved, meet the homogeneity requirements of the RPU concept applied to national and regional planning. The detailed, quantifiable data (crop yields and associated production inputs at the soil family and series level) to conduct an analysis of variance and determine the exact way to stratify resources into optimal units for national planning are not available at this time (in 1977). Future work, to generate such data, would increase the precision and accuracy of analytical results by suggesting groupings which would future reduce heterogeneity.

The initial RPUs delineated in the Dominican Republic were each described by their predominant lands, climatic characteristics, soil characteristics, soil map units, and soil subgroups (See Figure 1).

An AID-appointed review team made the following judgements relative to the RPU concepts and the RPU delineations in the Dominican Republic:

> For purposes of CRIES, the RPU concept appears valid in trying to obtain working units of area sufficiently homogeneous with respect to agrophysical features so that average estimates of agricultural responses for each of the designated RPUs can be anticipated. ...
>
> It is also recognized by the CRIES study that actual agricultural responses will differ within the RPU as presently delineated and that only with more precise soil and plant life zone data (such as the family and series levels of soil classification) would such variation be eliminated. This refinement could ultimately result in more RPUs. ...
>
> The concept of RPU appears sound. On the basis of available data and their reliability, the criteria used for

Figure 1: Summary Table of Characteristics of a Selected RPU of the Dominican Republic, 1977

Soil Properties and Special Features		Soil Map Units				
		ITEe FP/A (4218)		IATa FP/A - VDCb FP/A (4112)		
		Subgroups		Subgroups		
		Fluventic Eutropepts	Aeric Tropic Fluvaquents	Typic Tropaquepts	Aquic Chromuderts	Fluvaquentic Eutropepts
Composition of Components	%	60	20	30	30	20
Slope	%	0-3	0-3	0-3	0-3	0-3
Depth to Bedrock	m	5	5	5	5	5
Soil Texture		mod. fine	mod. fine	fine	fine	fine
Coarse Fragments		nonstony	nonstony	nonstony	nonstony	nonstony
Permeability		moderate	moderate	very slow	very slow	mod. slow
Reaction		slightly acid	slightly acid	medium acid	slightly acid	slightly acid
Salinity		nonsaline	nonsaline	nonsaline	nonsaline	nonsaline
Available Water Capacity		high	moderate	moderate	moderate	high
Flooding		occasional	occasional	occasional	occasional	occasional
Soil Drainage Class		well drained	somewhat poorly drained	very poorly drained	somewhat poorly drained	mod. well drained
Base Saturation	%	50	50	50	50	50
Mean Annual Precipitation	mm	1600-2000		2000-2200		
Mean Annual Temperature	c	25-27		25-27		
Local Relief	m	5		5		
Elevation	m	2-60		0-20		
Parent Material		stream alluvium		stream alluvium		
Distribution of Map Units	%	50		50		

developing the RPU is perhaps the best alternative at this stage in the development of the project. However, qualifications of estimated coefficients for possible variance should be emphasized in the use of data and in results obtained from their use.

The number of RPUs developed for the Dominican Republic appears to be appropriate in light of the existing levels of classification of the two principal components -- soil resources and plant life zones, on which they are based. ...

The criteria use in defining the RPU are clearly specified in the Land Resource Base Report and the limitations are pointed out. Caution against misconceptions relative to equating RPU boundaries with soil boundaries and false expectations of things like homogeneous yields within the same RPU is sufficiently documented but many require continuing reiteration throughout the study and particularly in interpreting study results.

Basically, the CRIES project is an assemblage of preexisting resource inventory data and agricultural statistics into a planning format by which computer models can be formulated to assist in developmental decisions at the national level. Entry of the data into the computer is achieved for a country with a geographic cellular system consisting of cells of one square kilometer size. Information on soils and plant life zones is used to formulate areal RPUs to which all other statistical data are related as much as is possible. The RPU is essentially a regional planning area within the country to which resources can be allocated in developmental programs in accord with the production potential and the needs of the population (Arscott, March 1978).

Revision of the RPU concept began in the Dominican Republic in early 1978. Early attempts at field verification of production coefficients met with opposition from agriculturists who criticized the RPU being defined as a homogeneous unit to which one or a few input-output coefficients could be assigned. When observed in the field, an RPU would typically have both hills and valleys. Local technicians recognized that these land forms would have substantially different production potentials. It was decided that the grouping of the agronomically-similar dominant phases of soil subgroups within each RPU would capture the major differences noted in the field observations. Furthermore, groupings were largely done on the basis of visibly identifiable characteristics such as slope, soil depth, and soil drainage characteristics. The new analytical units within each RPU formed were referred to as Groupings of Dominant Soil Subgroups (GDSS) and are identified as unmapped percentages of each RPU map unit (CRIES, May 1979).

Costa Rica:

Land Resource Base Report: Costa Rica summarizes the classification system, methods, and materials for classification (CRIES, January 1980). Several changes were made in definitions (not necessarily concept), and nomenclature of the RPU and its composite unmapped portions and the methods used to make such delineations.

The RPUs were renamed as Resource Planning Units rather than Resource Production Units to avoid any connotation that the unit could be represented by single-value input-output coefficients for agricultural production. Concurrent with the development of the GDSS concept in the Dominican Republic, the CRIES staff developed the Production Potential Area (PPA) concept. PPAs were to be the unmapped but agronomically homogeneous components of the Resource Planning Unit.

RPUs and PPAs were defined as follows:

> Resource Planning Unit — A geographically-delineated unit of land (not necessarily contiguous) that is relatively uniform with respect to land form, kinds and patterns of soil bodies, climates, water resources, and potential vegetation.
>
> Production Potential Area — A PPA is an aggregate area of individual soil bodies and associated micro-climates within an RPU 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 and regional analysis and planning (CRIES, January 1980).

Efforts of CRIES to assemble a soil map of Costa Rica were coordinated with the Natural Resource Division of the Office of Agricultural Sector

Planning. A soil map was compiled on nine topographic sheets of 1:200,000 scale. Mapping units were based on associations of phases of soil subgroups.

A "Crop Climate Taxonomy" was developed to classify selected climatic conditions of Costa Rica. The system was designed to capture the major factors which influence plant life -- temperature, moisture, and light. Indicators of these factors were selected and defined in terms of standard weather records. Two levels of classification were conceptualized in the taxonomy -- primary and secondary. Primary level taxa were based upon day length, annual precipitation, and seasonality of precipitation. Primary categories were divided into secondary taxa using monthly precipitation during the wet season, average monthly temperature during the wet season, and the occurrence of frost.

Using the primary and secondary levels of the Crop Climate Taxonomy all Costa Rican weather stations were classified and located on topographic map sheets. Weather stations, once classified, were used to form the nuclei of the crop climate map units. Each map unit was delineated by drawing lines between nuclei made up of one to many stations. The positions of these lines on the crop climate map were fixed by a process that involved the field examination of terrain for changes in vegetation and cropping practices. Topography was also taken into account. Existing floristic material, especially the Holdridge Life Zone maps, was also used. At the primary and secondary levels of the Crop Climate Taxonomy, each map unit depicted associations of climates occurring in repeating patterns across areas or gradations to other climates.

The actual process of creating the Costa Rican RPU map involved superimposing transparent copies of the soil and crop climate maps over topographic maps that were used as reference maps. Areas uniform with respect to both climate and soil patterns were delineated as RPUs. Complete RPU descriptions were not developed for Costa Rica. Rather the 72 RPUs delineated were defined on summary sheets relative to dominant soil map units, dominant and subdominant soils and their percent composition of each RPU, primary crop climate taxa, range of average annual temperature and precipitation within each RPU, and seasonality of rainfall within each RPU. PPA descriptions were not provided for Costa Rica.

Due to the informal nature of the collaborature arrangements between the CRIES project and the participating Costa Rican institutions at the time of the distribution of the land resource inventory, no follow-up was made to determine the level of acceptance achieved or the refinements made in these RPU delineations.

Nicaragua:

The Plan of Study of Nicaragua called for the use of concepts and methods similar to those that were concurrently being employed in Costa Rica. Project activities in Nicaragua were suspended in September 1978. Prior to that date the national cadastral agency (CATASTRO), with some limited assistance from a CRIES soil scientist, completed a soils map at a scale of 1:250,000 using Soil Taxonomy. Field work was not conducted for the development of a crop-climate map. Therefore, no attempt was made to develop a Nicaraguan RPU map.

Syria:

The land resource inventory for Syria employed concepts and methods similar to those in Costa Rica. However, PPAs were described in detail and much more attention was directed towards interpretation of the land resource inventory completed in Syria.

In Syria, information about the kinds and distribution of soils was found mainly in generalized country studies and individual irrigation and drainage project studies. Data on the physical and chemical properties of the soils, and cultural practices were relatively meager. Syrian soil scientists supplemented the available documents with their personal knowledge and experience. Utilizing such sources and other available data on geology, climate, vegetation, topography, and geologic age, soils were reclassified in terms of Soil Taxonomy.

Climatological data were obtained from atlas and reference materials in Syria. Floristic data were obtained from a vegetation map of Syria and an accompanying plant list. Weather stations were located on working maps. Each of the 18 map units of the crop-climate map was delineated by constructing lines between nuclei made up of one or more weather stations with similar annual and wet season climatic characteristics. An input to this process was the field examination of the terrain for changes in vegetation and cropping practices.

The actual process of delineating RPUs involved superimposing transparent copies of the soil and crop climate maps over the topographic maps that were used as reference maps. Areas uniform in respect to both soils and climate were outlined. PPA delineations were influenced by several characteristics including annual climate, wet season climate, soils, and topography.

Initially the Syrian RPUs were described in general terms and the PPAs described by soil and climatic characteristics including taxonomic nomenclature for principal soil components and the crop climate zones. Participating country meterological specialists thoroughly reviewed the crop climate descriptions for the PPAs. They found the proxy variable latitude to be an inadequate indicator for temperature in the temperate areas of Syria. They also objected to the crop climate taxonomic nomenclature. Participating country specialists considered the taxonomic nomenclature to be redundant and conflicting with certain nomenclature of Soil Taxonomy. Their comments on redundacy were that the taxonomic names used to define the climate of the PPAs fully exhausted the information on climatic parameters (measured or inferred) and did not reference any higher order taxonomic class that would provide additional information useful to Syrian analysts in interpretation of agronomic conditions in the PPA. Certain terms used in the crop climate were common in nomemclature with terms in Soil Taxonomy.

In the revision of the RPU and PPA descriptions, the taxonomic names for the climatic conditions were deleted. All the descriptive information on the climatic parameters important to plant adaptability and productivity was retained. Those temperature parameter estimates that were inferred through the use of the proxy variable latitude were replaced by temperature values obtained through interpolation of the values reported in the Syrian climatic atlases.

The PPAs delineated for Syria provided the basis for interpretations for agricultural production. The distribution, size, and associations of the individual PPAs and their patterns with respect to other PPAs were specified to aid planners in screening management options for program implementation. The patterns of PPA distributions and the management constraints that they would impose were defined as follows:

> Intricately Patterned PPAs. When two or more PPAs generally occur in patterns composed mostly of individual PPA bodies of less than five hectares, they will be described as intricately patterned. For national planning, such PPAs are considered as a single unit and represented by a single-valued input coefficient (productive factors) and an output (yield) coefficient.

Finely Patterned. When two or more PPAs generally occur in patterns composed of individual PPA bodies usually larger than five hectares they will be described as finely patterned. For national planning, finely patterned PPAs are considered as individual units for most management options but carry size constraints for some program and project purposes.

Coarsely Patterned. When individual PPA bodies occur within an RPU in coarse patterns that are predominantly larger than 100 hectares, they are described as coarsely patterned. Such PPAs are treated as separate units for national planning.

Fifty-three RPUs ranging from 7,000 to 4,000,000 hectares were delineated. The majority were between 25,000 and 200,000 hectares. The RPUs tended to be relatively small in the intensive agricultural areas and large in the mountainous or arid expanses with limited agricultural potential. The number of PPAs per RPU ranged from one to four. Most RPUs contained coursely patterned PPAs.

Two levels of interpretation were made from the PPA descriptions. The first level was the general interpretation for agriculture. Ratings were provided for inherent productive capacity, susceptibility to erosion, and most intensive land use.

Inherent productivity denoted the capacity of the soil to produce acceptable yields of adapted crops. It was inferred from available information on soil minerology, parent materials, soil reaction, and moisture relationships. Ratings were very low, low, moderate, and high.

Susceptibility to erosion was inferred from soil type, range of slope, and soil texture (and without consideration of current land use or vegetative cover). Ratings were very low to slight, low, moderate, and severe.

The most intensive land use denoted the recommended use affording maximum sustained production of cultivated crops or permanent vegetation consistent with the potentials and limitations imposed by the soils and climate. The ratings were cropland, pastureland, rangeland, and woodland.

As a separate water resource and water use assessment, an activity not undertaken by CRIES in other countries, was completed for Syria and correlated to the land resource base information, more definitive statements about the most intensive land use were possible. Cropland use could be differentiated relative to irrigated and nonirrigated uses. The availability of water resource and use characteristics by RPU also assisted in the second level of interpretations, crop recommendations.

Major crop recommendations were made by PPA. They were intended to denote where major crops or major crop groups are adapted and provide some indication of yield potential under alternative management level. Yield potential ratings were qualitatively expressed as high, medium, or low.

When a crop or crop group was rated "high", conditions in the PPA were reported or inferred to be compatible with the known requirements of the crop or crop group. In the case of single crops, it was necessary to generalize requirements as though all varieties were similar. In the case of crop groups, it was necessary to generalize for different species. When a crop or crop group was rated "medium", conditions in the PPA were reported or inferred to be marginal, in one or more ways, with respect to the known requirements of the crop or crop group. In the case of crop groups, conditions may have been marginal for one or more crops in the group. A "high" rating implied a possibility of yield comparable to the upper values reported in agronomic literature for a given level of management. Similarly, a "medium" rating was intended to suggest that such high yields were unlikely to be obtained in the PPA. When a crop or crop group was rated low, conditions in the PPA were reported or inferred to be incompatible with several of the known requirements of the crop or a crop in the crop group. A "low" rating meant that yields could be expected to be highly variable from year to year. The"low" ratings were also used to acknowledge that crop with highly variable yields were traditionally cultivated to some extent in the PPA.

The crop groups employed for the recommendations in Syria were:

1.	small grains:	barley; wheat (soft and hard)
2.	fruit trees:	all woody perennials grown for fruit or nuts except olives, citrus, and grapes
	a. rosaceous fruit trees:	almonds, apples, apricots, cherries, peaches
	b. non-rosaceous fruit trees:	figs, pistachios, pomegranates
3.	oil crops:	peanuts, sesame, sunflower
4.	cotton:	all species of Gossypium (Malvaceae) by implication, but keyed mostly to the requirements of Gossypium herbaceum
5.	pulses:	chickpeas, haricot beans, lentils, vetches
6.	tuber/bulb crops:	garlic, onions, potatoes, sugar beets
7.	vegetables:	cucurbits (melons, squash, snake cucumbers, etc.); solanaceae crops (tomatoes, eggplants, etc.); cauliflower; brassicaceae crops (other than the above, by implication); okra
8.	olives	
9.	grapes	
10.	citrus	

Honduras:

The RPU and PPA delineations were developed for Honduras using procedures similar to those in Syria.

In Honduras information about the kinds and distribution of soils was found mainly in generalized studies dealing with the country as a whole or in major portion. Some additional detailed information was found in special studies such as a few large scale soil maps of small areas or those on soil related subjects such as land use, forestry, and climate. In general, data on the physical environment, the physical and chemical properties of the soils, and cultural practices were meager.

In previously published works, several systems of classifying soils had been used. By using descriptive materials that were available and field reconnaissance of several important valleys, the soils were reclassified in terms of the Soil Taxonomy. For those areas for which no pedological classification was available, classification was inferred from available data on geology, climate, vegetation, topography, and geologic age. Landscapes were characterized in terms of slope ranges and nature of the underlying materials. Slope ranges were estimated from topographic maps and from satellite imagery. The base map for the soil map consisted of the sheets of the 1:500,000 topographic map of Honduras. Soil map units were delineated on mylar overlays.

The selected climatic parameters considered were those of importance in determining plant distribution and agricultural potential. These included seasonality, length of the wet season, average annual precipitation, average annual temperature, and monthly precipitation and temperature during the wet season. Plant distribution is affected by the presence or absence of seasonality. Some plants such as coffee or mango require a dry season to initiate the flowering process. Other plants such as cocoa may not require a dry season. Some, such as the oil palm, produce optimal yields where no dry season occurs, but also produce in areas with a pronounced dry season. Because some plants have seasonality requirements, the presence of these plants was used to predict seasonality where weather station data were unavailable.

Since plant growth is retarded by water stress, the length of the dry season became important. Whether a month is considered dry is important to determine the length of the dry season and is also somewhat arbitrary, but depends on the average precipitation and temperature of that month. An even better measurement would be the period of time between rainfalls of a certain intensity relative to temperature, however, such data are seldom available.

Average annual precipitation was used to indicate total precipitation initially available to plants. How much of this available moisture can be used is determined in part by the air temperature which is represented by the average annual temperature. These parameters are used as guidelines for suggesting locations where rainfed crops might grow.

Data sources for the climatic delineations included meterological data from weather stations, Holdridge Plant Life Zone maps, vegetational and floristic field observations, and other meterological studies.

Information on soils and climate was combined to provide an RPU map (See Figures 2 and 3) and to provide descriptions of RPUs and PPA descriptions. The detailed descriptions at the PPA level provided tabular information of soils and climate and the taxonomic nomenclature of the dominant soil subgroups (See Figure 4).

In the Land Resource Base Report for Honduras general interpretations of agriculture were made to indicate the potential of the physical environment for supporting agricultural endeavors (CRIES, November 1980). There was no intent to consider the economic feasibility of alternative management practices or kinds of land use. Recommendations were made about the suitability of soils for specific uses based on knowledge soil scientists had of soil features and attributes.

Soil potential for cropland use is a partial expression of the expected performance of soils in a given climate and under a particular kind of

Figure 2: Resource Planning Units
Republic of Honduras

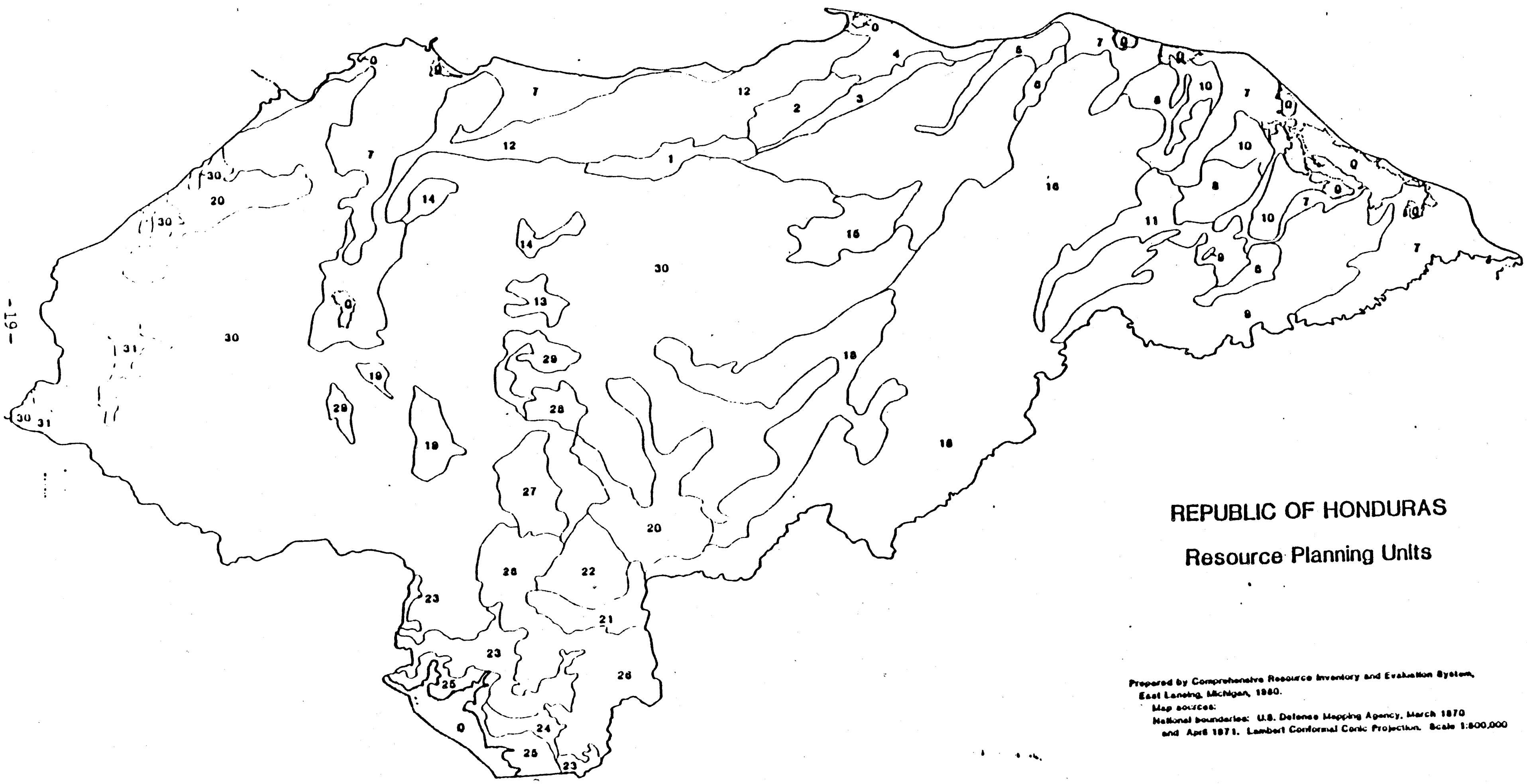

Figure 3: Republic of Honduras

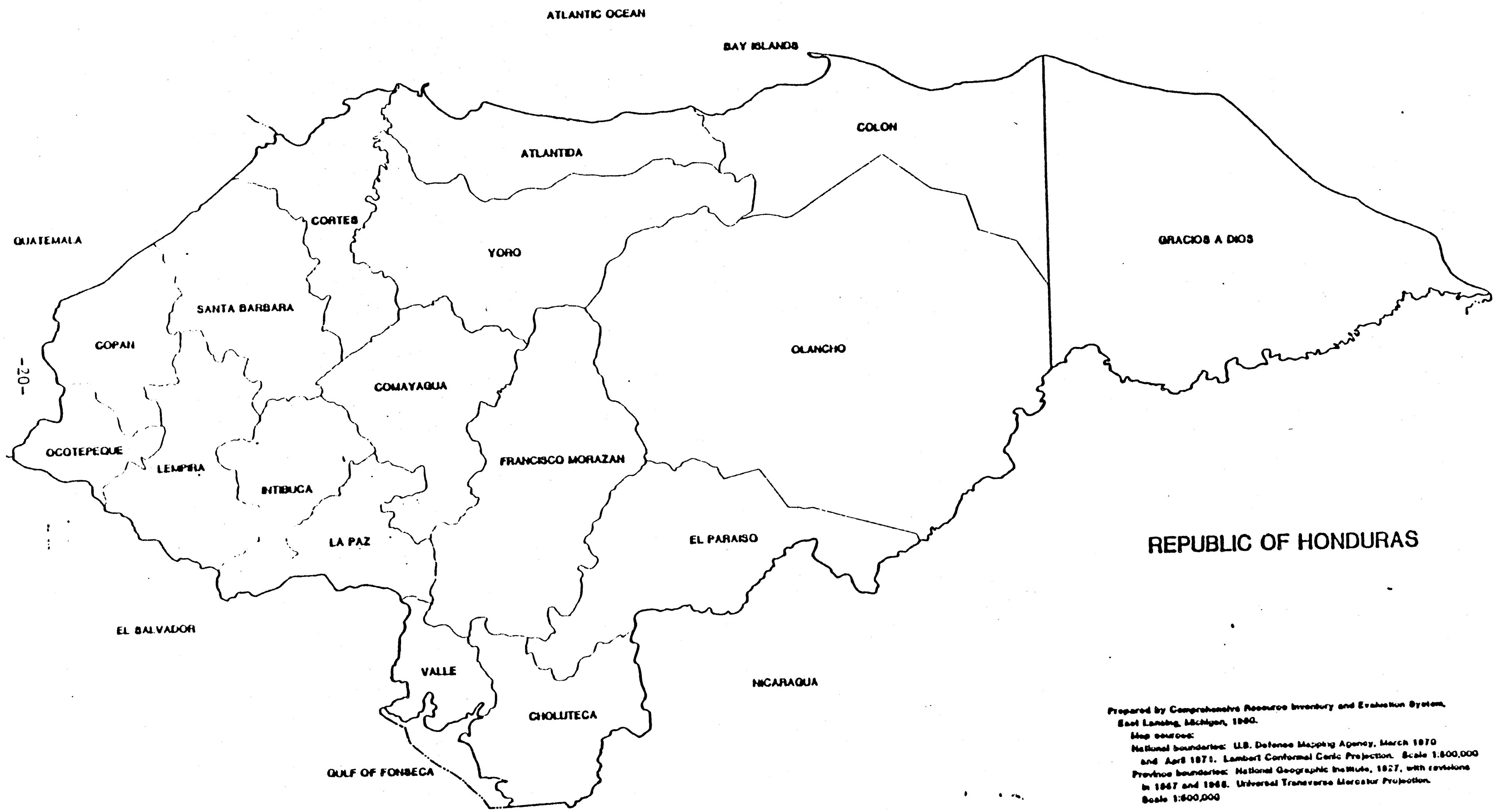

Figure 4: Summary Table of Characteristics of a Selected RPU of Honduras

PPA PROPERTIES	RPUx-PPA 1	RPUx-PPA 2	RPUx-PPA 3
GENERAL			
elevation	0-2175 m	100-500 m	70-750 m
dominant slope	30%	16-30%	3-15%
portion of RPU	90%	5%	5%
CLIMATE			
- Annual			
wet seasons (no.)	1 (in some areas there is no distinction between the rainy and dry season)		
average precipitation	(1300)[2/] 1550-3550 mm.		
average temperature	23-27°C		
- Wet Seasons			
average monthly precipitation	150-300 mm.		
average monthly temperature	23-26°C		
months	From May through October; from May through December, January or February		
- Dry Seasons[1/]			
average monthly precipitation months	Very variable due to the variability of the wet season.		
SOILS			
principal components	Lithic Eutropepts Lithic Rendolls Typic Tropohumults Typic Dystrandepts	Typic Tropohumults Typic Dystrandepts	Typic Tropohumults Typic Dystrandepts Fluventic Eutrochrepts
depth to bedrock	50-100 cm.	50-100 cm.	50- 200 cm.
texture	mod. coarse/fine	mod. coarse/fine	mod. coarse/ mod. fine
coarse fragments	non-stony/ very stony	non-stony	non-stony
permeability	moderate	moderate	moderate
available moisture capacity	moderate	moderate	moderate
drainage class	well/somewhat excessively drained	well drained	mod. well/well drained
flooding	none	none	none

(continued)

Figure 4. (cont'd.)

PPA PROPERTIES	RPUx-PPA 1	RPUx-PPA 2	RPUx-PPA 3
<u>INTERPRETATIONS FOR AGRICULTURE</u>			
soil potential for cropland	Management Type I poor, II poor, III poor, IV poor	Management Type I fair, II fair, III poor, IV good	Management Type I good, II fair, III fair, IV good
factors limiting land use	slope; shallowness; stoniness; erodibility	slope; erodibility	slope; erodibility

[1]/Dry season data are residually estimated by subtracting wet season data from annual data.

[2]/Data in parentheses are relatively minor in extent; they are transitional to adjacent RPUs.

management. Only the physical characteristics of the soil such as texture, internal drainage, depth, and so forth, were considered. Chemical characteristics of the soils were not known; they would be needed in order to evaluate fully the productive potential of the soil resource. Ratings of soil potential were to be used for planning purposes and were not intended as specific recommendations for land use. Three soil potential ratings were estimated for four different kinds of cropland management.

> A good rating implies high production potential at low long-term risk to the soil and for the expected crop. Soil limitation and limitations of climate are minor or nonexistent. If necessary, soil limitations are easily correctable by manipulation of the surface soil.
>
> A fair rating implies average production potential and some risk to the soil resource. Soil limitations present some difficulty in use of equipment and require special management practices to produce above average yields naturally occurring in a PPA rated good. These limitations include moderate wetness, low available water capacity, erodability, slope, subsoil restrictions, salinity, and poor physical conditions for tilth. In those areas where soil limitations are minor or nonexistent but seasonal dryness is important, a fair rating is also used.
>
> A poor rating implies low yields or unacceptable production potential and/or high risk to the long-term productivity of the soil resource. Either severe climate or severe soil limitations may result in a poor rating. Typical soil limitations include slopes (greater than 30 percent), extreme droughtiness, drainage condition (poorly or very poorly drained, or excessively well drained), long periods of flooding, high salinity, and shallow rooting depth (less than 50 cm) (CRIES, November 1980).

The four types of cropland management were:

- I. No use of inputs and no land preparation.
- II. Some input use and use of animal power.
- III. A high level of input use and use of mechanical power for land preparation and cultural practices.
- IV. Tree crops.

Artificial drainage, flood protection, and irrigation to correct soil or climate limitations were not explicitly treated in this rating of soil potential. As a result, PPAs described as being poorly drained or excessively drained or that are subject to long periods of flooding were generally rated poor. PPAs otherwise good but subject to seasonal dryness were rated fair. Installation of drainage or irrigation to correct such problems would probably often be found where management type III was practiced. The agricultural production potential of the PPA would then be significantly higher.

Limitations and restrictive features of the physical environment, principally those related to soils and climate, affected either directly or indirectly the use of land for productive endeavors. The following attributes of the soil and climate are those which to some degree adversely affect soil potential ratings and land use.

Soil features:

- shallowness to bedrock
- depth to restricting layer
- wetness
- susceptibility to flooding
- steepness of slope
- texture -- sand, clay
- stoniness
- extreme acidity, sodicity, or salinity
- erodibility

Climate features:

- seasonal dryness

Summary and Future Directions:

The CRIES project has had the opportunity to research various concepts and methods for the classification of land resources into relatively homogeneous land resource areas. An attempt was made to incorporate the concepts of climate and soil taxonomies into a unified system to provide agronomists with the necessary information sets from which to assess plant adaptability and productivity. The initial attempt was to develop a climate taxonomy parallel to soil taxonomy and apply the taxonomic concepts to achieve relatively homogeneous resource area delineations. Problems were encountered largely due to the high correlation between certain parameters common to both taxonomies. There was no conceptual base available to resolve which taxonomy took precedence for situations where there was conflict over particular parameter values germane to both.

The current definition of an RPU is patterned after the definition of major land resource areas from the Conservation Needs Inventory of the Soil Conservation Service; USDA. In the U.S., the land resource area concepts and delineations have been used as relatively homogeneous units for national planning and policy analysis. The only difficulty has been communicating the scope, magnitude, and purpose of these areas for analyses and planning. It has been difficult for certain scientists to look beyond the variability in the detailed information contained in such units and to understand how homogeneous such units are with respect to patterns of detailed information and the agricultural and socioeconomic patterns associated with the resource patterns.

In future inventories and evaluations RPU and PPA concepts and definitions will remain similar to those employed in Syria and Honduras. At the discretion of the in-country team and for the use of national field technicians PPAs may be visually interpreted in a manner similar to the GDSS concept adapted by the SIEDRA team in the Dominican Republic. However, such modifications can distort the agronomic homogeneity of the PPAs and reduce inter-country comparability needed for technological transfer. The methods and procedures for delineating the RPUs and PPAs have been modified in Honduras to eliminate the conflicts in taxonomies by making delineations according to soil and climate criteria specified in Soil Taxonomy and providing descriptive information on the climatic conditions. The descriptive materials would be similar to those in the Syrian and Honduran land resource inventories. RPUs would continue to be described as physiographic regions that are relatively uniform with respect to land forms, kinds and patterns of soil bodies and climates. Climate and climate variability will be described for each RPU. PPAs will be described as an aggregate of individual soil bodies within an RPU which are sufficiently homogeneous with respect to plant adaptability, potential management requirements, and productivity to be reliably depicted by unique estimates of those parameters for national planning and policy analyses. The patterns of climatic variability and the relationships of these patterns to the general patterns of PPAs will also be descriptively presented in the PPA descriptions. Where available water resource information will also be provided in a descriptive format by RPU and PPA.

Continued emphasis will be placed on the soil or physical resource interpretations that are possible from the land resource inventory. General interpretations for agriculture were given increased attention in Syria and Honduras. Crop and crop group recommendations were made by PPA in Syria. All such interpretations would be added by increased local participation. For instance, rather than specify a rather wide array of potentially-adaptable crops, it is more reasonable to evaluate the adaptability of a crop or several crops for which a country is attempting to achieve self sufficiency. Likewise, investigating the adaptability of a crop or crops that the country has prior experience in producing for export can also be of immediate value.

The question of how to allow for permanent man-made modifications has been raised by project scientists and others. Measures such as stone terracing, deep plowing, drainage, and irrigation improvements should be treated on a project basis. Other permanent man-made modifications that are in place are generally acknowledged in the RPU and PPA descriptions if the data on such measures are assessable. Irrigation development data are often available. However data on land surface modifications and drainage are often difficult to obtain. Where available such information would often dramatically reshape the agricultural interpretations that could be made.

MAJOR LAND USE CONCEPTS AND PROCEDURES

Several methods have been used by the CRIES project to develop major land use information. Knowledge of current use of the nation's resources is needed if important questions relative to how agricultural production might be expanded are to be answered. Among these are: (1) What portion of the land base suitable for cultivated agriculture is currently cultivated?; (2) What are the resource limitations on agricultural use of currently uncultivated lands? Additionally there exist equally important questions relative to the means of increasing total agricultural production if the entire land resource base suitable for agricultural production is under some form of use -- agricultural or not.

The choice of method to determine major land use by RPU and inferentially by PPA has been a function of the availability and reliability of alternative sources of data and cost.

Some countries have census data sets on major land use and cropping distribution patterns reported at five or ten year intervals. Less frequently countries collect census-type land use information on an annual basis. Because all such information is generally collected by internal political boundaries, allocation methods are required to distribute these data to RPUs. Occasionally auxiliary sources of mapped land use data are available from a commodity commission or another project activity. Often the data are found to be limited in usefulness because they do not fully exhaust the land resource base, i.e., only land used for agricultural purposes has been surveyed, or the data are out-of-date and not representative of current land use.

In the absence of other reliable data on land use, visual interpretation of Landsat imagery has been used to develop maps of major land use and/or cover types. Visual interpretation of Landsat is a cost effective method for delineating major land uses. Land cover/use classifications are selected to be closely compatible with the land use categories for which statistics are periodically collected by the participating government.

The methods and concepts employed in each country are now discussed.

Dominican Republic:

Major land use information was derived largely from the 1971 Agricultural Census. Because the census accounted only for land in agricultural uses, the land areas in agricultural uses were subtracted from the total land areas in each region to establish nonagricultural uses by region. Total land area in each region and RPU were estimated by digitizing the base map with province and national boundaries and the RPU map and then using the Geographic Information System to cross-tabulate RPU areas by region. Census estimates of major agricultural land use were assigned to RPUs by using the ratio of the size of the RPU to the total region as the proportion of land in agriculture for the region to be assigned to each RPU. Additional adjustments were made to the assignment of major land use to RPUs based on non-census information of irrigated and nonirrigated areas.

Major concerns were expressed about the tentative nature of the major land use delineations by RPU. Major concerns were the untimely nature of the major land use data and the bias that might stem from the enumeration which was done only for major agricultural land uses.

Two alternative methods were evaluated. Intralab, a unit of NASA, conducted a computer classification and analysis of Landsat data for two test sites. Sampling rates varying from 1 in 2 pixels (50%) to 1 in 128 pixels (less than 1%) were tested. The order (largest in areal extent, next largest in area, etc.) in which land cover types occurred in both test sites were basically identical. Since the processing of the pixels for computer classification is but a small portion of the total costs to conduct a computer-assisted land use/cover inventory, the cost savings from sampling the pixels rather than classifying all pixels is nominal relative to the overall cost of the inventory (NASA/GSFC, 1977).

The second method was the visual interpretation of Landsat imagery to obtain a Level I USGS classification of land use/cover. Photo interpretation was used to interpret 1:1,000,000 color composite positives of Landsat scenes enlarged to 1:250,000.

The cost of the visual interpretation of Landsat to establish land use/cover classes was approximately \$1.40 per square kilometer for the four small test areas. Although this cost, when extrapolated to the entire country, appeared to be substantial, in comparison to the estimated \$1.00 per square kilometer for just the computer classification of the pixels, it seemed reasonable. (The Intralab cost of \$1.00 per square kilometer did not include any salary costs, travel costs, etc. for limited field checking, verification, etc.). Furthermore, some of the fixed costs of verification would be substantially reduced when spread over a project to classify the major land uses for the entire country (CRIES, August 1977).

Though additional funding provided by the Development Service Bureau of the AID, a land use/cover map was developed for the entire country using visual interpretation methods.

The final land cover/use classification categories were:

1. Urban and Built-Up: Man-made structures for residential, industrial, commercial and transportation-related land uses in contiguous areas of more than 1 km^2.

2. Agriculture: Land use for the production of food and/or fiber.

   2.1 Sugar: Major agricultural areas with 75% or more of the land planted to sugar cane interspersed with few other major crops except improved pasture.

   2.2 Mixed Agriculture: All other major agricultural areas with 75% or more of the land used for field crops and tree crops.

   2.3 Marginal Agriculture: Less intensive, agricultural areas with 25 to 74% of the land used for field crops and tree crops. Usually characterized by smaller fields interspersed with unimproved pasture, range, trees and open land in hills and mountains.

   2.4 Pasture: Predominantly improved pasture used for grazing.

3. Rangeland: Areas with a predominant brush and grass vegetation cover. Limited potential for grazing. Presence of Xerophylotic plants common in the foothills.

3.1 Limited Rangeland: Areas with major limitations for grazing caused either by steep slopes or heavy brush cover.

4. Forest: Forest lands with a crown closure of 75% or more.

   4.1 Predominantly Deciduous

   4.2 Predominantly Coniferous

5. Wetlands: Areas with a hydrologic regime accommodating aquatic or hydrophytic vegetation. Excluded are areas in rice production.

6. Barren/Open: Areas with exposed soil and little or no vegetation cover. Surface mining areas are included in this category.

7. Water: Inland water surfaces.

8. Cloud Cover: Areas where from August 1972, to February 1979, cloud free satellite imagery could not be obtained (CRIES, August 1980).

The total area in each of these categories is measured using the Geographic Information System. Areas of each category were provided for each of the planning regions.

Costa Rica:

Major land use data were available from the Agricultural Census of 1973. No attempt was made to allocate major land uses to RPUs. Regional major land uses were considered in the preliminary analyses completed for Costa Rica.

Nicaragua:

Many different sources were consulted for major land use data in Nicaragua. The Uso de la Tierra, 1974, was considered to be the best source of major land use. This particular source combined several different types and dates of land use information including 1:20,000 maps of the Pacific and Central zones interpreted from aerial photography in 1968-69 and 1971 land use interpretation of side-looking radar of the Atlantic zone mapped at a scale of 1:100,000.

These major land use data were related to the eight major regions of Nicaragua for subsequent analyses. As RPUs were never delineated for Nicaragua, no major land use estimates by RPU were attempted.

Syria:

Major land use data are reported for Syria on an annual basis. Statistics are reported for the following categories: Cultivable land; Steppes and Pastures; Rocks and Sand; Water; Buildings and Roads; and Forest. The "Cultivable land" category was defined as land which can be planted with trees or crops as followed:

Its explicit subcategories were the following:

1. Cultivated: land usually in agricultural rotation.
   (a) Perennial or seasonal crops.
   (b) Land fallowed for two years or less.
2. Uncultivated: land which can be cultivated if some form of land improvement precedes cultivation.

The major land use "cultivated land" is further classified:

1. Fallow: land prepared for the next cropping season or land in a rotation and not cultivated for two years or less.
2. Crop: land planted to various crops, classified as winter crops, summer crops and fruit trees, and divided as follows:
   (a) Irrigated: agricultural land which has an uninterrupted water resource available for two agricultural years or land which may have a deficient water resource for no more than one

season in no more than four years. This includes pumped and gravity fed irrigation.

(b) Nonirrigated: rainfed agricultural land planted to crops or forest trees.

With the precise definitions of major land use and major agricultural categories, the Syrian statistics were additive for total nonagricultural and agricultural uses. Three years were analyzed to determine if there were major shifts in land use and if there were procedural problems involved in the definitions of concepts or data aquisition methods. The analyses indicated that most changes in major land use were either conceptual or the result of improvements in data collection.

When the major land use statistics were reviewed at the state (mohafaza) and county (montika) levels, similar findings were obtained. The categories — "uncultivated" and "cultivated" and the subdivisions of the "cultivated" category — fallow, irrigated, and nonirrigated, provided more diagnostic information that revealed dynamic changes in land use. Shifts in the areas reported at the county and state levels among these categories often indicated a short-term resource constraint such as an insufficient supply of irrigation water attributable to a shortfall in reservoir storage or a failure of an irrigation system. The ratio of fallow to cropland allowed a preliminary specification of rotation patterns — i.e., crop-fallow, crop-fallow-fallow, etc., for nonirrigated cropland areas (CRIES, November 1979).

A visual interpretation of Landsat imagery to provide a generalized land cover/use map for Syria was conducted. The interpretation categories were: intensive agriculture, extensive agriculture, range, water, urban, forest, orchards, and barren.

Several uses were made of the general land use statistics obtained from the mapped information. For example, the State Planning Commission was concerned that in its annual statistics on major agricultural land use were consistently being underreported. Theoretical correspondence between the interpreted land use categories and the major land use statistics reported annually by the government was specified. The correspondence was:

Interpreted Categories	Reported Categories
Intensive Agriculture + Extensive Agriculture + Orchards	Cultivable Land (cultivated + uncultivated)
Range	Steppes and Pasture
Barren	Rocks and Sand
Water	Water
Urban	Buildings and Roads
Forest	Forest

Applying this theoretical correspondence directly to the statistical information demonstrated some incongruity between the two sets of information (Table 1, part A.). For example, the cultivable land categories were in very close agreement but interpreted Range substantially overestimated reported Steppes and Pasture, while interpreted Barren substantially underestimated reported Rocks and Sand. The problems of correspondence were associated with the operational definitions of categories adapted during the interpretation process. Range was defined to include land that could potentially support grazing activity. Field information and supplemental material did not allow the interpreters to distinguish grazing from non-grazing activity in the Steppe areas; consequently all of this land was classified within the Range category. The reported information does distinguish between grazing lands categorized as Steppes and Pasture, and non-grazing categorized as Rocks and Sand.

Table 1.
Comparison of Interpreted Land Cover/Use and Reported Land Use Information from the Syrian Statistical Abstracts.

	Mapped Information	Reported[1] Information	Difference (Mapped-Reported)	Percent Difference
	-----	km²	-----	
Part A:				
Intensive Ag., Extensive Ag., Orchards (cultivable land)	58,929	58,728	+ 201	+ 0.3
Range (Steppe & Pasture)	122,845	85,420	+ 37,425	+ 43.8
Barren (Rocks & Sand)	2,617	32,740	- 30,123	- 92.0
Water	1,014	1,027	- 13	- 1.3
Urban	290	2,736	- 2,446	- 89.4
Forest	1,498	4,540	- 3,042	- 67.0
Total	187,193	185,191	+ 2002	+ 1.1
Part B:				
Cultivable Land	58,929	58,728	+ 201	+ 0.3
Range (Steppe & Pasture, Rocks & Sand)	125,462	118,160	+ 7,302	+ 6.2
Water	1,014	1,027	- 13	- 1.3
Urban	290	2,736	- 2,446	- 89.4
Forest	1,498	4,540	- 3,042	- 67.0
Total	187,193	185,191	+ 2002	+ 1.1

[1] Annual Agricultural Statistical Abstract: Syria 1976 and 1977.

The analysis of resource problems and RPU agricultural production potentials was facilitated by cross-tabulation of the land cover/use information mapped from Landsat imagery with the RPUs. The current uses of land were summarized by RPU (Table 2). CRIES conducted a preliminary comparison of the general agricultural interpretation on most intensive land use and the crop recommendations with the major interpreted uses pertaining to agriculture. In general, this comparison showed that current uses of the land resource base of each RPU were similar to the recommended uses. Occassionally, current uses exceeded those that were recommended, especially in certain areas that were in intensive agriculture. Irrigated agriculture was not considered desirable in certain RPUs due to the existence or potential for severe soil erosion problems.

A more exhaustive examination of the cross-referenced RPU and current land use information sets was made by the resident production economist on the Syrian Agricultural Sector Assessment Project and counterpart Syrian technicians. RPU and PPA characteristics, together with the advice of Syrian soil scientists and agriculturalists, were used to divide Syria into eight regions. Comparisons were made in each region by RPU between the current land use as derived from the land cover/use map and the estimated crop suitabilities. Such comparisons identified lands by RPUs and regions which could be safely retained in or brought into cultivation, cultivated lands which should be shifted to other uses, such as range, and lands with irrigated crop potentials (Table 3).

Honduras:

In February 1981, the project staff in the Ministry of Natural Resources requested a series of technical assistance to classify major land

Table 2
Interpreted Land/Cover Use Information by
Resource Planning Units1/

RPU	LAND COVER/USE CATEGORY (KM^2)								
	Intensive Ag.	Extensive Ag.	Range	Water	Urban	Forest	Orchard	Barren	RPU Total
1	0	28	8,977	0	0	0	0	646	9,651
2	0	792	248	1	8	0	0	783	1,832
3	107	2,347	722	1	35	0	1	67	3,280
4	0	1,026	459	0	17	0	1	63	1,565
5	18	712	1,093	0	3	0	8	0	1,834
.									
.									
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.									
.									
57	198	2,359	1,558	41	0	0	0	0	4,156
58	0	54	306	0	3	0	86	0	449
Land Cover/Use Totals	6,828	50,226	122,845	1,014	290	1,498	1,875	2,617	187,193

1/The complete table is in CRIES Land Use Information Report for Syria.

Table 3.
Production Potential and Present Land Use by Resource Planning Unit and Type of Farming Region, Syrian Arab Republic[1/]

REGION AND RPU	AREA WITH POTENTIAL FOR: RAINFED CROPS (000 HA.)			IRRIGATED CROPS (000 HA.)			OTHER (000 HA.)	PRESENT USE[2/] (000 HA.)				TOTAL AREA (000 HA.)
	HIGH	MED.	LOW	HIGH	MED.	LOW		EXTEN-SIVE	ORCHARDS	INTEN-SIVE	OTHER	
COASTAL												
28	73	-	-	18	-	-	2	45	21	18	9	93
TOTAL	73	-	-	18	-	-	2	45	21	18	9	93
MOUNTAIN												
29	4+	-	-	-	-	-	21	3	1	0	21	25
30	-	-	260	-	4	-	113	203	57	4	113	377
36	-	66	-	-	9	-	133	50	16	9	133	208
37	-	-	-	-	21	-	33	6	—	21	27	54
58	-	14	-	-	-	-	31	5	9	0	31	45
TOTAL	4	80	260	-	34	-	331	267	83	34	325	709
LOWLANDS												
26	-	298	-	82	-	-	4	241	28	82	33	384
34	-	21	-	-	56	-	9	8	0	56	22	86
35	-	8	-	-	-	-	34	21	1	0	20	42
47	46	-	-	2	-	-	1	21	16	2	10	49
TOTAL	46	327	-	84	56	-	48	291	45	140	85	561
UNDUL. PLAINS												
20	-	83	52	31	-	-	667	371	1	31	430	833
23	-	23	-	15	-	-	-	33	0	—	5	38
24	-	37	6	5	38	-	5	52	0	4	35	91
25	90	-	-	11	-	-	101	83	2	11	106	202
27	-	4	-	-	1	-	20	2	0	1	22	25
38	-	181	-	3	-	-	-	160	0	3	21	184
48	-	297+	-	5+	-	-	95	297	0	5	95	397
49	-	-	-	-	12+	-	75	73	0	12	2	87
57	-	-	84	-	20	-	312	236	0	20	160	416
TOTAL	90	625	142	70	71	-	1275	1307	3	87	876	2273

[1/] The complete table is in the Syrian Agricultural Sector Assessment, Summary Report, Volume I.

[2/] Includes land only with potential or presently used for range, pasture and forest plus non-agricultural uses for road, urban areas, water or barren.

use through the visual interpretation of Landsat imagery and to provide associated training.

AGRICULTURAL CROPPING PATTERNS AND PRODUCTION STATISTICS

The previous section explained procedures employed to relate current major land use to political subdivisions and RPUs. This section will explain the concepts and procedures used to disaggregate the major land use category "cultivated agriculture". To provide a baseline for comparative analyses of land use under alternative policies and programs to achieve agricultural production potential, it is necessary to explain "land use by crops". Except for Syria, none of the countries participating with CRIES had adequate measures of the physical area of cultivated land available for crop production.

Generally, secondary sources report crop areas harvested. Hence, auxilary data sets are required to derive the physical area of land occupied by crop. These include crop calendars and the specification of intercropping and multiple cropping patterns. For example, published statistics will report one harvested hectare for each of maize, beans, and short-season vegetables for one calendar year. If it is established that maize and beans are intercropped and the short season vegetable is planted subsequent to the maize and bean harvest, then there is only one, not three, physical hectares of cultivated land. The annual use intensity ratio would be 3.0.

Similar problems were faced when trying to establish total agricultural production levels (yield x area harvested) since there were generally several estimates of the total production of a crop. Published estimates, therefore had to be reconciled and "normalized" to an average or representative annual level through the participation of country technicians. The reliability of doing this varied by country because of the widely varying amounts of national/regional knowledge of such statistics held by any one technician, biases held by such persons, inaccuracies in published data, influences of weather, etc.

Obtaining estimates of the crop use of land and normal production levels are heavily dependent on available data sets. No generalized set of procedures exist for establishing either. The remainder of this section provides a brief description of particular efforts in each country provided technical assistance.

Dominican Republic:

Harvested area of crops was available at the national and regional level from the 1971 Agricultural Census and yearly estimates of particular crops were available for more current years. The physical area of cropland available for production was established for each region. The sum of the harvested area in each region was divided by a multiple cropping coefficient (established by a separately conducted Cost of Production Survey, 1976) to establish the physical area of cropland in each region. RPU-level harvested areas for each crop and the total physical area available for cultivated agricultural were assigned through proportional allocation for each region.

More recently the SIEDRA staff revised all such estimates through field interviews with agricultural advisors in each Region.

Costa Rica:

The Agricultural Census of 1973 provided data summaries at the national, regional, and province level on major land use, and area planted and production by crop. The Central Bank publishes national estimates of crop production on an annual basis. The Consejo Nacional de Produccion publishes national area planted and production estimates for grains. Several combinations of these data sets were evaluated using a basic national-level linear programming tables with regional and national-level production and physical area constraints.

Nicaragua:

A variety of sources were used to establish crop use of land by region. These estimates were reviewed by the regional supervisors of the national extension service and the local agents to validate the estimates.

Syria:

Syria annually publishes major land use estimates, cultivable land estimates and harvested crop estimates at the national, state and county levels. Crop uses of land are reported by season, by annuals, perennials, and fruit trees, and by irrigated and nonirrigated production. As major land uses are separately reported, ratios of the intensity of the crop uses of land were made directly.

Use-intensity ratios were calculated by comparing crop use of the land to cultivated land. Crop use of the land was partitioned by production system (irrigated or nonirrigated) and by season of crop planting (winter, summer, and perennial). Cultivated land use was partitioned into irrigated, nonirrigated and fallow land. Four ratios for nonirrigated land and two for irrigated land were calculated using county data.

The following is an example calculation of the summer, irrigated ratio for one montika (county). For 1977, Rastan montika's irrigated summer crops subtotalled 8,155 hectares and perennial (fruit trees) irrigated crops subtotalled 455 hectares. In the summer of 1977 irrigated, cultivated land subtotalled to 10,954 hectares.

The land use intensity for this example is:

$$\frac{\text{Irrigated Summer Crop Subtotal for 1977}}{\text{Irrigated Cultivated Land for 1977 - Irrigated Perennial Subtotal for 1977}}$$

Substituting the appropriate values, the irrigated, summer ratio for Rastan is:

$$\frac{8{,}155 \text{ hectares}}{10{,}954 \text{ hectares} - 455 \text{ hectares}} = .777$$

The use-intensity ratios were developed to assist agricultural planners in assessing the land resource base. The ratios were particularly helpful for identifying areas where multiple cropping and intercropping were being practiced, for identifying crop rotations, for identifying resource constraints (particularly irrigation water supplies), and for identifying procedural problems in the collection and reporting of land use and crop use of the land data.

In the example, a use-intensity ratio of .777 for irrigated, summer crops in Rastan was calculated. A corresponding ratio of .264 was calculated for irrigated, winter crops. The first observation in interpreting the ratios is that irrigation is much more extensive for summer crops, nearly triple the winter crop irrigated area. The second observation is that the two ratios sum to 1.041 which would imply that slightly more than 100 percent of the irrigated cultivated land available for the production of annuals (other than perennials) was actually cropped. This may have resulted from limited multiple cropping of summer crops following winter crops on the same land.

By contrast, the same two ratios add to .728 for another county. This suggests that there may be some problem with irrigation in this county. The actual problem (interrupted supply and/or delivery system) is not discernible from the information used to calculate the use-intensity ratios. Another possible explanation for the ratio being substantially less than one is a reporting problem in the data collection. If the area in question lies in a transitional rainfall zone, it may happen that, in a year of particularly good rainfall, an in-place irrigation system would not be fully necessary. The land would still be classified as irrigated cultivated land but some of the cropped area would be rainfed and reported as nonirrigated cropped land. Ordinarily, nonirrigated cropped land in Syria's administrative units is far more extensive than irrigated cropped land. Consequently, a shift of some cropped area from irrigated to rainfed agricultural production (even though an irrigation system is in place) may not be detectable by examining the nonirrigated use-intensity ratio for a corresponding increase. If the irrigation system was used only on a supplemental basis, the cropped area might be reported as rainfed or the land might be classified as nonirrigated cultivated land. The wide variety of possible interpretations merely accentuates the agricultural planners' needs for further information.

Two sets of seasonal use-intensity ratios were calculated for nonirrigated agriculture. One set excluded fallow land from the calculations. The other set includes fallow land in the base for rainfed agriculture.

For the example montika, the two sets of ratios for one year were:

(1)	Nonirrigated:	Summer	.085
		Winter	.885
			.970
(2)	Nonirrigated with fallow:	Summer	.045
		Winter	.469
			.514

The first set of ratios add to .970, indicating that slightly less than 100 percent of nonirrigated cultivated land was actually planted. Land classified as nonirrigated cultivated may not be planted, particularly winter crops, if there is a rainfall deficiency at the time of planting. However, when the sum is so close to 1.00, the difference may result from reporting discrepancies. These ratios also suggest that the rainfed agricultural production is almost exclusively a winter crop practice.

The second set of ratios were calculated using fallow land as a dryland agricultural practice and their interpretation gives a clue to the type of crop rotations practiced in a region. In this case, the sum of the ratios was .514, the ratios were calculated as:

$$\frac{\text{cropped land}}{\text{cultivated land + fallow land}}$$

This suggests a crop-fallow rotation as the dominant rainfed agricultural practice. This does not suggest the total absence of continuous production or crop-fallow-fallow rotations; rather it suggests the dominant rotation for the montika is crop-fallow.

Honduras:

No activities have been initiated in Honduras to initiate the identification of cropping patterns and agricultural production by RPUs. It is expected that selected regional activities will be implemented to establish cropping patterns by RPUs within the major agricultural valleys.

Summary:

There is no homogeneity in the basic data sets found in developing countries from which to derive cropping patterns and production statistics. To establish a production pattern and production statistics baseline for subsequent analyses ad hoc, but conceptually reasonable, methods have to be applied.

INFORMATION MANAGEMENT SYSTEMS AND ECONOMIC ANALYSIS

The Geographic Information System (and its several earlier versions under a variety of different names and/or acronyms) has been used in each of the countries. It is designed to capture, verify, and analyze mapped land resource and use information and other mapped information.

The Agroeconomic Information System (and its several earlier versions under a variety of different names and/or acronyms) has also been used in several of the countries provided technical assistance. This system is designed to capture, verify, and analyze agricultural production, cost of production, and other information initially formatted in tabular data sets.

A variety of analyses have been conducted from information provided through use of the two systems. In each country the Geographic Information System has been used to identify the extent of political boundaries, RPUs, and land use features where appropriate maps were developed or available from secondary sources. Cross-tabulations between land use and RPUs have been useful in providing general indications of land available or suitable for the expansion of cultivated agriculture. Specific uses of this information system for allocations among various mapped units are presented in the country-level report provided to each participating country.

Information available from these two information systems has facilitated several economic analyses. Those illustrative of the analyses will be discussed. These are the linear programming model developed for the Dominican Republic, the linear programming and goal programming models for Costa Rica, and the single equation crop area response models developed for Syria.

Dominican Republic Linear Programming Model

The model developed for the Dominican Republic was a cost-minimizing L.P. As a demand-driven land resource model, it had the theoretical ability to reflect interregional comparative advantage of agricultural land resources to the extent of estimating a competitive equilibrium under a variety of constraint sets.

The assumptions of the analytical model were:

1. Crop yields are homogeneous by production technique within planning regions and RPU. Associated production costs are homogeneous by production technique within RPUs within planning regions.

2. Input-output coefficients were constant within the relevant range, i.e., constant returns to scale exist.

3. Purchased input prices were constant and were specified at the farm level.

4. Inputs within activities were perfect complements.

5. Total production within each RPU within each planning region was limited by the fixed quantity of land that was currently used for cultivated crop production in the same RPU and region.

6. The objective function was specified to minimize the total non-land cost of production.

7. Minimum total production requirements, by crop, were determined exogeneous to the model.

Two kinds of constraints were used: a) minimum national and regional crop requirements; and b) active cropland (irrigated and non-irrigated) in each RPU within each planning region. Initial national production requirements were set at representative historical production levels for the major crops. Regional requirements were set at 90% of regional normalized production levels to restrict interregional shifts in lieu of interregional transportation costs and marketing patterns. Active cropland constraints were based upon the land inventory and placed at current estimates of cropland acreages.

Aggregate data were available to develop proportional estimates of the non-interplanted ("solo") and interplanted areas of major crops. These proportional values were used to divide harvested areas of the major crops into "solo" and interplanted portions. Conventional, single-crop activities were constructed for 13 items and introduced in the model in those regions with substantial historical production levels. Minor acreages of some listed crops were added on "other" crops category.

The interplanted portion of crops plus sweet potatoes was computed as a composite hectare of crop activity in fixed proportions for each region. Hence, one hectare of interplanted annual cropland represented portions of several crops.

Crop yields in the product row were reduced by the composite distribution factors. A crop representing only 10% of the area of the intercropped hectare received 10% of its usual yield. To control the amount of interplanting and to insure a realistic distribution of "solo" and interplanted activities, a constraint row of minimum hectares of annual interplanted crops was created. The right hand sides, by region, were specified to insure minimum amounts of interplanted annual crops at current levels. Activities for intercropped perennials were treated similarly.

Survey data that were available indicated that a significant portion of annual crops were multiple-cropped (planted more than once) during the year. Multiple cropping coefficients by regions were developed and used correspondingly to adjust coefficients in the land row. Hence, if data indicated that 25% of the annual cropland was multiple-cropped, the factor in the land row was 0.8 hectares instead of the usual unit hectare. Yields were unadjusted, since 0.8 hectares of land produce 1.0 hectare of production on an annual basis.

Algebraically, the model was expressed as follows:

Objective function:

$$\text{Min } F = {}_{i\,j\,k}\ X_{ijk}C_{ijk}$$

i = 7 regions
j = 30 RPU (irrigated and non-irrigated)
k = 15 crop activities

Constraints:

Land constraints for the i^{th} region and j^{th} RPU

$$ {}_{k}\ X_{ijk}(LD)_{ijk} = (TLD)_{ij} $$

$$ {}_{k}\ X_{ijk}(LI)_{ijk} = (TLI)_{ij} $$

Regional Production constraints for the i^{th} region and k^{th} crop:

$$ {}_{j}\ X_{ijk}Y_{ijk} \quad (RD)_{ik} $$

National production constraints for the k^{th} crop:

$$_{i\ j} \quad X_{ijk} Y_{ijk} \qquad (ND)_k$$

where:

X_{ijk} = unit area of crop k on RPU j in region

C_{ijk} = cost of production of crop k on RPU j in region i

N_{ijk} = net returns from producing crop k on RPU j in region i

$(LD)_{ijk}$ = nonirrigated land use per unit of crop production k on RPU j in region i

$(TLD)_{ij}$ = non irrigated land availability of RPU j in region i

$(LI)_{ijk}$ = irrigated land use per unit of crop production k in RPU j in region i

$(TLI)_{ij}$ = irrigated land availability of RPU j in region i

Y_{ijk} = yield of crop k on RPU j

$(RD)_{jk}$ = exogenously determined quantity demanded for crop k in region j

$(ND)_k$ = exogenously determined quantity demanded for crop k nationally

Solution values of the model were checked with estimates of the apparent existing cropping pattern. Through several model iterations progress was made towards providing model solution values that approximated regional and corresponding RPU cropping patterns using national and regional historical production levels as constraints.

The ability to obtain model solution values consistent with expectations developed from data on historical performance in the agricultural production subsector did not diminish the concern for verification and/or refinement of data inputs into the information systems. Data refinement needs were outlined to move the initial information management systems and RPU level analytical model from the demonstration phase into the subsequent GDSS level phase where usefulness for agricultural policy analysis could be realized. The SIEDRA staff completed the refinements of the major information sets through field interviews with agricultural advisors in each Region. No attempt was made by the SIEDRA staff to revise the LP model through the incorporation of the new information sets.

Initial RPUs were delineated by the CRIES staff through the use of existing materials, field checking, and limited consultation with Dominican counterparts. It was suggested that a vigorous review and field checking of RPU descriptions and delineations be conducted by SIEDRA soil scientists. The SIEDRA staff subsequently revised and refined the RPU delineations based upon their knowledge and field observations. In addition to a field review of RPU boundaries, the SIEDRA staff made field interviews to refine this initial, tentative set of national production and harvested area totals. Subsequent visual interpretation techniques were employed to replace the major land use information derived from census data which was considered out-dated. Cropping patterns in the initial model were derived from various sources. Additional information and/or the refinement of initial cropping pattern information was conducted through subsequent efforts on a regional basis by the SIEDRA staff. Additional information on crop production calendars was obtained by the SIEDRA staff on a regional and RPU basis.

The specification of crop production techniques by crop within RPUs in the initial model was derived from survey data. In the initial model the objective function values represented the average total costs per hectare, excluding charges for land use, corresponding to each crop production technique identified. These objective function values were derived by matching regionalized cost of production estimates published in cost of production reports with the crop production techniques identified. The need for substantial additional cost of production verification and refinement was recognized. Again the SIEDRA staff subsequently collected additional data on a regional basis from which to derive a more meaningful set of cost of production estimates.

The initial analytical model in the Dominican Republic served two major purposes -- it provided a mechanism for evaluating the suitability of available data sources for national-level agricultural resource planning and it demonstrated the need for improved information to be derived from improved or additional data sources. The information requirements of the initial model were fulfilled by the information management systems transferred to the Dominican Republic. These information management systems have been used to accommodate the management of improved information sets derived largely from the regional data collection activities of SIEDRA and/or the collaborative activites of the SIEDRA staff and the CRIES project staff.

Costa Rica Linear and Goal Programming Models

As part of the evaluation of the different sources of agricultural information, a series of cost minimization linear programming models were constructed for Costa Rica. The models were designed to demonstrate the implications of selecting one data source over others for use in formal policy modelling or in actual policy decisions. The models were not intended to be of the quality necessary to be useful in policy analysis. The models were designed for purposes of evaluating data quality.

The models were constructed with the same structure and using the same data preparation procedures; however, different sets of data were used in each model. For example, three sets of data for yields and production totals were derived from the (1) Agricultural Census of 1973, (2) Central Bank, and (3) a variety of other sources, such as the banana federation, coffee federation, the National Production Council, etc., aggregated into one set. Two sets of costs of production were used. The inputs for each cost of production were standardized to make the estimates derived from different methodological procedures more comparable.

Several steps were usually taken to reconcile data from different agencies. For example, the CNP (Consejo Nacional de Produccion) published annual estimates on national production, area planted and some costs of production for the basic grains. Parts of this information for recent years was available on a regional basis. However, the regions used by the CNP were not identical to either the Ministry of Agriculture's regions or those of the Office of Agricultural Planning (OFIPLAN). To make an integrated data set, the data from the various sources had to be resummarized to a standard regionalization.

The L.P. models minimized costs of producing the 1973 national production of each crop. The only other constraints were the availability of cropland and the requirement that each region produce at least 90% of the proportion of national production it had achieved in 1973. The comparative advantage for each crop was easily recognized by searching for those regions where the optimal production exceeded the regional production constraint in the model results.

The planning regions of OFIPLAN were used in the models in place of some land resource classification. This regionalization implied that all land resources within a region were of homogeneous quality. The models only addressed comparative advantages in this crude sense. The models did not consider other relevant determinants such as labor, product prices, land tenure, infrastructure, transportation costs or fixed investments in orchards or land improvements.

The models were analyzed in two different ways. First, the cost of production estimates were held constant and differences in the yield and production information were reviewed. Secondly, three sets of yield and production total information (Census, Central Bank, and Aggregated) were held constant and the implications of the use of Central Bank versus Ministry of Agriculture costs of production were examined.

In the first set of tests the comparative advantage among regions changed for some crops with changes in yield and production data (holding costs of production constant). For example, the Pacifico Norte region had a comparative advantage in maize production using Central Bank yield and production data while the aggregated data set showed the comparative advantage for maize to be in the Central region. Other regional changes were associated with changes in data sets for rice and coffee.

In the second set of tests the comparative advantage among regions changed from some crops with changes in the cost of production data (holding yield and production estimates constant). When Central Bank costs were used the Pacifico Norte region was relatively more efficient in the production of maize and sugar cane than other regions. When MAG costs of production were used the Atlantico region demonstrated a comparative advantage in maize production and the Pacific Central region a comparative advantage in sugar cane production.

The two sets of tests demonstrated the sensitivity of the L.P. models to the quality of cost of production, yield, and agricultural production data.

A preliminary multiple objective regional land base model was also developed for Costa Rica. The multiple objective approach was used to quantify trade-offs between a variety of national sector objectives and to study the regional implications. In constrast to the single objective function L.P. model previously discussed, the multiple objective model is designed to provide an opportunity cost analysis of conflicts between objectives functions.

The following national agricultural sector objective functions were used in the Costa Rican Analysis:

1. Maximize labor employment.
2. Maximize export earnings.
3. Minimize cost of production.
4. Self-sufficiency in basic grains (corn, beans, and rice).

The study used a goal programming model that allows the use of a multiple objective function. Model results, in the short and medium term, at the national and regional level, were obtained.

Syrian Crop Response Models

Although the results obtained were mixed, efforts were made in the Syrian Sector Assessment to develop statistically estimated equations that would predict the likely area responses of selected major crops; that is, the area of land that would be planted to certain crops in response to the influence of certain variables such as prices and weather. Such area response predictive equations, were needed to predict the consequences of alternative target prices for commodities such as wheat, barley, cotton, sugar beets, and others and to determine crop planting response to wholesale crop information.

The estimation technique used was multiple linear regression, with the area planted to non-irrigated crops related to the crop's own price, to the price of competing crops, and to selected weather variables. For irrigated crops, the area planted was specified as a function of the crop's own price, the price of competing crops, and the prices of major purchased inputs.

Equations were fit at the county level for any county that historically accounted for one percent or more of national total area planted to a selected crops, either nonirrigated or irrigated. State level equations were fit for any state that included more than one county which satisifed the one percent criterion.

Crop area response predictive equations for crops with announced prices were statistically estimated for the following crops for which the Syrian Arab Republic announces prices: Wheat: irrigated and non irrigated; Barley: non irrigated; Cotton: irrigated; Sugar Beets: irrigated; and Lentils: nonirrigated.

The results of these single equation models were mixed. Examples of predictive equations that were considered useful are presented:

The area response predictive equation for irrigated wheat in Al-Rakka was:

$$y = -9{,}517 + 36{,}523\ APW - 176\ FI + 250\ RMI,$$

where

y = area planted to irrigated wheat in the current year by Mohafaza;

APW = the announced price of wheat lagged one year used to approximate the expected price for the current year;

FI = the national fuel price index used as a proxy for the cost of fuel consumption in wheat production; and

RMI = the national raw materials price index used as a proxy for the cost of the raw materials used in irrigated wheat production.

Most state-level estimated equations had relatively high coefficients of determination (R^2). However, the (slope) coefficient associated with the announced price of wheat (APW), parameter was, in each case statistically insignificant.

The area response predictive equation for nonirrigated wheat in Aleppo was the following:

$$y = -790{,}718 + 3{,}754{,}656\ APW + 2{,}181\ ONDP,$$

where

y = the area planted to nonirrigated wheat in the current year by state during the period 1971 through 1977.

APW = the sum of the deflated announced price of wheat and the deflated bonus in the Damascus region in the previous time period.

ONDP = the precipitation (mm) during the planting season of October, November and December.

RWL = the ratio of the sum of the deflated announced price and bonus of wheat to the deflated announced price of lentils, both lagged one time period.

The announced (target) prices for agricultural commodities, used alone or in conjunction with other commodity price series for inputs such as fuel and materials and with precipitation variables, explained only limited proportions of the variation in areas planted to these selected commodities.

These relatively inconclusive statistical results may have occurred because of: (a) excluded variables, (b) the impact of institutional constraints, particularly nonfree market conditions, (c) incomplete or inaccurate information, and (d) incomplete understanding of the nature of the problem or a misspecification of the problem -- for example, the pricing system may impact area and yield together rather than just area planted.

Crop area response predictive equations for crops considered responsive to wholesale prices were statistically estimated for the following crops, considering their respective wholesale prices lagged one production period: Potatoes, irrigated; Cucumbers, irrigated and nonirrigated; Chickpeas, nonirrigated; and Watermelon, nonirrigated. Results of these single equation area response predictive models were mixed.

INSTITUTIONAL RELATIONSHIPS

Several of the goals, purposes, and outputs of CRIES relate to the institutionalization of the methods and procedures in each participating country: specific reference in the goal statements to this issue was:

> "To expand the number and enhance the capability of developing country planning personnel to construct and use such an information base and analytical system". (Refer to p.1, this report).

A purpose of this overall activity specific to this issue was:

> "To internalize utilization of the techniques developed as part of the project and integrate the system with sector analysis activities in the countries". (Refer to p.2, this report).

One of the expected outputs of the overall project activity specific to internalization was:

> "In-country capability to construct, refine, and utilize the system in each country as an integrated component of the sector planning activities". (Refer to p.2, this report).

Accomplishments made with respect to goals, purposes, and outputs specific to internalization will be summarized by country in this section.

Dominican Republic

Expansion of the number and enhancement of the capability of personnel to develop an information base and a management/analytical capacity can be addressed by viewing the staffing pattern and the training provided to the staff put in place by the participating country.

When CRIES assigned a resident advisor to the Dominican Republic in October 1977, the counterpart Dominican unit consisted of one Dominican advisor. In February 1978, the Dominican staff was expanded by the assignment of two technicians, one with training in agricultural business and another with training in plant physiology. Subsequent to the change in the administration of the Dominican Republic Government, seven additional specialists were added in late 1978. Their specialities included agricultural economics, statistics, farm management, soil classification, irrigation, and livestock production. In early 1979, an agronomist and computer scientist were added to the multidisciplinary team. The project team's staff has remained at twelve, although some have been occasionally away from the Dominican Republic on educational leave.

Training to enhance abilities to develop, manage, and analyze information for assessing food production potentials was accomplished in several ways. The four primary forms of training were provided by: (1) the resident advisor of the CRIES; (2) CRIES staff providing seminars and workshops in the Dominican Republic; (3) the Dominican Republic team receiving training from CRIES or other entities in the U.S. and occasionally third countries; and (4) formal university training.

The CRIES resident advisor provided day-to-day training on the technical aspects of the project and provided guidance in administrative procedures.

Several formal and informal training sessions were conducted in the Dominican Republic by U.S. - based CRIES staff. Between March 1978, and September 30, 1980, approximately 30 days of formal and informal training was provided in the operation of the Geographic Information System including considerable instruction in how to geocode maps. Some 25 days were provided on linear programming. A project soil scientist provided over two weeks of informal consultation and instruction. Perhaps the most widely accepted instruction during this two and one-half year period was that offered in remote sensing and photo interpretation techniques. Some 20 days of formal instruction, involving 30 Dominican participants, was provided by CRIES on the rudimentary and advanced elements of photo and Landsat imagery interpretation.

In addition to the total of 90 days of training sessions provided to the Dominican counterpart staff and technicians from other Dominican agencies and institutions, considerable training was also provided by CRIES concurrent with the performance of their technical assistance activities. The specifics of all forms of training provided concurrently with technical assistance activities would be burdensome to document. A few selected examples includes training in questionnaire design to obtain major agricutural land use data, instruction in the incorporation of socioeconomic analysis into watershed planning, and guidance in the specification of appropriate logistic support and ground truth procedures to conduct light aircraft aerial surveys of small study areas to obtain crop use data.

A third type of training involved Dominican technicians attending short term training sessions in the United States or third countries. Generally two or three from the counterpart staff attended such sessions. The Dominican advisor worked with the CRIES project staff in East Lansing, Michigan, in 1977 for a brief period to obtain skills and technical assistance in specifying alternative crops to sugar cane by RPU. The technical alternatives were specified from the preliminary information sets that had been derived and specifications of needed information to conduct an analyses of economic feasibilities was outlined. In 1978 a team again visited the East Lansing office to discuss on the modelling and non-modelling uses that could be completed through use of the Dominican Republic's information sets. During this session the linkages between agricultural sector analyses and agricultural resource inventory and evaluation were thoroughly reviewed. Later in the same year three Dominican technicians were in East Lansing to assist the CRIES project staff in the interpretation of aerial photography and field data related to a suspected cane rust outbreak in the Dominican Republic and to refine their photo interpretation skills.

Finally, formal university training is underway in the Department of Resource Development at Michigan State University for two members of the Dominican counterpart staffs.

Some limited observations can be offered in addressing the achievement of the major specific output related to internalization — "in-country ability to construct, refine, and utilize the system as an integrated component of sector planning activities". The counterpart staff was initially placed in the Subsecretariate for Planning, Secretariate of Agriculture. In this unit economic analysis was stressed. The CRIES counterpart staff was considered to be, at least informally, a contributing unit to the sector analysis unit.

With the change in the Dominican Republic Government in 1978, the staff was moved to the Subsecretariate for Natural Resources, Secretariate of Agriculture. The unit has a heavy physical resource evaluation orientation. Subsequent to the transfer to this subsecretariate, the CRIES counterpart staff was elevated in status from the program to departmental level and became the Department of Inventory, Evaluation and Regulation. In 1980, it is named the Department of Natural Resource Inventory. Its charge was principally physical inventories and assessments of mountainous areas with marginal agricultural activity and watershed management. The interests of the counterpart staff in economic analyses and in sector planning activities have diminished.

Costa Rica

Activities of CRIES in Costa Rica were initiated in May 1977, and officially terminated in March 1979. Unofficial collaboration has continued with the Costa Rican Institute of Technology (ITCR), and with the Inter-American Institute of Agricultural Sciences (IICA).

When the project was initiated, the lead Costa Rican agency was the Agricultural Sector Planning office (OPSA) in the Ministry of Agriculture. The National Geographic Institute and the Institute for the Development of Natural Resources were designated as cooperating agencies to assist OPSA in the implementation of the project.

During the first year of the project OPSA provided counterparts to complete soil inventory activities and to evaluate secondary agricultural data. CRIES collaborated with OPSA in outlining activities to support a sector analysis effort being conducted by another external donor and provided partial funding and assistance in questionnaire design for an OPSA farm survey. All arrangements and collaboration with OPSA was discontinued in September 1978, with a change in OPSA leadership.

CRIES pursued formalizing arrangements with the University of Costa Rica and the Costa Rica Institute of Technology (ITCR). These efforts were discontinued in March 1979 at the request of the AID Mission/Costa Rica. However, subsequent to this date CRIES has provided informal assistance to these institutions.

In June 1979, the Geographic Information System (GIS) and editing software packages for survey data, a frequency distribution package, a regression package, a linear programming package, and a cross-tabulation package were installed at ITCR. The systems analyst and a project agricultural economist seminared with faculty and students of ITCR and the University of Costa Rica and technicians from InterAmerican Institute of Agricultural Sciences (IICA) on the theoretical aspects and applications of these packages. "Hands on" examples were used in the seminar to carry the application from the problem identification stage to the final stage of evaluating the analytical results related to each policy alternative.

Under separate contractual arrangements, the CRIES has provided GIS and training to support IICA's use of GIS in its PIADIC project in several Central American countries. Three weeks of seminars were given at IICA for personnel from all of the Central American countries on the methods for conducting natural resources inventories and the use of GIS in managing and analyzing natural resource information.

The GIS is currently being used by IICA for geographic and socio-economic analyses. The training program that CRIES provides to support the use of GIS, including natural resource inventory concepts and procedures, is now included in course offerings IICA offers to member countries.

In Costa Rica the GIS system is being used for one planning region to correlate information on resource conditions with socio-economic survey information. Resource information on soil conditions, land use, plant life zones, hydrologic conditions, and other factors is being correlated with the socioeconomic data to evaluate the relationships of size and quality endowments of resource holdings with production costs, income levels, and other measures of social and/or economic well-being.

Nicaragua

Activities of CRIES in Nicaragua were initiated in June 1977, and suspended in September 1978. The counterpart agency to the CRIES project in Nicaragua was the Agricultural Sector Planning Directorate (DIPSA). During this short period of time close collaboration with the professional staff of DIPSA led to the initiation and completion of a considerable number of information sets.

The national topographic map, at a scale of 1:250,000 was transferred to a mylar base and provincial and county boundaries were geocoded and measured. Area measurements for the country, the agricultural planning regions (collections of counties), and provinces were compared with official tables and reconciled. Because of the lack of adequate computer facilities at DIPSA, no training was provided to DIPSA personnel on the use of GIS.

In collaboration with the national cadastral agency, CRIES completed a soil map, scale 1:250,000, using the USDA Soil Taxonomy. As the Nicaraguan counterparts were well-versed in the concepts and applications of this taxonomy, no additional training was considered necessary.

The CRIES project's agricultural economist worked closely with DIPSA's agricultural economists and agronomists in deriving information on major land use, cropping patterns, and crop cost of production. These information sets, and information on transportation costs for agricultural crops by planning region, were in the process of being verified by Nicaraguan extension agents and a project resident advisor had been tentatively extended an offer of employment when the overall activity was suspended.

Syria

The activities of CRIES in Syria were directed at assisting the Government conduct an agricultural sector assessment. CRIES activities were coordinated with those of other subcontractors to the lead agency charged with implementation, the USDA Office of International Cooperation and Development (OICD).

The institutional arrangements developed in Syria were at the project level. The project, the Syrian Agricultural Sector Assessment Project, was put in place as a joint U.S.-Syrian activity for only the duration of the technical assistance. Syrian participants on the project were scheduled to be reassigned to their respective ministries at the end of the technical assistance activity.

Two Syrian soil scientists with photo-interpretation skills participated with the members of CRIES staff in the interpretation of major land use from Landsat imagery. In addition, these scientists were provided with additional instruction at CRIES project facilities in advanced techniques in imagery interpretation. Upon completion of this period of instruction, and the culmination of the Project, these technicians were reassigned to the Directorate of Soils, Ministry of Agriculture. They expected to be able to use their advanced training in photo interpretation to accomplish soil survey activities scheduled in their directorate.

The Director of Agricultural Statistics, the Director of the Computer Center, and a Chief Programmer from the Computer Center of the Central

Bureau of Statistics collaborated with the systems analyst and computer programmers of CRIES to arrange for the transfer of the Syrian information sets, GIS, and AEIS. This team was provided complete instruction in the use of both systems for continued use by the Bureau of Statistics in the processing and analyses of agricultural sector information.

Honduras

The Honduran activity has been completed through its first phase. In this phase the CRIES project personnel collaborated with Honduran technicians from the Ministry of Natural Resources in resource problem identification, inventory of the resource base, development of a plan of analytical work for the next two years. In phase two, CRIES staff will provide technical aid to ministry personnel in specific activities of the plan of work.

APPENDIX A

END-OF-ASSIGNMENT REPORT OF CRIES RESIDENT ADVISOR IN THE DOMINICAN REPUBLIC

END-OF-ASSIGNMENT REPORT - October, 1980

I. TECHNICAL AND CONCEPTUAL ASPECTS OF CRIES

A. Land Resource Base Inventory

1. Original RPU Concept. (CRIES 77-1)

The original RPU concept is excellent as a land classification unit for land use planning -- a soil, climate and water unit. It has the theoretical benefit of adding water information to soils units. The operationalization of the basic RPU concept suffered seriously in D.R. in the beginning because we were talking about land use potential without having information on water availability (surface, underground) included in our RPU descriptions. In summer 1978 SIEDRA obtained a water specialist to fill what was then an embarassing void. Use of the Soil Taxonomy to establish international soils standardization in RPU mapping is an important long term goal. The RPU mapping suffers from lack of an internationally accepted climatic taxonomy. Holdridge's life zones worked well in the D.R. as many people are familiar with the large, multicolor OAS maps of 1967.

2. Concept and Method Revision for the D.R. (SIEDRA No. 1, 2, 3)

In 1976-77 there was no land use data available by ecological unit in the D.R. CRIES/SIEDRA was to assist the sector analysis project (ANSE) in modifying both its 1976 farm survey questionnaire and the SEAPLAN quarterly survey questionnaire to obtain RPU-keyed production information. Thus, no attempt was made to obtain what was viewed as duplicate funding for a separate SIEDRA land use survey.

As things evolved, however, the follow up to the 1976 farm survey was repeatedly postponed (it's still in limbo) and the quarterly survey was determined to require too many modifications to become a multipurpose survey. In the interim, while hoping to eventually use the farm survey results, SIEDRA had to establish an alternative data base development methodology. What evolved was a series of interviews with regional (7 SEA regions in the country) agricultural specialists and local producers to obtain data on major land use, yields, input use and costs, land tenure, and farm size.

A preliminary questionnaire was developed and field tested in late 1977. It became immediately apparent that the RPU concept was too aggregated for obtaining production data from micro-oriented field specialists. The irony of standing in an area of hills and valleys and calling it a "relatively homogeneous" RPU was not lost on the specialists. Consultation with Ellis Knox after the February, 1978, project evaluation in Lansing resulted in the conceptualization of a visually identifiable RPU subunit called the GDSS (Grouping of Dominant Soil Subgroups).

The GDSS was intended to capture the essence of the visually distinguishable subdivisions of RPUs (literally, hills versus flat land in most cases) which the field specialists were pointing out, while maintaining fidelity with the soil taxonomy. It was determined after some trial-and-error GDSS delineation that phases of subgroups could be grouped within individual RPUs to provide GDSSs visually distinguishable by the non-soils trained regional specialists and farmers on which SIEDRA had to rely for its initial data base.

Due to lack of soils maps with adequate detail, GDSSs are currently identified and described as unmapped percentages of RPUs. This situation has caused problems in other multidisciplinary aspects of project work, particularly with use of map-based PADRE and inability to capitalize on visual impact of a map of our basic analytical unit.

Another serious problem with the RPU concept in the D.R. is that it was applied with emphasis on crop oriented agricultural production units, which was consistent with SEAPLAN orientation. Since the fall 1978, transfer of SIEDRA to SURENA, however, it has become slowly but increasingly apparent that SURENA wants a more non-crop mountain area orientation for SIEDRA in order to avoid competition with SEAPLAN. With all of the mountainous areas mapped as a handful of mountainous RPUs (especially RPU 2), we were severely limited on the data we could provide on land use in the mountains. In the early 1980 final version of the RPU map a few more RPUs have been delineated in the mountainous regions, but we have no data for many of the units. This situation may be worsened with the micro-oriented natural resource management (NARMA) project unless further mapping of pilot study areas is accomplished and some form of sampling is used to estimate (quantify) land use parameters in these marginal cropland areas.

3. Progress on Revisions by SIEDRA Staff

A revised national RPU map was finalized in Spring, 1980, after three years of evolution through the GDSS conceptualization and field verification of RPU map unit delineations and descriptions of GDSSs. The GDSS descriptions and interpretations are being published on a regional basis and all should be published by 30 September. Regional water documents will lag at least six months behind the land base publications, because of the water specialist's being assigned major administrative responsibilities beginning last fall.

There have been discussions about the desirability and feasibility of cartographic and taxonomic disaggregation of the current RPUs/GDSSs in high priority areas, particularly in support of the NARMA watershed planning activities. Detailed soil maps are available in the major agricultural valleys and could be easily reinterpreted to GDSS maps. On the other hand, little soil mapping has been done in areas of greatest interest to NARMA. This would be the logical next phase for the land classification work, and, in spite of two years of inter-departmental jurisdictional negotiation which have prevented long term programming of this type of increasingly-micro emphasis by SIEDRA, the disaggregation is expected to proceed during NARMA development.

4. Application RPU/GDSS System to Other Countries

In principle a worldwide RPU/GDSS system of classification makes very good sense from the standardization and information transfer standpoints. From the operational standpoint, however, I see some problems ahead. First, is the dilemma that the GDSS seems to be the most aggregate level of classification with which agricultural technicians can relate in the D.R., yet maybe too detailed for use in countries much larger than the D.R. where field interviews are required to obtain data. If there are countries with current or planned farm surveys which can be used directly in the RPU/GDSS system this specific problem will not exist.

Second is that the GDSSs are not mapped in this country and the prospect is that the soils maps and/or soil scientists required to do the national mapping won't be available here for at least a decade. At best SIEDRA will have to proceed on a piecemeal priority basis as mapping and mappers become available in areas of SURENA interest. Not having a map and/or an understanding of our analytical units has seriously hampered SIEDRA ability to interest key administrators in the project, most of whom cannot make the logical jump from an RPU map to an unmapped GDSS component. Many of the SIEDRA staff also have the same problem, which contributes greatly to inefficiencies in all aspects of their work.

Third is the problem of selling the system as a "national/regional: system which "should not be used for project planning". Our experience here has been that many people ignore our written and verbal warnings and try to use our data for project planning, only to become disillusioned with our system when they find out it "won't work" at that level. I suspect this could be a source of misunderstanding in other CRIES countries unless carefully planned for ahead of time.

Fourth is the lack of Spanish language examples of actual use of land classification systems for data collection, analysis and policy purposes. Before I came here I was unable to obtain documented cases of river basin planning impact on public policy. During my three years in the D.R. we still don't have good documentary evidence -- even in English (Cornell workshops are best). In the absence of such documentation in Spanish many GODR administrators have been reluctant to actively pursue ties with SIEDRA.

B. National Level Crop Statistics

1. Original Concepts and Methods (Harrington's draft "Land Inventory and Crop Totals", dated July 1977)

Harrington's work in the D.R. did a lot to "grease the skids" before I arrived, and his statistical work on crop totals was instrumental in strengthening SEAPLAN's credibility as an agricultural statistics organization. His document is still the best that has been produced here.

2. Revised Concepts and Methods

Because of statistic personnel problems encountered from the initiation of the project, the region-by-region approach to data gathering (see D, below), and the SURENA mountainous area orientation, national level crop statistics are only being developed as aggregates of regional statistics. SEAPLAN has been working on national statistics based on the quarterly survey and is supposed to publish a 1971-79 time series in the near future. SIEDRA will use these data as control totals against which to check and coordinate regional totals if SIEDRA finishes the regional surveys to produce national crop data after the current. CRIES funding terminates on 30 September. Given the SEAPLAN/SURENA dichotomies vis-a-vis mountainous areas and economic analysis, I question whether SIEDRA will be working directly with national or even regional level crop statistics. My guess is that their production statistics will become increasingly oriented toward individual watersheds with limited concern for national/regional data aggregation and economic analysis.

3. Application to Other CRIES Countries

The SIEDRA situation is difficult to generalize. The two critical factors influencing SIEDRA flow from the differences in SEAPLAN/SURENA operational orientations: (a) SURENA is mountainous area oriented, and (b) SURENA is non-economic analysis oriented. The rigidity of these differences has only become clear after nearly two years of attempting to integrate work between SURENA and SEAPLAN. Consistent collaboration between the two institutions has not proved possible. Perhaps the institutional problems will not be as acute in other CRIES countries.

C. Crop Area, Yield and Production estimates by Region, RPU and GDSS

1. Revised Methods. (SIEDRA No. 4, 5.)

As mentioned in A, above, the RPU was supplemented by the GDSS as the SIEDRA analytical unit early in 1978. That change dictated the establishment of a new, GDSS level, data base. When preliminary attempts to plan the data collection through the ANSE farm survey indicated that that might prove infeasible for at least a year, and with no support for financing a separate SIEDRA farm level land use survey, an alternative data collection methodology was established. Agricultural specialists of the seven SEA regional offices were to be interviewed to obtain the required data. These specialists are of two types: (a) product specialists responsible for a specific product throughout the region, and (b) geographic area specialists responsible for all agricultural production in a given sub-region. The questionnaires and interview procedures were field tested in Summer, 1978, and the first regional interview took place in December of that year (SIEDRA No. 4). Follow up interviews were conducted early in 1979 and sample comparisons of land use allocation and yields were made among: (a) the original CRIES RPU level estimates, (b) SEA estimates by production area, and (c) the SIEDRA interview results. There was close comparability among the SEA and SIEDRA estimates, while, not surprisingly, the original CRIES estimates were significantly different both in terms of allocation of crops to RPU/GDSS and of yields and production costs (SIEDRA No. 5). The decision was made to continue the regional interviews as the SEA estimates were not detailed enough (particularly in terms of input quantities and prices) for SIEDRA purposes.

Both LANDSAT and aerial photography studies have been carried out by the U.S. CRIES staff, with limited SIEDRA participation. Under terms of a $100,000 June, 1978, grant based on the earlier LANDSAT study, work has been carried out on: (a) development of a national general land use cover map from LANDSAT imagery interpretation, (b) determination of optimum combination of film, format and altitude for aerial photography to supplement both LANDSAT on the macro level and the proposed (most recently postponed until 1981 because of a 1979 hurricane) SEA farm survey on the micro level, and (c) restratification of SEA's 8 year old area sampling frame using remote imagery. Low priority by SEA on its survey activities, and the hurricane, have hampered work on (b) and (c).

Conduct of all imagery analysis in the U.S. and lack of formal training has not permitted SIEDRA to learn remote sensing analytical techniques at a functional level. The remote sensing work in general and the early 1980, well-received, remote sensing workshops in specific, have stimulated local interest in remote sensing and it is anticipated that SIEDRA will receive increased SEA financial support in that area in the future. Jurisdictional discussions with the largely ineffectual, university-housed, Geographic Institute may continue to hamper SEA efforts in developing an internal remote sensing capability to an adequate degree.

2. Progress on Revisions by SIEDRA Staff

SIEDRA will have published five regional documents on yields, production area, and costs of production, by GDSS for major crops by the ends of FY-80. Because of the SURENA (and thus, SIEDRA) emphasis on mountainous areas and non-economic analysis, there is a question as to whether SIEDRA will finish the other two sets of regional interviews and catalog the results for further analysis. In the future SIEDRA probably will become heavily physical and agronomic science oriented in the mountainous areas of the country. They are continuing with plans for a plant zoning project in which GDSSs will be prioritized for production of about one hundred plant species. They are thinking in terms of using interview-derived yields as the zoning criterion and leaving economic analysis to "other organizations". I see real integration of SIEDRA and farm survey efforts as a possibility where there is clear and timely mutual interest in specific watershed/local areas. Additional technical assistance will be required to effect the "critically important integration of SIEDRA and area sample frame efforts."

The remote sensing work (photo interpretation and cartography) will likely continue, but with an increasingly micro (watershed) focus. As the NARMA project develops SIEDRA will be asked to assist in watershed mapping and planning. Because of high sugar prices and domestic political problems, there has been no interest expressed on the part of the State Sugar Council (CEA) in follow up on the cane rust study.

3. Application to Other CRIES Countries

Again, it's hard to generalize from the SIEDRA experience. In countries where statistics programs will support and integrate with the CRIES work adequately from the beginning or where they can be "educated" to do so during the first year, many of the SIEDRA problems (little interest in national statistics, non-crop emphasis, mountain orientation) will not arise. SIEDRA was fortunate to be able to stimulate a demand for its proposed products and to be able (through delicate negotiations) to transfer to an organization, SURENA, which would adequately support the work (except for economic analysis).

Remote sensing (THE PHOTOMOSAIC) has been a very stimulating calling card for us from the beginning. The fact that remote sensing is a professional interest of the SURENA Subsecretary has assured its prominence in SIEDRA since August, 1978. We have been fortunate that the Subsecretary is knowledgeable of remote sensing capabilities and limitations, and has supported our labor extensive approach. There probably will be increasing criticism in the next few years in AID of overselling capital intensive RS technology worldwide without careful checking of user needs, but we should be on safe ground in the D.R. I suggest that continued conscious emphasis be placed on (eye-catching, where possible) realistic, appropriate technology in all aspects of CRIES work in other countries.

D. Economic Variables

1. Cost of Production of Major Crops

a. Revised Concept and Methods. (SIEDRA No. 4, 5, 10; July 1977 memo on sugar-cane; MSU's CEA report; Sutton's March 1978 memo (See C.1., above).

2. Influence of Economic Analysis on Natural Resource Use

a. Pricing Policies

SIEDRA has had no impact on pricing policies to date, as no price-oriented studies have been undertaken. While not specifically price-oriented, the current rice study could impact on foreign exchange and water pricing policy.

b. Other Policies

1) Sugar-cane production. Although carried out on a confidential basis, newspaper articles at the time implied that the rudimentary sugar-cane study of July 1977 may have influenced a crop diversification project of the GODR.

2) Sugar-cane rust. The August, 1978, and follow up research on cane rust assisted the CEA in ascertaining the nature and extent of the potential cane production crisis. It is rumored that the CEA will buy two light aircraft which will be used part time for aerial photography monitoring activities.

3) CEA land use improvement. MSU's 1979 proposal for improvement of CEA production efficiency was well received. However, as world sugar prices increased in 1980, interest subsided in what was viewed as a "sugar-cane reduction" project. When prices drop, there will be renewed interest in cane land diversification, and MSU's proposal may be resurrected.

4) Eastern Cibao Valley development planning. In late 1979 and early 1980 several SIEDRA soils technicians were asked to assist in an OAS-advised regional development study of part of the Cibao Valley. Their work focussed on land use interpretation for agricultural productivity estimates. To the extent that the resulting development plan is implemented, SIEDRA will have influenced land use policy there.

5) Central Region rice production. The current rice study analyses Central Region GDSSs for rice suitability and profitability, and has involved major DR rice production organizations to various degrees. The study is intended to influence selection of future rice expansion areas, but may also impact on water pricing and foreign exchange policies.

6) Reclamation of Enriquillo Valley soils. The SIEDRA technical coordinator headed a local professional engineering society committee to organize a seminar on the reclamation of saline/sodic soils near Lago Enriquillo (RPU 29). This has resulted from his conversations with Knox concerning the feasibility of such reclamation.

7) Bao Watershed plan. Early conversations among SIEDRA and other SURENA technicians directly influenced the development of the

Bao Watershed conservation plan in 1977-78. These conversations and CRIES's memo on the review of the draft plan led to increased emphasis on socio-economic factors in the final plan, which is now one year into implementation.

8) Winrock Livestock Research Station selection. A Winrock Representative used the original CRIES 77-1 to identify possible areas for establishment of a goat research center in 1978. The center is currently under construction in the area initially selected from the CRIES document.

9) AID Mission NARMA Project. The CRIES methodologies are being applied in a number of ways in the NARMA Project. SIEDRA soils data and the preliminary CRIES land cover map (from LANDSAT imagery) have been used to estimate erosion levels in eight major watersheds in the process of prioritizing areas for NARMA project development. The land cover map will be overlaid on the RPU map and estimates will be made of improper land use in mountainous areas.

10) The U.S. based MITRE Corp. used the CRIES/SIEDRA RPU information or prioritize areas for possible energy plantation establishment in a consultant's report to the AID Mission in 1980.

11) Private Dominican companies. Several local private companies have requested information from SIEDRA on where specific plan species can be grown. Red beans and African oil palm are two recent examples.

12) National aerial photography - CRIES technical assistance has been instrumental in clarifying photographic requirements in the SEA and other agricultural institutions.

13) An IDB consulting team is using CRIES/SIEDRA information in a large irrigation project prefeasibility study.

3. Analytical Modelling. (SIEDRA No. 10; Kemph thesis; CRIES 78-1, 2; Users Guide draft.)

a. Economic Analysis

The LP model (MADRE) was very useful in the first year of the project in providing an organizing framework for data collection. To date the only use made of MADRE has been for economic analysis training. A regional LP model for rice land use analysis may be completed by end of FY-80. Given the current SURENA orientation away from economic analysis and data collection (discussed above), it is doubtful that MADRE will or should be used for policy analysis in the future. It is hoped, however, that SIEDRA resource inventory information will be used by SEAPLAN in future agricultural sector planning.

The current rice study involves benefit-cost and partial budgeting economic models, neither of which is computerized. Again, the future use of even these relatively simple economic models is in question.

b. Non-Economic Analysis

The geoprocessing program (PADRE) has been used for generating maps to provide visual impact in SIEDRA regional meetings. Recently it has been used for macro land use analysis in NARMA development. The main drawbacks to its past use have been: (a) outdated maps with no programs for revision and/or adding new maps, (b) unmapped analytical units -- GDSSs, and (c) low cost of manual analysis of maps versus total costs of maintaining a full (geocoding, programming) PADRE use capability. Until GDSSs are mapped, I don't think SIEDRA will use PADRE to any great extent. Now that the new RPU map is installed, cross-tabulations of RPUs, general land use, administrative boundaries, seem to be creating interest among certain users. As detailed watershed mapping is finished and the full blown RAP system is finally installed, PADRE may be used for its intended purposes, but mostly at the watershed level.

In the agrophysical analysis of the rice and similar studies, a manual process of crosstabulation of plant input requirements with GDSS characteristics has been used. Computerization is critical for widespread and timely use, but a series of inexperiences SIEDRA programmers has prevented program development.

Future use of FORTRAN-based programs in the DR may be suspended if a new WANG VS 2200 computer is installed as planned next FY. This system currently has no FORTRAN compiler available. SIEDRA is planning to install its own terminal. The Mission has been advised that the WANG computers are to be installed in 5 Missions worldwide by FY-82, and in all Missions eventually.

c. Application to Other CRIES Countries

Again, difficult to generalize. SIEDRA has not used MADRE/PADRE much here because of lack of data/map entry capability and lack of economic analysis capability. At the same time SIEDRA has not had programming capability/support to develop the benefit-cost, partial budgeting and agrophysical crosstab programs of more immediate need. Development of these more basic analytical models and presentation of a "menu" of all available models might be a better approach in other countries. That would allow more flexibility in selection of appropriate analytical models for specific countries. That flexibility would be offset by the high cost of support for additional models. The need for WANG compatibility must be determined.

II. INTERNALIZATION

A. Goals, Objectives, Strategy

1. Goals

The goal of the DR internalization phase was to create a viable multidisciplinary resource inventory and analysis unit in the Dominican Republic to provide accurate assessments of the impacts of alternative land resource uses and choices. This meant establishing a competent technical staff and developing and maintaining the linkages between data input agencies and product users.

2. Objectives

The objectives of Phase II were to:

a. Establish a multidisciplinary staff of Dominican Republic technicians (SIEDRA).

b. Train and motivate the SIEDRA staff in the use, refinement, and application of the CRIES system in land resource inventory and analysis.

c. Develop two-way communications with primary data generating agencies.

d. Develop two-way communications with multilevel DR and US/DR decisionmakers in order to identify relevant policy issues related to the use of resources in rural areas.

e. Refine Phase I data and methods to develop a sound information base.

f. Conduct pilot analyses of impacts of alternative land resource use options.

g. Communicate analytical results to decisionmakers.

It is important to point out that, given the experimental nature of this first-country CRIES effort, objectives were made specific enough to provide strong, coherent, direction to internalization efforts, yet broad enough to allow the critical flexibility and rapid response to unforeseen problems necessary to establish project credibility and concern for local needs.

3. <u>Strategy</u>

The strategy employed in internalization was influenced by three key dimensions of the work: dynamics, multidisciplinary nature, and linkages with data inputs and product users. Major elements of the strategy included:

a. Developing and maintaining interest and support, without creating unrealistic expectations.

b. Working through Dominicans to influence other Dominicans rather than directly.

c. Keeping a low, competent, profile.

d. Keeping support demands consistent with (increasing) output.

e. Developing reliable data <u>before</u> analysis.

f. Adjusting <u>all</u> inventory and analytical techniques to the technical competence of SIEDRA staff, data sources, agency facilities, and product users.

g. Allowing the project to take credit for public successes, while giving individual credit where due internally, and maintaining a team spirit.

h. Maintaining long-term project direction toward comprehensive, multilevel land use analysis, but searching for short-term, high impact, activities to maintain the interest and support of administrators.

i. Assuming the initial leadership role and then "phasing out" as DR leadership was developed.

j. Remembering the SIEDRA personnel have to live with the results of our activities, while Americans can return to the U.S.

B. Administrative Arrangements and Organizational Location

My CRIES resident position was negotiated with the AID Mission so that 75% of my time was allocated directly to CRIES/SIEDRA and 25% was devoted to Mission activities related to CRIES (specifically, monitoring the land use elements of Ag. Sector Loan II). An office and limited secretarial assistance was provided at the Mission. On the DR side, I initially shared a small office with a single SIEDRA staff member and two other people, with no assigned secretary or other administrative (transportation, xerox, etc.) support. Today SIEDRA (now the Department of Inventory, Evaluation and Regulation, DIEO) has an office suite for a dozen technicians and full administrative support.

C. Progress Toward Objectives and Unplanned Achievements

Substantial progress has been made toward all objectives. By individual objective, the high points of progress are:

1. Establish a Multidisciplinary Staff of Dominican Republic Technicians (SIEDRA)

When I arrived in October 1977, the SIEDRA "Project" consisted of one Dominican advisor, and was considered semi-formally as a subcomponent of the on-going AID/Washington, centrally-funded Sector Analysis Project in the Subsecretariat for Agricultural Sector Analysis (SEAPLAN) (Figure 1). In February 1978, the SIEDRA staff was expanded by the assignment of two technicians trained in agricultural business and plant physiology. The Dominican advisor was temporarily reassigned from June 1978 to January 1979. Under the new (August 1978) government, SIEDRA was assigned five specialists in agricultural economics, statistics, farm management, soil classification and irrigation. Two more (soil classification, pasture/livestock production) joined the staff in November. In April 1979, a computer programmer was assigned. The plant physiologist left the staff in Febraury 1979, for a plant physiology research administration position. Another agronomist, who was on the SIEDRA staff for several weeks in early 1978, is now one of seven regional SEA directors and has considerably strengthened SIEDRA communications with specialists in his and other field offices.

In December 1979, SIEDRA became the Department of Inventory, Evaluation and Regulation (DIEO). In addition to its previous SIEDRA responsibilities, DIEO was asked to recommend land use regulations to the government. A legal advisor was added to the staff in mid-1980, as was an agro-business specialist.

Only one of the twelve current staff members can speak or read English. One specialist has a Costa Rican M.S. degree and two are in the U.S. in graduate school. The others have either two year or four year DR university degrees. Only one has any previous administrative experience.

2. Train and Motivate the SIEDRA Staff in the Use, Refinement, and Application of the CRIES System in Resource Inventory and Analysis

Training of SIEDRA staff has been done in four primary ways: resident advisor, CRIES TDYs to DR, SIEDRA TDYs to U.S. and third countries, and formal university training. As resident advisor I have touched on all administrative and technical aspects of the project. Methods of training have included formal lecturing, multidisciplinary group self-critiques, and one-on-one interaction in individual disciplines. Both the specialists and I have learned a great deal from this interaction.

CRIES TDYs to the DR have complemented resident training. Heaviest emphasis to date has been on soils/climate classification, production potential estimation, and remote sensing.

SIEDRA TDYs to the U.S. and third countries involved one or two technicians in each case, for (a) sugar-cane land production alternatives in 1977; (b) SIEDRA/Sector Analysis Project general orientation in 1978; (c) on-the-job training photo interpretation for cane rust monitoring in 1978; (d) technical document review in 1979; (e) sector analysis short-course in Guatemala, 1979; (f) geography short-course in Ecuador, 1979; (g) remote sensing seminar in Costa Rica, 1980; and (h) cartography for 6 months in Panama, 1980.

Formal university training is underway in natural resource development for two Dominicans who are expected either to join the SIEDRA staff or to be in key administrative positions to influence SIEDRA. One is currently working part-time without compensation for the CRIES staff while finishing his M.S. degree.

Motivation of the SIEDRA staff is manifested in three primary ways: lack of personnel turnover, desire to further formal training, and willingness to work extra hours with no compensation. Only four of 16 technicians who have been assigned to SIEDRA have left for other positions. All have demonstrated active SIEDRA support in their new roles. All but two of the current staff members have indicated a strong desire to pursue advanced university degrees and then return to strengthen the SIEDRA staff. The SIEDRA personnel also characteristically have been willing to work extra hours week-days and week-ends when necessary.

These personnel characteristics are not evident in many DR projects. It should be noted that this motivation has been created and maintained to date among a very diverse group of disciplinary specialists with little or no previous experience in adapting to the difficulties of multidisciplinary research efforts, and through a critical change in project directors.

3. Develop Two-Way Communications with Primary Data Generating Agencies

SIEDRA has had multiagency contacts through meetings and seminars to obtain primary and judgmental data. These data have been processed and returned informally, with questions and comments, to the originators. The purpose of the two-way interaction is to obtain and develop the best available data and to encourage data coordination. Coordination with the responsible Dominican agencies is felt to be the best way to improve data reliability and consistency among agencies.

The five major SIEDRA interagency data coordination efforts to date have been related to: (a) national crop production and area statistics; (b) soils classification; (c) 1979 Farm Survey; (d) aerial photography acquisition; and (e) SEA/AID Natural Resource Management (NARMA) Project. In July 1977, two CRIES staff members met with representatives of some 15 DR ag. statistics agencies to discuss inconsistencies among agencies in methodologies and resulting estimates. One result of meeting is that the current director of the SEA Data Bank is implementing a program to obtain a single consensus set of sectoral estimates for major production statistics.

Beginning in February 1978, and with periodic CRIES TDY assistance, an informal National Soils Commission was formed under SIEDRA aegis. The purpose of the Commission was to keep abreast of soil classification activities and to improve interagency methodological consistencies. A result of these efforts is the nearly unanimous use of the U.S. Soil Taxonomy and U.S. Soil survey methods, providing the basis for rapid comparisons for resource data in mapped areas of the DR as well as for incorporation into the SIEDRA/CRIES information system.

Early in 1977, the CRIES staff began analyzing the 1976 and proposed 1979 (since postponed to 1981) Farm Surveys of the SEA-Ag. Economics Department for possible incorporation in the CRIES information system. CRIES/SIEDRA personnel worked with survey personnel to develop modifications which would make the survey results useful to SIEDRA/CRIES without adversely affecting their usefulness to others. The result of this coordination was both a more useful (though with many serious limitations for SIEDRA use) questionnaire design and a better understanding of SIEDRA/CRIES purposes and needs within the SEA.

The fourth major SIEDRA/CRIES effort at interagency primary data coordination was in eliminating duplicate costs of aerial photography coverage by the National Cadastral Survey and the State Sugar Council (CEA). Through activities with both agencies on various aspects of SIEDRA/CRIES work, it was determined that both agencies were planning to contract aerial photographic coverage of overlapping geographic areas. A cost sharing plan was proposed by CRIES and accepted by both agencies. This resulted in the opening of an interagency communication channel which heretofore had not existed, and in the savings of $18,000.

The fifth major interagency effort by SIEDRA is their participation in the development of the Natural Resources Management (NARMA) Project proposal for AID Mission loan funding. SIEDRA soils/water data and the CRIES preliminary land cover (LANDSAT-derived) was combined with information from other agencies to make soil erosion estimates as part of an overall process of quantified prioritization of watersheds for prioritization of watersheds for project development. The final land cover map and RPU/GDSS information has been used to estimate improper land use in the DR. SIEDRA is expected to play a key role in data coordination throughout the planning and implementation of the project.

4. Develop Two-Way Communications with Multilevel DR and US/DR Decision-Makers in Order to Identify Relevant Policy Issues Related to the Use of Resources in Rural Areas

A formal CRIES/AID Mission linkage was provided under the administrative agreement for the CRIES resident advisor position. Early AID Mission interest was primarily in the CRIES resident loan monitoring activities (soil classification, fertility, conservation in rural areas) and in the resident's development of a preliminary Project Identification Document (PID) for Natural Resources Management in 1978. As a result of increasing DR interest in SIEDRA/CRIES activities, such as SEA and CEA letters to the Mission requesting a post-FY 79 extension of CRIES technical assistance, the Mission has increased its attention to the project's present and potential role in the NARMA loan development and implementation.

CRIES resident communications with the U.S. Embassy have taken the form of informal interactions with the Ag. Attache's office on data and method questions, a continous link with the IAGS (Interamerican Geodetic Survey) on cartographic and remote sensing mutual support, and a 1978 briefing to the U.S. Ambassador and his staff on important aspects of CRIES/SIEDRA work.

SIEDRA communications with Mission and Embassy policy-makers have been almost exclusively through the CRIES resident.

SIEDRA communications with DR policy-makers have been established through meetings, reports, memos, seminars, and information folders. At the national level, SIEDRA communicates through its direct administrator, the Subsecretary for Natural Resources (SURENA), to the Secretary of Agriculture. The current Secretary, on the basis of numerous 1978 multiagency meetings in which SIEDRA was discussed, took direct personal interest in promoting SIEDRA from project through program to departmental status and in increasing the SIEDRA budget from about $10,000 in 1977 to its current level of about $0.5 million. The Subsecretary is asked periodically (informally) to assist SIEDRA in identifying and prioritizing policy issues for data inventory and evaluation planning purposes.

SIEDRA has many informal communication channels with agencies outside of SEA, including the Office of the Technical Secretary to the Presidency (STP), which has overall responsibility for the performance of the national economy and through which all government operating budgets and expenditures must be approved.

SIEDRA has cooperated with the National Cadastral Survey in developing a methodology for evaluation of land values on the basis of agricultural productivity. SIEDRA also participated in land evaluation studies on an IDB-advised project with ONAPLAN.

In addition to linkages with these national level policy-makers, SIEDRA has critically important communications with regional and subregional decision-makers. This interaction is largely related to production data gathering but also results in important ground-level identification of policy issues, and program and project needs.

There has been little SIEDRA interaction with the DR private sector to date, except in identifying GDSSs with potential for producing specific plant especies.

5. Refine Phase I Data and Methods to Develop a Sound Information Base. (See I-A and C, above.)

6. Conduct Pilot Analyses of Impacts of Alternative Resource Use Options. (See I-E, above.)

7. Communicate Analytical Results to Decision-Makers

Once the rice policy analysis is completed, results will be discussed directly with relevant decision-makers. This will help assure that the decision-makers actually are informed of analytical results and projected policy impacts, and can take them into account in their decision-making. Decision-makers at both the policymaking-level and at the field implementation level will be included in the discussion, with the approval of the Secretary of Agriculture. Feedback from decision-makers will be used to improve the usefulness of future resource analyses.

D. Obstacles to Progress/Recommendations

As partly discussed in I, above, the major technical obstacles to overall institutionalization have been: (1) the complexities of multidisciplinary/multiinstitutional integration/coordination; (2) the non-mapped GDSS analytical units; and (3) lack of adequate computer support. It is very possible that we have been too ambitious here in trying to implement all disciplinary aspects of the project (soils, water, cropland, rangeland, forestland, techniques and costs of production, income, LANDSAT, aerial photography, computer use, survey techniques, statistics, etc.) among a group of technicians who have difficulty in grasping even their own individual disciplines. Dr. Cesar Lopez believed in a multidisciplinary, multiinstitutional systems approach to land use problem solving. Thus, until he left the project in June 1979, we pushed ahead vigorously (if slowly) on all fronts. Under subsequent directors the focus has narrowed to non-cropland and non-economic concerns, with reduced interagency communication.

Perhaps that was a natural evolution: start broad in order to feel-out local government interest, then narrow the focus to priority subject matter areas and specific problems. Certainly had we had a narrower economic analysis focus in SEAPLAN the project would have died because we would not have attracted sufficient SURENA interest to effect the project transfer. We were fortunate, too, that SURENA was a brand new, growing entity in 1977-78 and was more willing to innovate than was the more established SEAPLAN.

The non-mapped GDSS problem is not easily resolved, as discussed in I, above. In countries similar to the DR, where planners have difficulty with macro concepts, perhaps the solution is to begin on a regional basis with the RPU/GDSS system. The benefit would be establishment of project credibility with both macro and micro-agriculturalists in a relatively short period. The danger would be that government priorities might (very likely?) shift among regions before full development of the regional data base. Again, perhaps SIEDRA evolution from national to micro in response to changing governmental interests is a natural one that should be considered in other countries. It always has been. After all, microimplementation is the ostensible objective of all macroplanning.

The computer support problem has become perhaps the single most critical bottleneck in the SIEDRA work. Use of a computer center programmer to support SIEDRA worked fairly well in the beginning for program demonstration purposes. SIEDRA was assigned its own programmer later in 1979 to handle expanding programming needs. The programmer was very capable and highly motivated, but moved to the U.S. after three months of orientation/familiarization and was replaced by another programmer with excellent credentials. However, after more than six months on the job there has been little progress on the programming needs of the project. This compuer situation may be even more important than the SEAPLAN/SURENA differences in SIEDRA's deemphasis on national statistics and economic analysis.

There have been a number of significant administrative obstacles to SIEDRA institutionalization. The major obstacle to project progress to date has been the question of language translation. This has been a problem in relation to the original CRIES documents, subsequent SIEDRA documents, US/DR letters and memoranda, and Dominican training in the U.S. and DR. The first translation of an original CRIES document (77-1, drafted in mid-1977) was not made until late 1978, and most documents still remain untranslated. Not a single translation has been published for even internal SIEDRA use. This lack of ducuments in Spanish has seriously limited the ability of the SIEDRA staff to promote and maintain support for the project among administrators. It has seriously decreased the efficiency of my resident training efforts by tying me up with repetitive mental translations of parts of the same documents over time. The credibility of the project as a technology transfer effort has been extremely difficult to maintain among both DR and U.S. administrators and technicians due to lack of translation to facilitate that transfer. CRIES never has been funded for translations, and a DR translator was available for only four months in 1979.

It appears as through a formal policy by USAID/Washington, providing central funding for documents with potential multicountry distribution and requiring a formal project agreement to define U.S. and/or host country translation responsibilities before initiation of the project, would increase project effectiveness in future CRIES countries.

A second major obstacle was "paralization" of the SEA during the 1978 election year. Funds and vehicles, never plentiful, were diverted from project use leaving few resources for project activities. SEA personnel were extremely concerned that any "rocking the boat" to try to obtain necessary resources for continuance of professional work would mean a loss of their jobs. It is to the great credit of the SIEDRA technical director that he was willing to risk his job in pushing for vehicles and funds to conduct SIEDRA fieldwork during the election period. Uncertainties of personal and family security during that period were such that, on several occasions, AID Mission personnel were advised not to report to work in the face of a rumored coup d' etat and political violence. Failure to support the project within SEAPLAN went beyond the election period, however, and led the two-man SIEDRA staff to negotiate, project transfer to SURENA in August 1978. The strong SIEDRA support in SURENA is reflected in their operational funding which has increased from $10,000 in SEAPLAN to $0.5 million in some level of SURENA. "Paralization" during the 1982 election compaign is expected.

A third major obstacle to progress has been the lack of administrative training and experience on the part of SIEDRA personnel. The multidisciplinary make-up of the program greatly exacerbates the situation. A great deal of time is wasted due to inability to handle routinely such administrative activities as meeting scheduling, stocking of expendable items, vacation scheduling, and reporting for sick leave.

A fourth major obstacle has been the low salaries paid to government employees, which has made attracting and retaining good personnel very difficult and delicate. One SIEDRA specialist recently left for a private consulting job paying over twice his SIEDRA salary. As the SIEDRA program continues to grow in prestige, staff personnel opportunity costs will increase and they will be bid away to other jobs if SIEDRA salaries and benefits cannot increase competitively. With no civil service or other institutionalized progressive promotion system in the GODR, this problem is expected to worsen over time.

A fifth major obstacle to continue progress is the lack of institutionalized communications' channels. Nearly all interaction between SIEDRA and outside agencies and individuals is on an informal, personal, basis. There is no written legal basis on which to continue interinstitutional cooperative arrangements when key personnel change jobs. Lack of formal documentation of communications' needs and mechanisms, in the face of high personnel turnover, means that much time must be devoted continually to developing new personal contacts as the new faces appear. Frequently, policies are changed and program support is eliminated simply because it is not possible, on a timely basis, to "educate" new administrators as to the benefits of maintaining and interaction with SIEDRA or other institutions. Formalization of these linkages would provide a critical necessary condition for reducing the adverse interinstitutional effects of personnel turnover.

Sixth, my ability to directly contribute to the SIEDRA technical work has been limited by the requirement to spend 25% of my time on non-CRIES activities. In spite of excellent Mission flexibility and cooperation, Mission needs often are not completely compatible with CRIES needs. As both AID loan implementation and SIEDRA activities increased in scope and complexity, my ability to meet these demands decreased. On the positive side, my access to Mission personnel and information was probably significant in integrating SIEDRA into the NARMA project and Mission training programs.

III. 1979 EVALUATION RECOMMENDATIONS FOLLOW-UP

Four strategic recommendations were made as a result of the CRIES/SIEDRA project review in the DR in 1979. Actions taken on each recommendation are listed below.

A. USAID/Washington Should Support CRIES for Two More Years

A one year extension for FY-80 was agreed to by SEA/USAID/AID Mission/CRIES. A further extension of USAID funding has been deemed unnecessary because of strong GODR support for the project. However, it is expected that technical assistance to DIEO (SIEDRA) will likely be part of the overall NARMA project.

B. USAID/DR Should Assign SIEDRA the Primary Responsibility in Developing NARMA Loan'

SIEDRA's focus to date has been on data collection and processing, with no planning or implementation responsibilities. SURENA is currently using SIEDRA in that role in developing the NARMA loan. Other SEA agencies and agencies outside of SEA are participating in loan development under the leadership of the Technical Coordination Office of SURENA.

C. USAID Should Finance SIEDRA Training

1. Agricultural Economics

The SIEDRA economist was sent (on GODR funds) to a 4-week shortcourse on sector analysis in Guatemala in 1979. Further economics training has not been feasible because of the SEAPLAN/SURENA jurisdictional uncertainty discussed in I, above.

2. Natural Resource Management

Two SIEDRA staff members began U.S. graduate programs in NR development and soil science early in 1980. One specialist is scheduled for a MS program at CATIE (Costa Rica) in 1981. Others will likely receive additional formal training under the NARMA loan.

3. Information Systems for Ag. Planning

Three SIEDRA technicians have participated in shortcourses (2 weeks area sample frame, U.S.; 3 mos. geography, Ecuador; 6 mos. cartography, LAGS, Panama) and two in a remote sensing seminar in Costa Rica. Additional training is being planned under NARMA.

D. In Short-Run

1. Retain Resident in Ag. Policy for at Least 2 More Years

As mentioned in A, above, a one year project extension was agreed to for FY-80. During this past year my resident work has been focused on the rice land use study. Future economic studies by SIEDRA are questionable, as discussed in I, above.

2. Expand SIEDRA with Economics/Systems Analysis Specialists. (See I and II - 4b, above.)

3. TDY Assistance in Resource Analysis and Sector Analysis. (See I, above, for sector analysis problems.)

CRIES provided FY-80 technical assistance in GDSS documentation, area sample frame restratification, remote sensing and computer programming. Additional technical assistance in resource analysis is likely under NARMA, with an emphasis on the integration of SIEDRA and area sample frame data collection efforts.

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